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Final report

project	**Optimising the productivity of the potato/brassica cropping system in Central and West Java and potato/brassica/allium system in South Sulawesi and West Nusa Tenggara**
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prepared by	Peter Dawson
co-authors/ contributors/ collaborators	Putu Cakra Putra Adnyana, Dr Mieke Ameriana (dec.), Mr Akhmad Arifudin, Mr Muhammad Assad, Rofik Sinung Basuki, Budi, Ms Rachelle Crawford, Mr Rudolf de Boer, Ms Caroline Donald, Pepen Effendi, Dr Michael Furlong, Ms Fiona Goss, Dr Nikardi Gunadi, Gunawan, Ms Baiq Nurul Hidayah, Ir Dadan Hidyat, Mr Terry Hill, Mr Himawan, Ibu Siwi Indarti, Mr Eko Istiyanto, Jayadi Sp, Mr Kunto Kumoro, Mr Kus Kuswardiyanto, Ms Rachel Lancaster, Mr Stewart Learmonth, Mr Baso Aliem Lolugau, Dr John Marshall, Mr Paul Mattingley, Dr Ian McPharlin, Mr Mufrodin Sp, Lilik Mukhibah, Prof Mulyadi, Mulyanto Sp, Ms Rini Murtiningsih, Ibu Warda Mustafa, Dr Nasrullah, Ms Sri Wahyuning Ning, Nurjanami, Ms Mien Pakih, Rahadi Spd, Ir Juju Rukmana Mm, Bambang Rahayu, T.P, Dr Peter Ridland, Mr Hidayat Sayono, Mr Frans Silva, Dr Eri Sofiari, Mr Achmad Sudjudi, Ir Suhari, Sulistyo, Ms Helda Tahir, Mr Andrew Taylor, Mr Bruce Tomkins, Mr David Tooke, Mr B Triman, Mr Andrew Van Burgel, Dedi Wahid Sp, Ibu Warda, Ms Julie Warren, Wawan S, Purwono Yunianto and Mr Zamzaini
approved by	Mr David Shearer, Research Program Manager for Agribusiness, ACIAR

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Contents

1 Acknowledgments

1.1 Dedication

Vale Dr Mieke Ameriana, 1957 – 2009

Indonesian Project Coordinator ACIAR Project AGB/2005/167

Mieke’s knowledge and eagerness to get involved in all project tasks impressed and strongly influenced all participants. She was seen digging tubers in far flung Indonesian fields as well as computing economic analyses of project outcomes. Mieke’s organisational and coordinating skills contributed greatly to the success of many project tasks and to the overall success of the project. She generously shared her time and experience with Indonesian officials, Australian visitors and farmers alike even though it meant she was away from her family often. We all appreciated her ever smiling and friendly nature.

We will never forget Mieke or her devotion and dedication to the project as well as her wonderful hospitality and friendship.

We pray for her. May God bless her.

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Apologies for the omission of many other contributors whose names have not been mentioned.

2 Executive summary

Aim

The project aimed to increase the production and profitability of the potato and cabbage system in West Java (WJ), Central Java (CJ), Nusa Tenggara Barat (NTB) and South Sulawesi (SS) through participatory technology transfer of appropriate market focussed crop management techniques. The main objectives were to:

- Adapt and apply robust integrated crop management (ICM) systems for potato and cabbage.
- Develop and implement low-cost schemes that significantly improve the access of smallholder vegetable producers to quality potato seed.
- Develop the capacity of project partners to use adaptive research and development strategies.
- Assess the potential to develop a potato seed producing area in eastern Indonesia.

A series of Farmer Field Schools (FFS) were run in each province as the platform for participatory field learning about potato and cabbage management as well as for investigations into overcoming production constraints identified in baseline surveys.

Identification of constraints

Baseline surveys of potato and cabbage crops collected data on crop agronomy, precise yield, production economics and post harvest management to identify factors contributing to both high and low yields and profitability. For potatoes; over-application of potato late blight disease (PLB) fungicides, low soil acidity, high potato seed expenditure, incidence of potato leafroll virus (PLRV) and a negative correlation between insecticide expenditure and yield were the constraints identified. For cabbage constraints were; clubroot disease, high fertiliser costs required to overcome the debilitating combination of clubroot and low soil pH, diamondback moth (DBM) and excessive insecticide expenditure.

Improved Farmer Field School Method to test constraints

Initial FFS methodology compared an integrated crop management (ICM) plot with a conventional plot but the many concurrent, disparate management changes between the plots made interpretation of the outcomes difficult and reduced the value farmers got from these activities. The second and third cycles of participatory field investigations were modified to allow the impact of single management changes to be planned and measured by farmers. These farmer field investigations focussed on specific constraints identified by the baseline surveys. These activities were supported by specially developed Technical Toolkits. These publications were aimed at farmer guides and facilitators. The toolkits describe how farmer groups can undertake rigorous but simple experiments to test constraints to production. The Technical Toolkits contained supporting information on standard operation procedures for managing potato and cabbage crops, background information on cropping constraints and tally sheets for the collection of essential data. The standardisation of the simple experiments contained in the Technical Toolkits meant that collaborating farmer groups could add rigor to their results by pooling data to allow statistical analysis of their results. A companion field pocket booklet facilitated the recording of treatment inputs and costs so the profitability of treatments investigated could be determined. Extension material aimed at farmers included Factsheets, posters and three DVDs. This new method of participatory field investigation allowed easier and more rigorous interpretation of the results. Farmer Initiated Learning (FIL) was the brand used to differentiate this new method from previous highland vegetable FFS practice.

An example of the improved results possible through the FIL approach is shown by PLB management activities in NTB which compared project recommendations of alternating systemic and contact fungicide applications with conventional practice. Conditions were challenging with rain almost every day of the crop's growth. Results from two farmer groups at Koang Londe and Mentagi showed yield for the project's alternating systemic-contact recommendation was significantly higher than conventional practice at 19.5 t/ha verses 18.0 t/ha. Efficacy, as shown by PLB incidence, was also significantly improved with the conventionally managed plot having 17% of plants infected while project's treatment plot had only 10% of plants infected. Pesticide costs for the project's recommendations were slightly lower. The fungicide component of costs under farmers' management was Rp 8.9 million per ha while the ACIAR method was Rp 8.5 million per ha. Farmers' management fungicide costs in this activity were 59% higher than shown in the baseline survey probably because of the extreme wet season. The result was the ACIAR treatment produced a gross margin of Rp 10.8 million per ha which was significantly greater, by Rp 4.0 million per ha, than the conventional treatment gross margin. These results show that the FIL methodology of LBD demonstration plots is an effective way for farmer groups to do their own research on crop management. They show that the ACIAR recommendations for PLB management are effective and produce greater profits than the farmers' usual disease management whilst reducing the risk of PLB resistance from developing. Farmers have reported they are already adopting the project's PLB management recommendations of alternative applications of systemic then contact fungicides, with better disease control and reduced costs. The present value to farmers of the project's alternating systemic-contact recommendations for PLB control over the next 10 years was assessed for WJ and CJ at Rp 18.1 billion or AUD 2 million. This analysis is conservative as it was based on the benefits of reduced PLB control costs in wet season crops and omits yield benefits.

Another successful example was the more complicated investigation by two cabbage farmer groups into clubroot management using replicated, factorial treatments of lime and a resistant variety. The farmers were able to complete this investigation with support from their guides who were in turn supported by the project's Cabbage Technical Toolkit. Application of lime with a resistant variety at the Bukit Madu farmer group (CJ) resulted in very highly significant increases in yield; 32.5 t/ha versus 15.8 t/ha. The same investigation done by the Pemuda Tani Vetran group (SS) showed significantly reduced numbers of plants infected with clubroot where soil pH increased from 4.5 to 6.2 by harvest. At this site the gross margin of the resistant cultivar with lime was Rp 9.5 million per ha while the control treatment on susceptible variety without lime was less than half at Rp 4.6 million per ha. The resistant variety Maxfield with lime produced the highest yields with no loss to clubroot in both FIL activities and so this combination is recommended for cabbage integrated disease management program. An economic projection of the value of this recommendation to farmers in WJ, CJ and SS shows a present value of Rp 89 billion or AUD 10.2 million.

Improved access to quality seed potatoes

To support seed potato production, investigations into potato cyst nematode (PCN) showed that the Sembalun Valley in NTB was:

- free from PCN;
- PCN cyst populations were shown to be killed in less than 60 days in flooded highland paddy soil meaning that similar soils in the Sembalun Valley will protect against the introduction of PCN under an annual potato cropping system.
- the species of PCN sampled from East Java, CJ, and WJ was identified as *Globodera rostochiensis* pathotype Ro2. This identification to pathotype is important for managing PCN as it allows resistant potato varieties to be identified.

In addition FIL activities which compared seed sources showed that Australian seed potatoes had comparable performance to Indonesian certified seed potatoes despite suffering poor storage treatment after arrival in Indonesia. These results open an opportunity to increase the supply of high quality potato seed in Indonesian by augmenting the Indonesian government certified seed supply system with a partial seed program based in the Sembalun Valley of NTB. The supply of Indonesian Certified G4 seed does not meet farmers' demand so inferior quality seed is used. This non-certified seed increases the risk of spread of pests and diseases. The wide distribution of PCN in CJ and its appearance in other provinces of Indonesia is most likely due to spread through non-certified seed. In the proposed partial seed scheme, imported Granola seed from PCN free areas of Australia would be cool stored after arrival in Indonesia while quarantine checks are carried out. The imported seed would then be multiplied one time in the Sembalun Valley which has medium seed degeneration rates compared to the high degeneration rates found in Java. The Sembalun Valley produces potatoes in paddy fields following the wet season highland rice crop. This cropping system gives good protection against PCN because the wet season flooding kills PCN. This partial seed program should provide seed at a lower price than imported seed. To realise this opportunity a seed potato system needs to be introduced to NTB and the farmers will require training in seed potato production and seed marketing. The Indonesian Government will need to issue import permits for Granola seed potatoes. The Sembalun Valley farmers now recognise the potential of seed potatoes to complement their processing potato production.

Other project Impacts

Project impacts were also assessed through farmer survey. Farmers reported that after the project pest and disease control decisions are based on crop monitoring so pesticides are now used more selectively. Improved understanding of active ingredients means that mixing of agricultural chemical has been reduced. Training of farmers in sprayer calibration also meant that spray applicators were better maintained and that pesticide application was more precise. Farmers reported that pesticide use has been reduced to 20–25 kg/ha per season. One farmer group quantified the cost savings as Rp 3.2 million per ha based on before-project-costs of Rp 9.4 million per ha while post-project costs were reduced to Rp 6.2 million per ha. Farmers were also now aware of the benefits of correct soil pH for vegetable production which should lead to more efficient use of fertiliser.

Social impacts of the project included: improved self confidence of participants who gained increased community respect; a strengthening of relationships between farmers; and the establishment of independent FIL groups. Gender impacts were minor, however women are dominant in determining how crop proceeds are spent and since participating in FIL some families now put aside farming capital for the following season.

Farmers reported that as a result of project activities they were now more aware of the environmental impacts of their farming activities than they had been at the start of the project. The reduced, more selective use of pesticides will indirectly improve environmental quality and of course influence the health of the farmers themselves. This will have a flow-on effect to the environment as there should be a net reduction in the amount of pesticides applied.

3 Background

The two major vegetable crops in the Indonesian provinces of WJ and CJ are potatoes and Brassicas which are normally grown in rotation. Potato and Brassica production from these provinces accounts for over 50% of the total Indonesian harvest for both crops, 1 million tonnes and 1.5 million tonnes respectively. Farmers producing these crops are mostly smallholders with 36% - 50% owning their land which averages just 0.5 ha. They grow these crops for cash rather than home consumption. Demand for potatoes is continuing to increase with the major processors unable to source sufficient quantities of potatoes from Indonesia and having to import raw materials. This unmet demand plus export opportunities to nearby Asian countries offer excellent opportunities for Indonesian farmers to improve productivity and supply without a negative impact on prices. The average yields for potato crops grown in these regions are 10–20 tonnes/ha which are low by international standards and reflect sub-optimal agronomic management, lack of high quality seed and pests and disease problems.

In July 2005, ACIAR commissioned a major scoping study to identify where investment built on earlier ACIAR work would yield significant impact. The most promising opportunity for ACIAR involvement was vegetable supply chains in Java rather than those for fruits and in other provinces. Vegetable production is a livelihood that enables farmers with limited land to earn significant income and to intensify their production. The other advantages of investment in vegetables over fruit are that:

- a greater number of farmers tend to be focussed on income generation alone and thus produce marketable quantities;
- farmers can more readily obtain returns on investments in better technology or marketing solutions due to vegetables' much shorter crop cycle than fruit; and
- there is greater geographic focus of the major vegetable-growing areas (compared with fruit-growing areas) in Indonesia allowing for geographical targeting of the project.

The scoping study showed that Indonesia is the largest producer and exporter of potatoes in South East Asia and a significant producer of leafy Brassicas, yet there is significant unmet domestic (and regional export) demand. To Indonesian consumers, potatoes are considered as a vegetable rather than as main dish, although potato has become one of the substitutes for rice as a source of carbohydrate. The booming of domestic fast-food industry over the last decade, in which potato plays a big part, has also changed the food habits of many youngsters in the middle-and high-income classes. Indonesian government agencies support potato and Brassica crops as priority horticultural commodities for research and development. Potatoes are commonly grown in rotation with Brassica crops and, during fieldwork for the design of the project, the team was consistently requested that the project focus on the system rather than only one of the crops.

With potatoes, the major areas requiring improvement are:

- systems for the availability of quality potato seed tubers, especially for frying/chipping processing varieties, and related production issues;
- better pest and disease management systems, particularly for PCN, leafminer fly (LMF) and PLB;
- focusing varietal selection and production of potatoes to meet market specifications, possibly including improvement of post-harvest handling.

With Brassica vegetables, the major areas for improvement of profitability are:

- implementation of field pest and disease management strategies;

- better handling systems for maintaining the quality and market-suitability of leafy vegetables.

Each of these areas can build directly on current ACIAR programs in Indonesia and elsewhere.

In its 2nd year the project was extended to SS and NTB following scoping studies through the Smallholder Agribusiness Development Initiative (ACIAR-SADI). Vegetable production is an important component of the rural economy in the highland areas of SS and NTB, although they are only minor producers on a national scale. SS produces 12,615 tonnes of potatoes making up less than 2% of Indonesian production and NTB produces just 307 tonnes, mainly in East Lombok, or 0.03% of Indonesian production. Potato, Allium (shallots) and cabbage are the primary vegetables grown in SS, and for NTB they are potato and shallots. Despite the small scale there are opportunities to increase potato/Brassica/Allium production significantly in these provinces. This increase in production can be enhanced and supported by the tools and technologies developed through the original project, primarily through the development of appropriate ICM and the use of suitable adoption strategies for the benefit of vegetable smallholders. The long term sustainability of a potato industry in Indonesia would be enhanced through the ability to produce seed potatoes. Initial scoping studies identified the potential of the Sembalun Valley in NTB to be a seed producing area, as it is likely to be free of PCN. To develop this potential and provide the foundation of a viable agribusiness enterprise in NTB an assessment needs to be made to prove the potential of the island as a potato seed producer.

4 Objectives

The aim of this project is to increase potato and rotation crop production and profitability through participatory technology transfer of appropriate crop management techniques which have a strong market focus.

The four major objectives are to:

1. Adapt and apply robust integrated crop production and pest management systems for potato and Brassicas/Alliums, developed in WJ, CJ, SS and NTB.
2. Develop and implement low-cost schemes that significantly improve the access of smallholder vegetable producers in WJ, CJ, NTB and SS to quality potato seed.
3. Develop the capacity of project partners to use adaptive research and development strategy to improve the potato and Brassica/Allium production systems in SS and NTB.
4. Assess the potential to develop a potato seed producing area in eastern Indonesia, creating viable agribusiness alternatives for smallholders.

5 Methodology

5.1 Project partners

The ACIAR commissioned lead organisation was the Department of Agriculture and Food, Western Australia with the project lead by Mr Terry Hill. Other Australian collaborating organisations were the University of Queensland and the Department of Primary Industries Victoria. The Indonesian Project Leader was Dr Eri Sofiari of the Indonesian Vegetable Research Institute (IVEGRI). Other Indonesian collaborating organisations were: Dinas Pertanian Dan Tanaman Pangan, Jawa Barat; Dinas Pertanian, Jawa Tengah; Lembaga Pengembangan Teknologi Pedesaan (LPTP); PT. Indofood Sukses Makmur Tbk, the International Potato Center - East and South East Asia and the Pacific (CIP-ESEAP); Assessment Institute for Agriculture Technology (AIAT) SS; Dinas Pertanian Tanaman Pangan Dan Hortikultura SS; AIAT NTB; Dinas Pertanian Provinsi NTB.

5.2 Project planning

The project initially targeted CJ and WJ provinces then added SS and NTB in 2008. In August 2006 all the organisations collaborating on the project met in Lembang WJ at a planning workshop to finalise partner responsibilities, timelines, budgets and reporting requirements. A project management team co-chaired by the Australian and Indonesian Project leaders and including nominees of the participating organizations was established to ensure strong integration of all activities.

5.3 Baseline surveys

5.3.1 Planning

The initial project workshop addressed the baseline survey and needs assessment components of the project. The project team assessed counterparts' skill requirements for undertaking the baseline survey and adjusted the training program accordingly. Training was provided in survey interview techniques, data collection, working in small teams, data analysis and report writing. The survey covered a number of issues for both potatoes and Brassica including seed supply systems. Practical training in soil and plant leaf sampling was conducted together with reporting format and requirements. Team members worked together to finalise the baseline survey questionnaires, Indonesian team members having been provided with a draft prior to the workshop. The proposed survey teams and Australian counterparts met with farmers to test and fine tune the questionnaire, ensuring that the questionnaire captures the required information, effectively assessing farmers' skill levels. During the workshop a draft project evaluation baseline survey was developed to facilitate the measurement of change attributable to the project. Arrangements for the collection and analysis of soil and plant leaf petiole samples were also finalised.

5.3.2 Design and scope

Baseline surveys were conducted in potato and Brassica crops for the wet and dry seasons in the first year of the project. Both agronomic and economic surveys were conducted for each crop. The survey data enables the identification of factors contributing to both high and low yields, and profitability. It also supports the analysis and monitoring of project impact. Key data was collected on plant agronomy, economics of production, chemical usage and post harvest management.

The baseline survey also determined problems associated with seed supply, source and quality problems and percentage of farmers using (i) imported certified potato seed; (ii) locally produced certified G4 (G = generation grown out from tissue culture) potato seed; (iii) locally produced non certified G4 - G5 potato seed; (iv) locally produced potato seed from trusted supplier; (v) locally produced potato seed from market; (vi) own stored new generation potato seed; (vii) old stored old generation potato seed (viii) other potato seed and help to identify players in the seed supply chain.

A 'Stratified Cluster Sampling' design was used where the provinces and districts/sub-districts (strata) were not randomly selected, i.e. stratified, but chosen because they are important potato growing regions. The farms (sites) were randomly chosen within each province. In addition a participatory rural appraisal was done of potato production in SS (Appendix 1 Annex 3). Agronomic and economic questionnaires used are contained in Annexes in Appendices 1 to 4.

Potatoes

A total of 88 respondent sites were chosen; 49 in Java, 20 in SS and 19 in NTB. In CJ a total of 24 farmers from 3 sub-districts in Banjarnegara (Pejawaran, Wanasaya and Batur) and 2 sub-districts in Wonosobo (Kejajar and Garung) were included in the survey with planting from January to May and harvest from April to August 2007, a 'dry season' crop. In WJ there were a total of 25 farmers with 5 each from 2 sub-districts in Bandung (Pangalengan and Kertasari) and 3 sub-districts in Garut (Cikajang, Pasir Wangi and Cisurupan) with sowing from November 2007 to March 2008 and harvest from February to June 2008, a 'wet season crop'. In SS there were a total of 20 farmers from 3 sub-districts of Gowa district (Malino, Tompobulu and Tinggimoncong) with planting from October to November 2008 and harvest from December 2008 to April 2009, also a 'wet season' crop. In NTB there were a total of 19 farmers from 2 villages (Sembalun Bumbung, 4 and Sembalun Lawang, 15) in the same district with planting from July to August 2008 and harvest from October to December 2008, a 'dry season crop'. The variety Granola was grown in CJ, SS and WJ and Atlantic in NTB. The farmer respondents were interviewed by enumerators and answered a comprehensive set of questions on their potato growing practices and conditions (Appendix 1, Annex 1) over 6 visits including harvest.

Cabbages

A total of 50 farmer ('respondent') sites (1 site equals 1 farm) were chosen from the 2 provinces; 25 in both CJ and WJ. In CJ and WJ five farmers were selected from each of the same as the potato survey. Cabbage crops were transplanted from June to October in CJ and from March to June in WJ and were considered 'dry season' crops.

5.3.3 Survey assessment

Enumerators acted as assessors and carried out various sampling (i.e. soil, plant, insect etc) and crop monitoring activities (i.e. crop growth and soil moisture status, incidence and severity of pests and diseases) at each visit. All these crop measurements, as well as yield, were made from a 50 m^2 plot pegged near the centre of each site. The enumerators (Dinas Pertanian and other staff) were trained in the monitoring of crops prior to the survey beginning. Agronomic practices and conditions were also recorded from farmer responses to the questionnaire.

5.3.4 Soil and plant tests

Before planting 25 individual soil samples were taken in a zigzag pattern across the sampling area from each 50 m^2 plot to a depth of 15 cm using a soil corer. All soil samples were bulked into a single composite sample in a plastic bag and forwarded to the laboratories at IVEGRI, AIAT NTB Mataram or AIAT SS Maros. Petioles were analysed for pH (H_2O and KCl), total N% (Kjeldahl) and %C (Walkley and Black 1934), extractable NO_3-N, NH_4-N (both in 10% KCl), P (Bray and Kurtz 1945 and Olsen *et al.* 1954), S, Al

(CJ and WJ only), Fe, Mn Cu, Zn (all in $NH_4CH_3CO_2$ at pH 4.8), exchangeable K, Ca, Mg and Na (all in $NH_4CH_3CO_2$ at pH 7.0) and particle size (% sand, silt and clay). The bases K, Ca, Mg and Na were reported as cmol (+) per kg (= 1 milliequivalent/100g).

For potatoes 30 petioles were collected from the youngest fully expanded leaf in a grid pattern across the 50 m^2 sampling plot from each site. The first petiole sample was collected when the length of the largest tuber was 10 mm and thereafter at 2 week intervals to a total of 4 samples. All 30 petiole samples were bulked into a single composite sample in a paper bag, for each site, and forwarded to the laboratories. For cabbages the youngest mature leaf was collected from 20 plants in a grid pattern as for potatoes over the 25 sites in both provinces 28 to 35 days after transplanting (first sample), the wrapper leaf (outermost leaf around the head) was similarly sampled from 20 plants at the early heading stage (second sample). Petioles or leaves were analysed for total N, P, K, Ca, Mg, S, Na, Cl (all in % DW) and total Al (CJ and WJ only), B, Fe, Mn , Cu and Zn (all in mgper kg DW).

5.3.5 Pest and disease type, incidence and control

Farmers recorded incidence of pests and diseases in the stored seed prior to planting and during the growth of the crop. Independent monitoring by the enumerators also recorded incidence (% of sites affected) and severity of pests (pest number/plant) and diseases (light, medium or heavy, % of plants affected per site) in the crop during five visits of the growing season. Control measures, such as chemical application and cultural methods prior and during the crop was recorded by the farmer.

Virus incidence was determined from a random leaf sample taken at each CJ and WJ site from every fifth plant within each sampling area to a total of 50 plants per site. All leaf samples were placed in plastic bags immediately and stored in cooler boxes to remain fresh. Samples were then submitted to the IVEGRI virus laboratory for testing for presence of potato virus X (PVX), PVY and PLRV.

5.3.6 Diamondback moth studies

The major natural enemy groups on diamondback moth populations were studied to provide a better understanding of their ecology and impact. The information would be used to provide good agricultural practice (GAP) guidelines to farmers.

5.3.7 Yield

The total, marketable and reject yield of the crop at each site was assessed from the 50 m^2 measurement plot. Potato tubers were graded into 3 sizes (<30, 30 - 50 and >50 mm diameter) with weight and number recorded. Yield was converted to tonnes per hectare for statistical analysis. For cabbages whole plants were weighed and counted.

5.3.8 Agronomic data analysis

Either regression analysis or analysis of variance (ANOVA) of the factor with yield was performed using Genstat v 13.0. In some cases it was not possible or relevant to relate the factor statistically with yield so frequency tables were used where percentage of total to respondent answers (where 1 farmer response = 1 site or farm) were presented.

Simple linear regression were used to analyse the relationship between the continuous measures of agronomic conditions (e.g. soil nutrient concentration), practices (e.g. rates of applied fertilizer) versus tuber yield across all the sites in each of the 4 provinces. A probability of < 0.10 was used as the minimum level of significance. The lower level of significance is considered more appropriate for surveys, compared with experiments, as in most cases there is much less control over the factors being tested. Concentrations of nutrients considered deficient, adequate or excessive (toxic) according to Huett *et al.* (1997) at the 10 mm tuber stage were shown as vertical lines on each regression.

ANOVA was used to determine the relationship for discrete measures of presence or absence (i.e. pest and disease), education (i.e. sources), irrigation (i.e. type) and weeds versus total yield across all sites in each of the 4 provinces. A probability (P) of <0.10 was used as the minimum level of significance rather than <0.05. The least significant difference (LSD) was used to separate means where significant differences were found. It is noted that in such analyses there is a 10% probability of detecting erroneous significant relationships i.e. incorrectly concluding that a factor either, positively or negatively, influences yield or has no effect on yield.

Combined % relative yield was used when all the data from all 4 provinces was to be combined together and analysed as a single data set. To produce the combined relative yield each site was presented as a percentage of the highest total yield for that province (i.e. the highest total yield was equivalent to 100%). This was repeated for all 4 provinces and combined into one data set.

5.3.9 Economic data analysis

Gross margin

For the baseline economic survey a standardised model for gross margin analysis was used which measured revenue from sales minus costs (predominantly variable costs) of production. Annex 1 in Appendix 2 contains the questionnaire used in the economic survey. The baseline survey focused on variable costs because vegetable production is small scale with limited use of capital equipment. The farms surveyed were of differing sizes and the results were converted to a per hectare basis to enable comparison.

Regression analysis

A sensitivity analysis was conducted to gauge the impact of changes in input costs on the gross margin using the Sensit Add-in in Excel. This was used to determine regressions that should be investigated. A yield and price sensitivity for the gross margin was also performed. Excel regression analysis was used to investigate whether there was a relationship between practices and farmer yields, prices and gross margin. Where no graph is presented there is no significant correlation found between the variables. Where necessary, counterparts and later the enumerators from the provinces were consulted to clarify any issues with the data. The regression analyses sought to find correlations between the following main variables shown in Table 5.1.

Table 5.1. Column headings show the main variables and the body of the columns shows the correlations that were investigated.

Gross Margin correlations investigated:	Yield correlations investigated:	Average price correlations investigated:
Yield		
Average price of produce sold	Average price produce sold	
Scale	Scale	Scale
Fertiliser expenditure	Fertiliser expenditure	Fertiliser expenditure
Insecticide expenditure	Insecticide expenditure	Insecticide expenditure
Herbicide expenditure	Herbicide expenditure	Herbicide expenditure
Fungicide expenditure	Fungicide expenditure	Fungicide expenditure
Quantity of seed used	Quantity of seed used	Quantity of seed used
Value of seed used	Value of seed used	Value of seed used

Validity of data

This baseline economics survey was conducted at the same time as the baseline agronomic survey which looked at agronomic, pathological and entomological factors and their impact on yield and quality/price (Appendix 1). The agronomic survey included a 50 m^2 plot in the crop cultivated by the farmer to provide accurate yield information. This data was used to cross reference the potato data provided as part of the economics survey by the same farmers. Where there was a difference of +/- 25% between the yield reported in the economics survey and agronomic yield plot data the results for that farmer were disregarded.

5.4 PCN studies

5.4.1 PCN status of Lombok

Potato cyst nematode survey at Sembalun, NTB.

A field soil survey was undertaken under the direction of consultant nematologist Dr John Marshall of JM Marshall Advisory NZ Ltd. Samples were taken on an intensive 3 x 3 pace grid with labour for soil sampling provided by Kelompok Horsela (**Ho**rticulture **Se**mbalun **La**wang farmer group). The soil sampling programme was completed and soil consigned to Plant Pathologist Baiq Nurul Hidayah, at the AIAT NTB laboratory.

All fields with a history of repeated potato production and therefore the highest risk of having acquired PCN were surveyed. The survey then moved to lower risk fields that had only produced potatoes using a long rotation over a number of years. Last, fields that had a single crop of potatoes were examined. Both terrace and paddy fields were sampled. A large scale cadastral map was used to show all sampled fields. The map was produced by Dr Marshall from digital data kindly supplied by Dr Heryadi Rachmat of the Government of NTB Mining and Energy Office. A formal diary was also made by the field staff of the Sembalun Dinas Pertanian office and a copy was sent to Baiq Nurul Hidayah at AIAT NTB.

The soil samples were processed in Sembalun Lawang village using a soil washing system based on a modified Fenwick Can elutriator. The soil samples were processed onto filter papers which were then examined with a stereoscopic microscope. Filter paper, funnels, Endecott sieves and a Fenwick can were provided by the project. The nematology equipment and microscope were transferred to AIAT NTB laboratories and established as a central facility. The remaining soil samples were processed at this facility.

5.4.2 Development of Sembalun as seed production area

Should the Sembalun Valley PCN survey show that PCN cannot be found, then this status must be maintained. The following methods were pursued:

1. Regulations. A proposal for Provincial regulations to be introduced to control the movement of potatoes into East Lombok was to be prepared by Dinas Pertanian NTB and BPTB NTB. The procedure for introducing regulations to protect PCN freedom of Lombok would be as follows:
    - Mandate of DPRD I – NTB (DPRD 1 = Provincial Level Parliament) proposing Sembalun Valley as free zone of PCN and a potato seed centre for East Indonesia;
    - Draft of seed regulations submitted to Governor and Dinas by Kepala Dinas Pertanian NTB (supported by AIAT with data/references by AIAT) based on the precedent of citrus regulations for NTT;
    - Draft by Governor and Dinas (supported by AIAT) then submitted to DPRD 1.

2. Dinas Pertanian NTB and Kelompok Horsela to develop seed production regulations for Sembalun Valley. These must include appropriate rotation times and continued PCN testing to ensure claim of PCN freedom can be justified.
3. AIAT NTB to help Kelompok Horsela ensure demand for seed potatoes can be met from local certified seed potato production. Supply of seed from Sembalun needs to be carefully planned to ensure local demand is met and threat of uncertified seed from outside is reduced. This will require improved storage so that seed ready for planting will be available from February until October.

The method used to achieve these 3 activities was for five key players from NTB to visit Western Australia (WA) to undertake a rapid appraisal of the systems in place in WA to protect the potato industry from PCN and other exotic pests and to supply high quality seed. This would enable the participants to understand what practical measures should be adapted to protect potato production at Sembalun. Before the study tour began the participants were asked to send draft regulations to the Australian partners so that these could be discussed during the study tour. The curriculum developed is shown in Appendix 5 Table 4.1.

5.4.3 PCN species identification

PCN species identification was done by the nematology group led by Professor Mulyadi at Gadjah Mada University (UGM) with guidance from Dr John Marshall. Soil samples were collected from potato planting areas shown in Table 7.21. PCN cysts were extracted from the soil samples by using the method of Shurtleff and Averre III (2000).

PCR

DNA was prepared from 80 nematode cysts as described in Appendix 5 Section 4.2. The DNA quality and quantity was identified by electrophoresis. The polymerase chain reactions (PCR) were carried out using primers PITSr3 and PITSp4 in combination with primer ITS5. Cycling conditions included an initial denaturation step of 94°C for 2 minutes, followed by 35 cycles of 94°C (30 s), 60°C (30 s), 72°C (30 s), and finished with one cycle at 72°C (5 minutes) (Skantar *et al*. 2007).

Morphology

Morphological identification to distinguish between *Globodera rostochiensis* and *G. pallida* were also done based on the morphological differences of the stylet knob of the larvae/juvenile and on the perineal pattern of the cyst. The number of PCN cysts in each of the soil samples was also counted.

5.4.4 PCN pathotype identification

Four populations of PCN collected by the UGM nematology group were sent to the Agri-Food & Biosciences Institute (AFBI) in Belfast, Northern Ireland for a differential screening test to identify their pathotype. The tests were undertaken by Mr Trevor Martin. Four differential potato clones were inoculated with the unknown *Globodera* cyst population; *Solanum andigena* CPC 1673; *S. kurtzianum* 60.21.19; *S. vernei* 58.1642/4 and Desiree, a fully susceptible potato cultivar. High reproduction rates of the cysts should take place on a fully susceptible host which indicates the cyst's potential capacity for reproduction. The cysts placed on *S. andigena* CPC 1673 will not reproduce if they are of the pathotype Ro1 but will multiply if they are of other pathotypes Ro2; Ro3; Ro5; Pa1 or Pa2/3. When the cysts are inoculated into *S. kurtzianum*, neither Ro1 or Ro2 will reproduce in high numbers. *S. vernei* will not allow Ro1; Ro2 or Ro3 to multiply in high numbers.

5.4.5 PCN population decline experiment

The study was designed by Dr Marshall. The Terylene bags were developed in New Zealand (Marshall 1997) and are twin skinned Terylene voile bags. The mesh size of the bag is small enough to contain nematode cysts and eggs within the bag.

1. The experiment was done in terrace soil in Pejawaran, Banjarnegara and paddy soil in Wonosobo. These soils were selected as they were similar to the terrace and paddy soils found at Sembalun NTB. The NTB soils could not be used for this experiment which involved introducing PCN as they were presumed to be free of PCN.
2. Fifty litres each of non-infected PCN terrace and paddy soil were collected and were brought to the UGM nematology laboratory. Each terrace and paddy soil was mixed well, stones and weeds were removed and the soil was checked for freedom from PCN.
3. Twenty five litres of terrace and paddy soil were taken and each soil-type was mixed well with 25% of new PCN infested soil (from a PCN propagation experiment, Appendix 5, Section 4.4.2).
4. The bag in each replication was tied and 5 replications (5 bags) of terrace soils were buried (below the soil surface) in Banjarnegara (potato planting area) and the other 5 bags of paddy soils were buried in Wonosobo (paddy planting area).
5. Over time 100 ml of terrace and paddy soils from each replication were taken to determine the number of the cysts or eggs present. Data were collected at 30, 60, and 90 days after Terylene bags were put in terrace or paddy soil. This experiment was done for a period of two planting seasons (180 days).
6. The data collected were: number of cysts in 300 ml soil from each replication and the number of the viable eggs in the cysts.
7. Regressions were fitted to relationship between cyst/egg numbers and time of burial using Genstat V13.0.

5.5 Training of trainers for potato-cabbage FFS facilitators

The extension component of the project commenced with a planning meeting with the key partners of the project. This was followed by a series of training of trainers (TOT), in the provinces. The team of master trainers, responsible for TOT included staff from IVEGRI and LPTP and farmer trainers who previously were involved in an FAO/CIP/LPTP project and achieved master trainer status. Twenty trainers were initially trained in each province. Curriculum development workshops to design training were then delivered through a FFS approach.

5.5.1 Training of trainers curriculum development workshops

A curriculum development workshop was conducted to design the outline of activities and prepare the logistics of the TOT. The TOT followed the line of activities of the FFS. For potato, integrated pest management (IPM) manuals developed by FAO/CIP/-LPTP were used (Tantowijoyo and van de Fliert 2006, Wahyuning *et al.* 2006). The TOT master trainers worked closely with IVEGRI and Dinas Pertanian staff to ensure that other components of the ICM training program could be added throughout the project as the results of the trials, GAP demonstration and seed supply chain training and research became available. Master Trainers practised knapsack sprayer calibration during a curriculum development workshop to ensure this fundamental aspect of crop management could be passed on to farmers. Master trainers also received additional training for Brassica IPM which was covered in less detail in the previous TOT. The curriculum development workshop developed a system for monitoring and evaluation of both TOT and FFS. The workshops were held prior to the start of the TOTs.

TOT using the Brassica and potato production systems was conducted in all provinces. In order to ensure that the same team of experienced master trainers was available for both TOTs, programs were run sequentially rather than simultaneously; the timing of the TOT program in each province was also determined by seasonal factors. In each province 2 trainers per farmer group were trained. The TOT program was facilitated by four master trainers. The trainers received support from Australian and Indonesian (IVEGRI and Dinas Pertanian) research staff.

5.6 Updating TOT/FFS curricula and training manuals, and develop extension materials

Existing Brassica FFS manuals were tested in the TOT activities and updated for the specific requirements to produce a publication equivalent to "*All About Potatoes. An Ecological Guide to Potato Integrated Crop Management*" recently released by FAO/CIP (Tantowijoyo and van de Fliert 2006). The FFS exercise manual, "FFS for potato IPM: a facilitators' guide" (Wahyuning *et al.* 2006) was also complemented with Brassica FFS field guides, as necessary. Trial results, the findings of the GAP demonstration and seed supply chain research and training components of the project were added to the FFS manuals as the information became available. Video was used to record key aspects of Australian seed potato production and protection. The video was made by study tour participants. A storyboard was used to plan video scenes of each component of the study tour to explain its relevant to improving the protection of the seed potato industry of Indonesia.

5.7 FFS through consecutive potato and Brassica seasons

Following TOT a series of FFS was run in each of the provinces by facilitator teams of two TOT graduates. Each FFS engaged 20 farmers and participants and met for about 4 hours weekly during the crop cycle (approximately 13 weeks). The FFS provided the platform for conducting participatory field trials on potato pest and disease problems for which no good management alternatives to pesticides yet exist. Methodology was to compare ICM plot against conventional practice. The 20 farmers participating in the potato FFS in CJ and WJ continued to participate in the Brassica FFS in the second phase of Cycle I. Farmers were introduced to topics of ICM such as:

- Pest/disease/natural predators in potatoes;
- Agro-ecosystem observations;
- Bio-pesticides;
- Group dynamics;
- Measuring soil pH;
- Balanced crop nutrition;
- Insect zoo;
- Viruses and their vectors;
- Tuber development phase;
- Weather and disease;
- Monitoring insect traps;
- Economic threshold;
- Tuber maturity phase.

Following the completion of Cycle I the baseline survey results were analysed the FFS methodology was modified to enable the impact of single management changes to be measured by farmers. Individual learning-by-doing (LBD) demonstration plots for the wet season potato crop in WJ 2008/09 were devised at the project review meeting and curriculum development workshop in Lembang in August 2008. The aim was to instigate demonstration plots that allowed the impact of single management changes to be measured by farmers. Factors identified by the potato baseline survey; PLB, soil pH, seed quality and insect management were examined. The design for all sites was:

- LBD 1, 3 sources of seed (imported G4 certified, Indonesian G4 certified and local (uncertified) seed).
- LBD 2, 5 lime treatments (nil, calcium carbonate at 2 rates and dolomite at 2 rates);
- LBD 3, PLB management comparing conventional control with the *systemic-contact-systemic* method based on Cáceres *et al.* (2007).

For cabbage factors identified in the cabbage survey for testing in LBD plots were clubroot and IPM.

This new methodology enabled farmer groups to investigate new management techniques and to verify performance claims. Collaboration between farmer groups by pooling results ensured rigorous comparisons were made as results could be statistically analysed. We call the new methodology Farmer Initiated Learning (FIL) or in Indonesian Pembela**jar**an Peta**ni** Pelo**por** or Jarnipor or PPP for short.

The 3rd cycle of participatory technology transfer activities were again modified by simplification to have a farmer group focus on just one LBD activity rather than several. Also improved information was developed to support trainers and guides.

5.8 Mid-term review workshop

The Project Management team was in regular communication throughout the project. Project monitoring reports were generated by the professional and management team every 6 months. These reports detailed progress and problems in implementing project activities, budget expenditure and changes and project impact.

A midterm review workshop was held in Year 3, here the Australian and Indonesian project teams together with representatives of farmer groups met to discuss the project. This workshop provided the opportunity to revise or repeat project activities if required.

5.9 Farmer conference/project evaluation workshop

Towards the end of the project a conference for farmers and trainers to share their learning and experiences and to evaluate the project was held near the border of CJ and WJ. Representatives of each collaborating organisation including farmer groups and PT Indofood attended to report on the project and share experiences and study results with project team members and local government officials/ policy makers.

The conference program was designed to allow farmers on the first afternoon, to break into 6 groups each with 10 members to discuss significant change stories elicited from the following questions. As a result of being involved in this project over the last 4 years:

1. What was the most significant change you observed in your village?
2. What was the most significant benefit for your farming system?
3. What was the most significant benefit for farmers in your group?
4. What was the most significant change in pesticide usage?
5. What was the most significant change in fungicide?
6. Other comments for future ACIAR projects.

Each group was allotted one of the questions to discuss in detail. Following these discussions each group recorded the key points around their question. The results of all the group's discussion were collated for presentation by the leader of each group on the following morning to the entire workshop.

Work plans for self-supporting follow-up activities were formulated.

The evaluation workshop provided recommendations for the *Conclusions and recommendations* section of this final report.

5.10 Impact evaluation of ICM activities

5.10.1 Survey of Brassica/potato farmer groups

Social impact studies were conducted in six districts across four provinces in 2010 by a team from LPTP. Informants during the impact study were:

- 54 FIL participating farmers from farmer groups from the districts of Bandung, Garut, Wonosobo, Banjarnegara, East Lombok, and Gowa,
- 30 non-FIL farmers from around the FIL locations
- 16 FIL facilitators consisting of facilitator farmers and agriculture office extensions officers
- District agriculture offices from Bandung, Garut, Wonosobo, Banjarnegara and East Lombok, the SS Provincial Agriculture Office, and the SS and NTB food crop research agencies.
- FIL activity reports from each group on the ACIAR program.

The methods used in this study were qualitative deductive methods put in context descriptively with cases as study findings. The methods used were as follows:

- Interviews (in-depth interviews, focus group discussions). Interview instruments can be found in the Annexes to Appendix 14).
- Field observations (visual photos, observations in the field)
- Analyses of documents (project proposals, activity reports, group documentation).

5.10.2 Case studies to identify social change impacts

PT Indofood and other users and marketers of potatoes and Brassica were also questioned to see whether potato and Brassica production systems have improved.

5.10.3 Economic evaluations of farmer initiated learning outcomes

The benefits of outcomes from FIL activities were valued by calculating the Present Value (PV) of the project benefits. The PV differs from the net present value (NPV) of project benefits as project costs are not subtracted from project benefits. Project benefits are calculated:

- Project benefits = Total PB x (attribution to the project) % x (chance of success) %.
- Discounted PB = PV of PB.

The analysis is based on real money terms which do not incorporate inflation.

Benefit of treating clubroot with variety and lime

The gross margins developed for the cabbage FIL LBD results of the Pemuda Tani Vetran farmer group (Table 7.18) were used to calculate the PV of the benefits of the work. The use of a local variety without lime is called the "without project" scenario while the use of the clubroot resistant variety Maxfield with lime is called the "with project" scenario.

Adoption rates for the use of lime and Maxfield within each scenario" were estimated for 10 years in the future. The 2009 area of cabbage production in SS (Badan Pusat Statistik 2011a) was multiplied by the adoption rate and the yield of each treatment to calculate production in tonnes. This production was valued using the value per tonne calculated from the gross margins. The sum of the 10 year's value for the "without project" scenario was subtracted from the "with project" scenario to calculate the "future value". A PV for this amount was calculated using the Excel NPV function with a discount rate of 7%, year 1 was not discounted. Likelihood of success for new systems developed and demonstrated by the project was 90%. Attribution of benefits to the project was 80%. Additional production can lead to falls in prices so the analysis included a number of alternative levels of price falls and their impact on the PV of project benefits.

Benefits of using PCN free seed for South Sulawesi

The PV of project benefits of preventing PCN from establishing and spreading in SS were estimated. PCN freedom can be assured by exploiting the opportunity developed through the project of an alternative supply of PCN free seed from NTB (Section 7.2.7). A gross margin was prepared for crops free or affected by PCN based on the SS gross margin presented in Table 7.5. The impact of PCN on potato production was reflected in the model by reducing yield by 55% which then reduces returns to break even (returns just cover costs). This yield reduction falls well within the estimated yield reductions due to PCN of 30 – 90% (Hadisoeganda 2006). Infestation rates for the "PCN infestation" and "PCN freedom" scenarios for 20 years in the future were estimated. The 2009 area of potato production (Badan Pusat Statistik 2011b) in SS was multiplied by the rate of spread to give the area affected. This affected area was valued by multiplying it with the PCN gross margin and adding this to the unaffected area multiplied by the free from PCN gross margin. The "PCN infestation" scenario has the yield and gross margin remaining constant over the 20 years of the analysis. Each year's value of the "PCN infestation" scenario was subtracted from that year's "PCN freedom" scenario value to give the benefit for the year. PV of benefits was calculated in Excel using the NPV formula, year 1 was not discounted and years 2 – 20 were discounted at 7% per annum. Likelihood of success for new systems developed and demonstrated by the project was 90%. Attribution of benefits to the project was 80%.

Benefit of improved potato late blight management

The gross margins developed from the PLB FIL LBD results of two farmer groups from NTB (Figure 7.13) were used as a basis to estimate the PV of the benefits of the work for wet season production. Whilst the LBD trial in NTB generated increased yields of 8.3% this was for very high use of fungicides (> Rp 10 million per hectare). Accordingly the analysis focuses on the benefits of reduced costs to control PLB rather than increased yields. The anecdotal evidence provided by the WJ and CJ farmers pointed to savings of 34% in pesticide costs and these savings are assumed to be mainly due to fungicides for PLB control using project recommendations (Section 8.3.1 Input costs). It was assumed that 50% of total production per province is grown during the wet season. A "with project" and "without project" scenario for WJ and CJ provinces was developed and annual benefits calculated from the savings multiplied by the area grown in the wet season and the appropriate adoption rate. WJ and CJ were only assessed as they will accrue the major benefits as individually their potato areas are an order of magnitude larger than that of NTB and SS combined. Adoption rates are shown in Appendix 2, Table 7.2. It is assumed that without the project the improved practices would be adopted at a much slower rate than with the project. The analysis is conservative assuming there is no increase in the area of potato grown across both despite increased profits resulting from reduced costs. Likelihood of success for new systems developed and demonstrated by the project is 80%. Attribution of benefits to the project is 80%. The discount rate is 7%.

5.11 Training Indonesian collaborators in pest and disease diagnostics and seed potato care and certification systems in Australia

This component of the project focused on developing the Indonesian research capacity to support the highland potato/Brassica production system. The Australian organisations in collaboration with IVEGRI and Dinas Pertanian (CJ and WJ) selected appropriate trainees. These trainees were selected based upon their capability to absorb new information and effect change upon return to Indonesia. The seed potato certification system training initially focused on high level policy makers to enable the establishment of a framework into which trained seed certification officers can be placed upon return from Australia.

A training needs analysis for IPM, ICM and seed certification was carried out in Indonesia. Existing materials available in Indonesia and Australia were reviewed and updated to reflect the research priorities identified through the baseline survey and FFS and trial findings.

Training was conducted in Indonesia (ICM), Victoria (Plant pathology diagnostics and treatment), WA (seed certification systems) and Queensland (Entomology identification and treatment). Trainees continue to receive post training support through regular visits and communication.

5.12 Development of suitable training materials on quality seed propagation for capacity building of seed producers, and on benefits and use of quality potato seed for potato farmers

This component focused on developing the capacity of Indonesian and Australian seed potato farmers through the provision of appropriate training materials.

Initial training provided to Indonesian farmers through the FFS was based on current training material available from sources such as the FAO, CIP and DAFWA. This material was revised and added to throughout the project as trial results and demonstrations of GAPs add to the knowledge available.

5.13 Development, training and implementation of improved practices for producing clean low-generation seed with and by lead farmers and/or commercial seed producing companies

The training program for seed potato producers aimed to improve their skills and in so doing change attitudes to enable a locally adapted seed certification system to be implemented. The initial training focused on crop management including crop hygiene, nutrition and irrigation. Trials and demonstrations incorporating “clean seed” from Australia grown in Indonesia over a number of seasons demonstrated the yield potential. Trials were also conducted into supply chain alternatives with seed produced in Australia followed through the supply chain to Indonesia where it was grown out by members of the FIL groups. This enabled both the producers and users of imported seed to gain an understanding of the importance of harvest, post harvest and storage issues on crop performance.

Seed certification policy makers and officers received training in WA on the effectiveness of locally adapted seed certification systems. This training was complemented by seed certification officers visiting FIL groups throughout the trials and demonstrations of clean imported seed being rapidly bulked prior to use by ware potato farmers.

6 Achievements against activities and outputs/milestones

Objective 1: To adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas/Alliums suited to Javanese NTB and Sulsel conditions.

no.	activity	outputs/ milestones	completion date	comments
1.1	Conduct project Implementation Workshop shared with activity 2.1	Project work plan developed. Survey & needs assessment document & detailed work plan for yr 1 – 2 developed; integrated with Activity 2.1 work plan.	Sep 2006 Aug 2008	Project workshop for CJ & WJ completed. Project workshop for variation in SS and NTB completed.
1.2	Training in survey and needs assessment design, data collection and analysis (shared with Activity 2.2)	Survey & needs assessment document.	Feb 2007 May & Aug 2008	Training in CJ & WJ completed. Training completed for NTB & SS, supporting Rapid Rural Appraisal undertaken by SS partners.
1.3	Activity 1.3: Conduct baseline survey (wet & dry season) for potatoes, Brassica & Allium farmers to determine cultivars, current yields, agronomic practices, pests including PCN, pesticide usage, post-harvest practices, logistics, & overall costs, including sources of supply, credit for purchases etc. (Shared with activity 2.3)	Document farmers' current potato/Brassica cultivation practices, needs & opportunities. Status of main pest and diseases and natural enemies Baseline for impact assessment established	2007 Feb 2009 April 2009	Baseline survey for wet season potatoes completed in CJ & WJ. Baseline surveys for dry season potatoes in CJ & WJ will not be undertaken due to logistical and cost related problems. Survey for cabbage completed in CJ & WJ. Baseline surveys completed for SS (15 respondents) and NTB (19 respondents).
1.4	Season-long training of trainers for potato-cabbage ICM FFS facilitators (2 events: WJ and CJ).	Groups of potato-Brassica ICM FFS facilitators established in 10 major vegetable growing sub-districts in WJ and CJ. Field sites established with trainers for proving best bet management	Jun 2007 (all) Jun 2008 Nov 2007 Dec 2007 Yr 3	Curriculum development workshops and TOTs completed. TOT NTB completed June 2008. TOT in CJ focusing on 5 key areas, August 2008 TOT SS completed. LBD plots established with specific best bet management comparisons planned.

no.	activity	outputs/ milestones	completion date	comments
		practices developed in survey (Activity 1.3 and 2.3)		
1.5	Updating TOT/FFS curricula and training manuals, and develop extension materials.	Updated curricula outlines and training manuals for FFS facilitators published (with seed selection information from Activity 1.4)	2009	Technical Toolkits developed for potatoes and cabbages providing information for guides to support FIL activities. The TTs describe how farmers can undertake rigorous but simple experiments to test new management techniques. 5 suggested example experiments are described for potatoes with appropriate support material: • standard operation procedure (GAP) • background information • tally sheets
		Extension materials (posters, fact sheets) published and distributed (with seed selection information from Activity 1.5)	Year 4 (For translated titles see Section 10.2) **Factsheets** • Ulat krop kubis • Diamondback moth • Penyakit Akar Gada • Penyakit Busuk Hitam pada keluarga kubis • pH tanah sangat penting untuk tanaman kubis • Memilih kentang bibit • Kista nematoda kentang di Indonesia • Penyakit Busuk Daun Kentang • pH tanah penting bagi tanaman kentang • Kalibrasi knapsack sprayer **Posters** • Mengundang Musuh Alaminya Hama Kubis • Pengelolaan penyakit akar gada pada kubis • Pencegahan penyakit busuk daun kentang • Mengundang Musuh alaminya Hama Lalat Penggorok Daun • Sama mengesankannya dengan Gunung Rinjani! **Books** • Kubis Peralatan Teknis • Kentang Peralatan Teknis • Memperbaiki penangan, penyimpanan dan distribusi kentang di Indonesia • Buku Catatan; Mengejar Keuntungan **DVDs** • Peningkatan profitabilitas kentang di Indonesia: melalui pengelolaan penyakit busuk daun dan hama serangga yang berkelanjutan Increasing. • Pencegahan terhadap nematoda sista kentang • Pencegahan dan pengkontrolan penyebaran penyakit akar gada pada tanaman kubis. **Website** • Website enables project information to be easily accessed. www.indopetani.com	

no.	activity	outputs/ milestones	completion date	comments
1.6	Implementation of multiple cycle FFSs that engage farmer groups in season-long learning and adaptive research throughout consecutive Brassica and potato cropping seasons	At least 80 groups of 25 farmers graduated from multiple cycle potato-Brassica ICM FFS	Apr 10 Aug 09 Jun 10 Jun 10	30 potato FIL completed in WJ 20 potato FIL finished in CJ 20 FIL competed in NTB. 13 FIL in SS
		System for good ICM practice for dry and wet season conditions confirmed	Yr 4	See FIL activities above
1.7	Project monitoring via 6 monthly reporting and mid-term review workshop *(shared with activity 2.6)*	Progress reported Revised work plan for year 3-4 and agreed action documented	6 monthly financial reports provided. Aug 2008	Project reports from all counterparts have been compiled and presented as per ACIAR's requirements mid-term review workshop completed
1.8	Farmer conference	Farmers impact evaluation documented	May 2010	Report completed.
1.9	Impact evaluation of ICM activities through i) survey of Brassica/potato farmer groups to measure changes in practices and perceptions and ii) case studies to identify social change impacts	Crop management, economic and social change attributable to the project documented.	Nov 2010	LPTP Social Impact Study report summarised in Social Impacts section with complete report added as Appendix 14.
1.10	Project evaluation workshop *(shared with activity 2.8)*	Achievements and lessons learned documented	4 June 2010	Documentation presented in Impacts section.

PC = partner country, A = Australia

Objective 2: To develop and implement low-cost schemes that significantly improve the access of Indonesian farmers to quality potato seed.

no.	activity	outputs/ milestones	completion date	comments
2.1	Project planning workshop, including preparation for training in survey design, analysis (Shared with activity 1.1)	Agreement on project implementation by project collaborators & detailed seed scheme work plan for year 1-2 developed; integrate with activity 2.1.	Sep 2006 Aug 2008	Project workshop for West and CJ successfully completed. Project workshop for variation in SS and NTB successfully completed.
2.2	Training in survey and needs assessment design, data collection and analysis	Survey and needs assessment document	Feb 2007 Aug 2008	Training in West and CJ Completed in year 1 Training completed for NTB in May 2008 and in SS August 2008,

no.	activity	outputs/ milestones	completion date	comments
	(shared with activity 1.2)			Supporting Rapid Rural Appraisal undertaken by SS partners (Jun 2008).[Attachment 1]
2.3	Conduct baseline survey to determine problems of seed supply chain, cultivars and percentage of farmers using imported certified potato seed, locally produced various generation certified seeds and uncertified seeds and review existing seed schemes. (Shared with activity 1.3)	Document of potato supply chain needs and opportunities Baseline for impact assessment established	On going	Greater access to affordable high quality seed is a major need. The other major need is to protect seed supply chain from PCN. Baseline survey in Java confirmed that seed quality affected yield and this constraint will be confirmed through activity 2.6 below. Baseline survey data collection completed for SS (15 respondents) and NTB (19 respondents) in April 2009. Currently being analysed.
2.4	Training Indonesian project collaborators in pest and disease diagnostics and seed potato care and certification systems in Australia.	Improved capability for Indonesian and Australian institutions	Yr 3	28 collaborators were trained in WA. The first training visit to WA was in November 2008 with 9 participants. The second was in February 2009 with 14. The third was in February 2010 with 5 participants from NTB. Sessions of the last training course were filmed for an Indonesian farmer audience for the DVD "Keeping Lombok Free From PCN"
2.5	Development of suitable training materials on quality seed propagation for capacity building of seed producers, and on benefits and use of quality potato seed for potato farmers	Appropriate training materials available to seed producers Addendum to current potato ecological production guide and FFS exercise manual on use of quality potato seed produced	2010	The Potato Technical Toolkit developed to support FIL activities. The TT describes how farmers can undertake rigorous but simple experiments to test new management techniques. A seed source comparison experiment is described. Factsheet *Kista nematoda kentang di Indonesia* and DVD *Pencegahan terhadap nematoda sista kentang*. Seed supply chain Australia. Survey identifying key areas of impact along supply chain in WA. Results of surveys presented to workshops in 2009 and 2010. Information presented to industry at association meetings. Review of Indonesian seed supply completed and alternative partial seed supply scheme proposed to augment existing seeds schemes.
2.6	Development, training and implementation of improved practices for producing clean low-generation seed with and by lead farmers and/or commercial seed producing companies	Improved seed production practices developed and implemented by key farmers/seed producers New information incorporated into extension material	2010 Apr 09 Sep 2008 Oct 2009	30 LBD plots of seed to be incorporated into FIL for the 2008 - 2010. Both Granola and Atlantic seed from WA was sent to Indonesia for planting material for these seed comparisons. 20 demonstration seed plots have been incorporated into FIL conducted in WJ. 8 more are being conducted in SS & NTB in 2009-2010. Seed training was a feature of NTB FFS.

no.	activity	outputs/ milestones	completion date	comments
				Seed bulking in NTB for re-use in Indonesia completed. Seed to be used in next season FIL in WJ. PCN survey of Sembalun in NTB found no PCN. Experiments by Gadjah Mada University determined cyst decline rates in 2 soil types which can be used to determine suitable rotation times to maintain PCN freedom of NTB. Resistant varieties will be the key to successful management of PCN areas of Indonesia. The pathotype of 3 collections of PCN from Java have been identified by as *Globodera rostochiensis* pathotype Ro2. This explains why both Granola and Atlantic, which are resistant to pathotype Ro1 but not Ro2, are being severely affected by PCN in Java.
2.7	Project variation monitoring via 6 monthly reporting and mid-term review workshop (shared with activity 1.7)	Progress reported Revised work plan for year 3-4 and agreed action documented	6 monthly financial reports provided – Oct 2006, May 2007, Oct 2007 Annual report provided May 2007	Project reports from all counterparts have been compiled and presented in keeping with ACIAR’s requirements
2.8	Impact evaluation through i) survey of seed farmer groups to measure changes in practices and perceptions and ii) case studies to identify social change impacts *(shared with activity 1.9)*	Document showing crop management, economic and social change attributable to the project	Nov 2010	LPTP Social Impact Study report summarised in Social Impacts section with complete report added as Appendix 14.
2.9	Project evaluation workshop (shared with activity 1.10)	Achievements and lessons learned documented	Yr 4	See activity 1.10 above.

PC = partner country, A = Australia

7 Key results and discussion

Key results are discussed in this section. A more complete treatment of the results can be found in the 14 appendices which are listed in Table 7.1. The key findings of the evaluation activities are presented in Section 8 “Impacts” and in full in appendices 13 and 14. The original source of the key results and impacts discussed below can be determined from a key found at the end of Figure and Table captions. The key is in the format (AX, F/TY) where A gives the appendix number and T/F gives the Table or Figure number).

Table 7.1. Titles of appendices from which key results and impacts have been compiled.

No.	Title
Appendix 1.	Baseline agronomic survey of potatoes
Appendix 2.	Baseline economic survey of potatoes
Appendix 3.	Baseline agronomic survey of cabbage
Appendix 4.	Baseline economic survey of cabbage
Appendix 5.	Potato seed system development - PCN
Appendix 6.	Potato seed system development - WA seed supply chain analysis
Appendix 7.	Potato seed system development - alternative seed supply system
Appendix 8.	FIL – potatoes Java
Appendix 9.	FIL – potatoes South Sulawesi
Appendix 10.	FIL – potatoes NTB
Appendix 11.	FIL – cabbage
Appendix 12.	Post harvest
Appendix 13.	Impact assessment - farmer conference
Appendix 14.	Impact assessment - social impact study

7.1 Integrated crop management systems for potato and Brassica/Alliums developed for West and Central Java, South Sulawesi and Nusa Tenggara Barat

7.1.1 Potato ICM Farmer Field Schools, 1st cycle.

West Java 2007/08.

Ten FFS were completed. Farmers received an introduction to ICM of potatoes. Farmers reported that the FFS meetings improved their knowledge and skills of potato production through observations and conclusions based on joint decisions and through direct practice. Specifically they had;

- Learnt to observe and analyse problems of potato production;
- Learnt about improved land preparation;
- Learnt to work with nature when producing potatoes;
- Used pesticides in a wiser manner; and
- Improved their pest and disease management.

In this 1st series of FFS a conventionally managed plot was compared with an ICM plot. Many management changes occurred between the ICM and conventional plots. This is a fault of this method because the effects of the individual management changes on yield and profit cannot be determined. In addition some of the ICM treatments selected for testing by the farmer groups were of questionable value. An example of these short comings is illustrated by the Taruna Tani Sauyunan group site where the conventional plot produced a longer lived crop with better canopy (Figure 7.1).

Figure 7.1. Farmer Field School plots of the Taruna Tani Sauyunan group in February 2008. A conventional practice plot was compared with an ICM (PHT = IPM in Indonesian) plot. The ICM plot was more affected by PLB than the conventional plot. The ICM PLB spray program was inadequate and ICM plot may have been adversely affected by a phytotoxic concentration of tobacco leaf spray. (A8 F6.1).

The ICM plot did not have as good control of PLB as the conventional plot. The fungicides applied are shown in Table 7.2. In the ICM plot only four botanical fungicides were applied and their application only began after 4 sprays had already been applied to the conventional plot. The conventional plot spray program shows an over-use of fungicides. For example ‘conventional spray 2’, a combination spray of Acrobat and Daconil, applied one systemic (translaminar) active ingredient (a.i.) from Acrobat (dimethomorph) with two protectants; the mancozeb component of Acrobat plus chlorothalonil, the a.i. of Daconil. Similarly ‘conventional spray 6’ combined the fungicides Equation, Daconil and Acrobat which meant that two systemic a.i. cymoxanil, dimethomorph and three contact a.i.; famoxadone (from Equation), chlorothalonil and mancozeb were applied together. In this last spray application of the five a.i. three are unnecessary or redundant.

The CIP PLB control recommendations for susceptible varieties under high disease pressure for Peru (Cáceres *et al.* 2007) will be a better guide PLB control under the similar Indonesian conditions. This PLB control program comprises:

- First spray at 80% emergence (unless uneven when applications at 50% and 100% emergence should occur) with a systemic to protect rapidly expanding tissue of a young plant;
- Alternate use of at least two systemic fungicides (each alternated with contact), a translaminar can be substituted for one systemic to reduce costs;
- Spray intervals of 5 - 7 days after a contact or translaminar and 7 - 14 days after a systemic (depends on disease pressure and systemic used);
- Each systemic should be used only a maximum of 3 times in the season to reduce the risk of fungicide resistance developing;
- Phenylamide fungicides (metalaxyl and mefenoxam) should not be used as Indonesian PLB strains are resistant to this fungicide.

To easily identify the main aspects of this program it was called the *systemic-contact-systemic* method. Note that the manufacturers of systemic/translaminar fungicides add a contact fungicide to the formulation to reduce the risk of resistant strains of fungus developing.

Table 7.2. Fungicide applications used in FFS at Taruna Tani Sauyunan in 2007/08. Fungicides considered redundant are shown in italic in the 'Conventional plot' column. If these are omitted this program is suitable as an ICM program with reduced applications of fungicides but similar efficacy. This program alternates systemic fungicides (which incorporate a contact fungicide in their formulation) with contact only fungicides. (A8 T6.3).

#	Conventional plot	Integrated crop management plot
1	Acrobat	
2	*Acrobat* + Daconil	
3	Acrobat + *Daconil*	
4	*Acrobat* + Daconil	Botanical fungicide
5	Equation	
6	*Equation* + Daconil + *Acrobat*	
7	Equation	Botanical fungicide
8	*Equation* (replace with Daconil)	
9	Acrobat + *Daconil*	Botanical fungicide
10	*Acrobat* + Daconil	Botanical fungicide
11	*Daconil* (replace with Equation)	
12	*Acrobat* (replace with Daconil)	
13	*Acrobat* (replace with other systemic)	
14	*Equation* (replace with Daconil)	

Acrobat a.i. = dimethomorph (translaminar) + mancozeb, reasonable curative with good to very good protectant, good to very good rainfastness

Daconil a.i. = chlorothalonil protectant with good to very good rainfastness

Equation a.i. = famoxadone + cymoxanil, protectant & curative with good to very good rainfastness

The conventional plot spray program used by Taruna Tani Sauyunan (Table 7.2) can be modified to follow the *systemic-contact-systemic* ICM program of Cáceres *et al.* (2007). This is shown by the plain typeface fungicides under 'Conventional plot' in Table 7.2. This program requires 14 fungicide applications compared to the 21 applications used in the conventional plot of the Taruna Tani Sauyunan farmer group.

The over-use of fungicides was also identified by the baseline economic survey of potatoes where a negative correlation was found between fungicide expenditure and gross margin in CJ (Section 7.1.2, Figure 7.3) while no positive correlation was found for fungicide expenditure and yield in the other provinces. Rationalising PLB spray programs will help to reduce pesticide applications without reducing disease control efficacy.

Use of traditional medicinal cures for human illness is common in Indonesia and traditional cures are also used in agriculture. The use of botanical fungicides to control PLB as shown under 'ICM plot' in Table 7.2 is promoted widely in Indonesia. Experimental evidence for the use of botanical fungicides was not found. PLB control with a botanical fungicide from betel nut was claimed by Lologau *et al.* (2003). Their application of betel nut extract commenced 30 days after planting while spraying of the comparison synthetic fungicide thiophanate-methyl began after a control threshold of 1 PLB lesion per 10 plants was reached. This threshold is now considered too high (Cáceres *et al.* 2007). The yield of all treatments reported by Lologu *et al.* (2003) was very low at 5.4 t/ha for the nil treatment, 6.3 t/ha for the botanical fungicide and 6.9 t/ha for the synthetic fungicide. An alternative conclusion that better explains these experimental results was that all spray treatments were applied too late after the disease had well established and all were equally ineffective. Stronger experimental evidence is warranted before botanical fungicides are recommended as a control for PLB in Indonesia.

Another FFS group, Berokah Tani, also appeared to have poorer PLB control in their ICM plot compared with the conventional plot. However the damage to the canopy may have been caused by a phytotoxic botanical insecticide (nicotinamide) rather than PLB. This farmer group tested an ICM insecticide program against a conventional program. However there was very little actual difference in the insecticides used between ICM and conventional treatments in the first 60 days (Appendix 8, Table 6.4). The ICM control methods used in the FFS ICM plots at Barokah Tani farmer group were not following best practice for LMF control. Faults were that:

- Broad-spectrum insecticides (pyrethroids, organophosphates) were being used early and would have eliminated natural enemies and exacerbated LMF problems; cyromazine and abamectin are better alternatives being effective against larvae and relatively safe against parasitoids. The aphid outbreak in the conventional treatment was typical for pyrethroid use;
- Appropriate treatments were not matched to the pests observed. Treatment for LMF should have been delayed until larval mines appeared, not on the presence of adult flies;
- Systemic insecticides for sucking insects (aphids and thrips) were not used. Imidacloprid would be very useful, especially seed application at planting.

Economic outcomes of the ICM and conventional treatment plots of the two FFS groups discussed above are shown in Table 7.3. The benefit:cost analysis (BCA) of the ICM plot at Berokah Tani was 1.90 which was less than the 2.38 of the conventional plot because of its lower yield of 11.7 t/ha versus 17.1 t/ha. This result was to be expected due to the early canopy death in the ICM plot due to either the failure to control PLB or the application of phytotoxic levels of bio-insecticide. However the Taruna Tani Sauyunan group, which also had early death of the ICM plot, due to its ineffective fungicide program, reported that the ICM plot BCA was 1.50 while that of the conventional plot was 1.45. There certainly would have been reduced yield in the ICM plot at this site but the high input costs of the conventional plot negated this yield advantage.

Table 7.3. Enterprise economic returns for conventionally managed and ICM plots in WJ 2007-08. (A8 T6.5).

Group	Yield (t/ha)	Income (Rp 000 000/ha)	Costs (Rp 000 000/ha)	BCA (benefits/costs)
Barokah Tani				
Conventional plot	17.1	42.6	17.9	2.38
ICM plot	11.7	29.3	15.0	1.90
Sauyunan Tani	-			
Conventional plot	-		33.5	1.45
ICM plot	-		26.4	1.50

Results for all ten groups are reported in Appendix 8, Table 6.5. The other eight sites reported an improved BCA in the ICM FFS plots however the reasons for the improved BCA were not identified. The FFS methodology of comparing and ICM plot against a conventional practice plot means that many management changes occur between the two plots and so the causes of any yield and profit differences are difficult to identify. For example at Taruna Tani Sauyunan changes between the ICM plot and the conventional plot included differences in: fertiliser rates, fertiliser type, fungicide types, time of fungicide applications and type of insecticides used. This means that this FFS method is not suitable for investigating new crop management techniques.

The farmers reported that they wanted to learn more about:

- Soil analysis;
- Seed care and information;
- Investigation of pest and disease agro-ecosystem/Improved pest and disease management; and
- How to increase yield.

This first series of FFS showed that to meet the farmers learning requirements a change of methodology was required that allowed specific crop management techniques to be tested.

Central Java 2008

In the first series of FFS in CJ in 2008 10 FFS groups were established. A comparison of the yield, income, costs and BCA of four of these farmer groups is shown in Table 7.4.

The conventional and ICM plots for the Trubus farming group reveal similar yields but the ICM plot had fewer costs resulting in a higher BCA. The savings were made in the ICM plot through reductions of fungicide and insecticide costs.

The Sekar Tani group had very low yields and both their ICM and conventional plots were unprofitable with BCA less than 1. The reason for this was that the crop died after just 57 days due to the effects of late blight and bacterial wilt.

The Bukit Madu group ICM plot had a much higher yield than the conventional plot but a lower BCA. This was a result of the much greater cost of purchasing the certified G4 seed and applications of plant growth promoting rhizobacteria (PGPR) in the experimental plot.

The Tunas Harapan Jaya group reported losses in both the conventional and ICM plots. These losses are the likely result of PCN being present in the field. The conventional plot using non certified seed without PGPR produced higher yields which, with lower costs, gave a higher, though still unprofitable, BCA.

Table 7.4. Yield, income, costs and benefit cost analysis from 2008 FFS plots in Central Java. (A8 T6.21).

Farmer group	Treatment plot	Yield (t/ha)	Income (Rp/ha)	Costs	BCA (benefits/costs)
Trubus	Conventional	18.0	2,970,000	1,860,000	1.60
	ICM	18.5	2,970,000	1,645,000	1.81
Sekar Tani	Conventional	3	375,500	2,033,500	0.18
	ICM	2	250,000	1,883,500	0.13
Bukit Madu	Conventional	13.4	1,327,750	953,750	1.39
	ICM	20.4	1,865,000	1,707,500	1.09
Tunas	Conventional	9.3	1,107,000	1,805,600	1.08
Harapan Jaya	ICM	8.4	1,024,000	1,725,500	0.59

NTB 2008

Eight FFS groups studied 1,000 m^2 plots. Activities included: monitoring and identifying insects, both pests and their natural enemies; as well as assessing disease levels. Also a focus of the FFS was a potato processing exercise of keripik production plus packing and transportation. Inputs and production of pairs of sites were recorded and presented as an average gross margin for the plot. Yields ranged from 20 to 26 t/ha with BCA of 1.51 to

1.85. Like the WJ FFS of 2007/08 NTB farmers received an introduction to potato ICM however they did not explore any new management techniques.

7.1.2 Baseline surveys of potatoes (excluding seed)

The potato baseline agronomic and economic surveys were completed during the first year of the project. These surveys aimed to identify constraints to production and propose technical solutions that could be tested by farmer groups. Baseline survey results pertinent to potato seed are reported later in Section 7.2.

Gross margins

Gross margins were produced for potato production in the four provinces (Table 7.5). Processing potato farmers in NTB achieved the highest income but also had the highest costs primarily due to the high seed cost as well as the highest pesticide expenditure. Their gross margin was Rp 16 million per ha. SS farmers achieved a Rp 25 million per ha gross margin which, despite the lowest yield, had an income of Rp 46.5 million per ha due to the high average sale price (Rp 3,736per kg). Seed is the highest input cost for all of the four provinces representing between 34% and 53% of total costs. Adiyoga *et al.* (1999) reported seed costs in WJ were 33 – 37% of variable costs so in 10 years there's been no "improvement". Adiyoga *et al.* (1999) predicted that the new Indonesian public certified seed scheme would change this situation. Fertilisers are the next highest input cost followed by fungicides and insecticides (pesticides). In CJ pesticides formed 22% of costs, 20% in NTB, 14% in WJ and just 6% in SS. Adiyoga *et al.* (1999) similarly reported that pesticide costs were the next greatest cost after seed at 20 - 30% of variable costs.

Table 7.5. Average input costs, returns and gross margins for potatoes in four Indonesian provinces. (A8 T6.1).

Item	NTB	South Sulawesi	West Java	Central Java
Crop Size (ha)	**0.22**	**0.675**	**0.32**	**0.55**
Yield (t/ha)	21.02	12.45	21.50	14.91
Price (Rpper kg)	2,700	3,736	2,113	2,403
Income (Rp/ha)	56,757,817	46,518,776	45,444,467	35,838,012
Costs (Rp/ha)				
Seed	21,564,471	7,371,151	11,667,289	8,506,820
Fertiliser	3,716,338	4,283,393	7,480,273	3,399,960
Insecticide	2,245,814	611,817	2,173,201	2,140,840
Fungicide	5,646,093	706,150	1,920,372	2,114,317
Herbicide	48,485	223,497	52,173	0
Planting	595,604	514,846	389,940	301,576
Hilling	1,214,708	470,427	220,575	314,935
Weeding	983,738	581,938	340,000	284,234
Labour other	459,948	689,245	475,734	967,394
Harvest	3,004,652	810,861	2,813,268	490,657
Equipment	47,593	1,236,306	424,907	325,215
Other	1,156,168	3,937,590	1,200,397	58,182
Total Costs	40,683,610	21,437,220	29,158,128	18,904,130
Gross margin (Rp/ha)	16,074,206	25,081,556	16,286,339	16,933,883
Benefit:Cost analysis (Income/expense)	1.40	2.17	1.56	1.90

Gross margin and yield correlations

The correlation of gross margin to yield was investigated to:

- Confirm that there is a correlation between yield and gross margin;
- Determine whether the Indonesian potato farmers can increase their gross margin by aiming to produce higher yields, i.e. that they are not at the point of diminishing returns; and to
- Determine indicative break-even (income = costs) yield.

Indicative breakeven yields for the four provinces were:

Central Java	9.8 t/ha
West Java	10.1 t/ha
NTB	12.9 t/ha
South Sulawesi	4.4 t/ha

That farmers in SS only need to achieve 4.4 t/ha to break-even seems unrealistically low and may be a result of the relatively small sample size.

R^2 values for gross margin and yield regressions for CJ, NTB and SS were from 0.69 or 0.68 showing that the regression equation accounted for 68 - 69% of the variation (Figure 7.2). However in WJ the R^2 value for a linear relationship wasn't as good a fit with an R^2 of only 0.47. A better fit was found with a relationship comprising two straight lines with a flat relationship between yield and gross margin after 25 t/ha. With this relationship the R^2 value increased from 0.47 to 0.69 (Figure 7.2 lower graph). This relationship which flattens after 25 t/ha may indicate that some farmers in WJ have reached the point of diminishing returns whereby the cost of inputs required to increase yield is not covered by the additional returns generated. This may indicate more inefficient production compared with the other provinces. This could be due to inputs being poorly targeted resulting in wasteful application of inputs. Yields above 25 t/ha may be able to be reached without this inefficiency as shown by the regressions for NTB and SS which increase linearly up to 40 t/ha and 35 t/ha respectively (Figure 7.2).

The correlations between gross margin and yield for NTB, WJ and CJ provinces shows that there is scope to increase gross margin through improved agronomic efficiency as gross margin continues to increase directly with yield (Figure 7.2).

Most farmers in all the provinces produced a positive gross margin from their potato crops: numbers of respondents with positive gross margins were 26 out of 27 in NTB, 22 out of 23 in SS, 9 out of11 in WJ and 8 out of 11 in CJ (Figure 7.2). The majority of farmers earn a return from their potato crop and this may influence them to spend heavily on inputs as they are confident their investment will be returned.

Potato late blight

PLB was the disease with the highest incidence recorded by baseline agronomic survey enumerators (Table 7.6). However the survey data showed no significant relationship between yield and incidence of PLB which we believe indicates that PLB is an insidious threat for potato farmers in Indonesia regardless of farmer ability. Therefore efficient and sustainable management techniques for PLB are required. The lowest incidence of PLB was a daunting 54% of sites in CJ; this relatively low figure is probably due to the CJ assessment occurring in the dry season when PLB disease pressure was lower.

Table 7.6. Incidence of disease (% of sites) in the field reported by survey enumerators* in Central Java, NTB, South Sulawesi and West Java. (A1 T6.7).

Disease	CJ	NTB	SS	WJ	Average
PLB	54	100	93	100	87
Bacterial Wilt	29	11	0	68	27
Blackleg	0	100	7	0	27
Nematode	8	0	0	0	2
Virus	4	0	7	8	5

***** trained crop monitors from Dinas Pertanian.

It is not surprising PLB was ranked the major issue as it is considered the major biotic constraint to potato production worldwide (Fuglie 2007), with yield reductions estimated from 15% (de Vries 2004) to 20% (Forbes 2009). With highly suitable weather conditions for the development of PLB epidemics (de Vries 2004); the use of the susceptible varieties

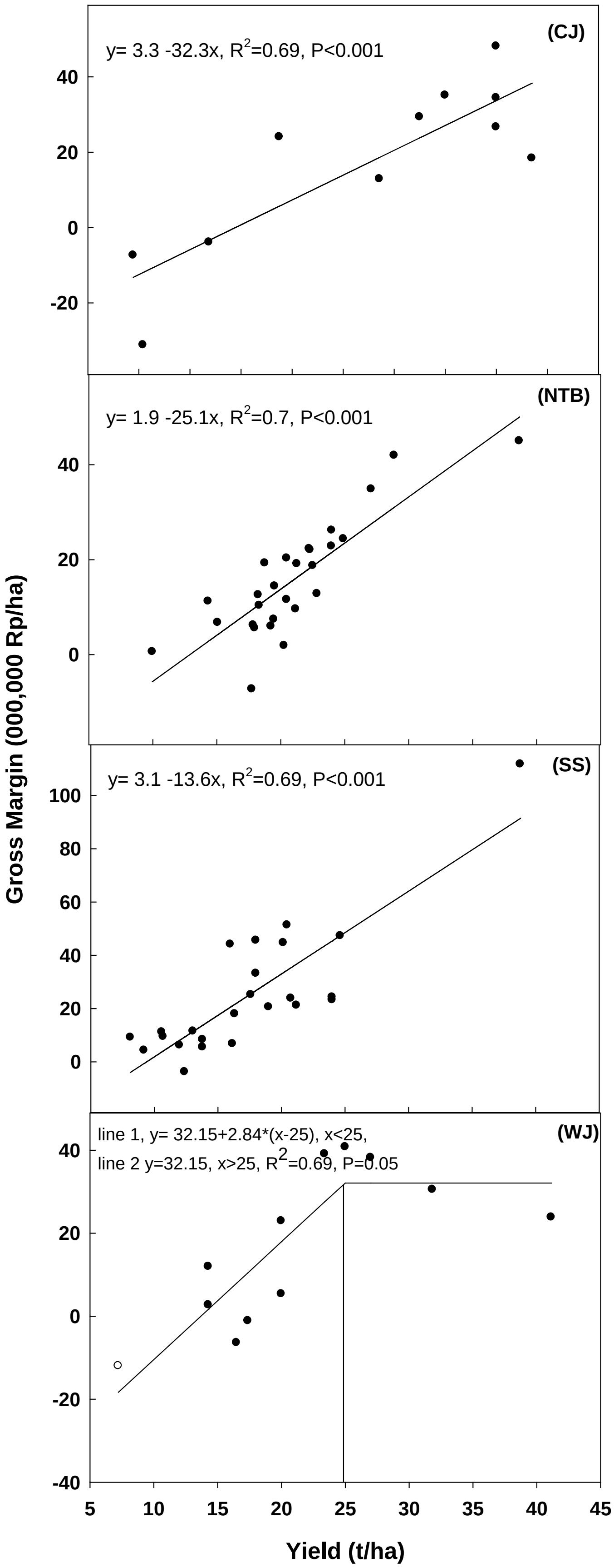

Figure 7.2. Linear regression of yield with gross margin in CJ, NTB, SS and WJ. (A2 F6.2).

Granola (de Vries 2004) and Atlantic (de Vries 2004); short or no crop rotations (Jayasinghe 2005) and use of high generation seed, controlling the disease is a constant requirement for Indonesian potato farmers. It is for these reasons that control of PLB was ranked the highest priority of needs for the improvement of potatoes in developing countries (Fuglie 2007).

Controlling PLB in Indonesia revolves around farmers using multiple applications of fungicides applied with either a simple backpack sprayer or motorised hand sprayer. Applications of up to 22 pesticides per potato crop have been recorded previously (Table 7.2, van de Fliert *et al.* 1999), with an average of 18 being used specifically to control PLB (de Vries 2004). The baseline agronomic survey showed chemical usage by NTB farmers comprised between 4 and 20 sprays per crop specifically for PLB (data not shown). This adds significant costs to the production of potatoes in Indonesia with conservative estimates of fungicide costs of US$224/ha and a total cost nationwide for PLB at US$180 million (de Vries 2004). Excessive and inefficient use of fungicides to control PLB in Indonesia has been reported in the past (van de Fliert *et al.*1999).

The baseline economic survey of potatoes found a negative correlation between fungicide expenditure and gross margin in CJ (Figure 7.3). No positive correlation for fungicide expenditure and yields was found in the other provinces (Appendix 2). Fungicide expenditure represents between 3% and 14% across the province averages. There is often no correlation between these inputs and yields and gross margins. Farmers are over-applying agro-chemicals in the hope of controlling diseases such as PLB.

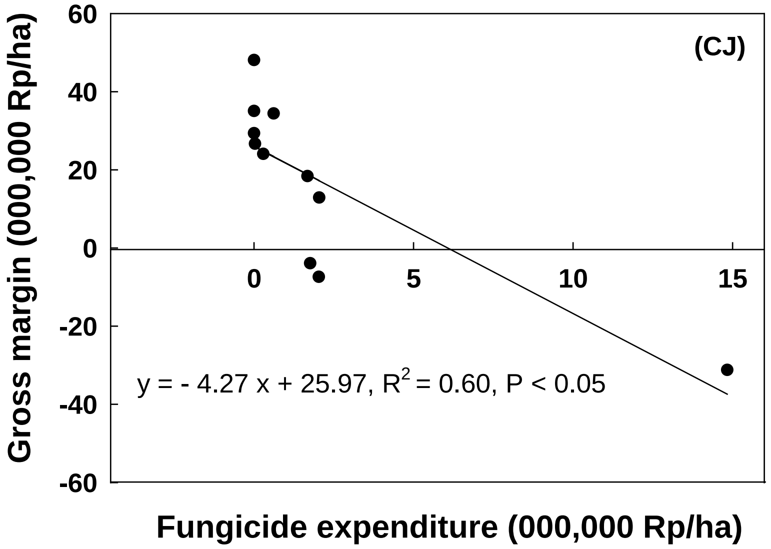

Figure 7.3. Linear regression of gross margin with fungicide expenditure (including labour costs to apply) in CJ. (A2 F6.11).

To combat the high use of fungicides used to control PLB resistant cultivars have been released in Indonesia but adoption has not occurred. This is a common in developing countries with CIP resistant varieties amounted to only 6% of potato area in 1997; a fall from the 40% which occurred in the 1990's (Walker *et al.* 2001). Market forces, the slow multiplication rate of potatoes, breakdown of resistance and poor or informal seed schemes have lead farmers to favour susceptible varieties (Forbes 2009).

The high PLB incidence PLB in the survey and the overuse of fungicides, both reported and demonstrated by The Taruna Tani Sauyunan farmer group (Table 7.2), shows that improved PLB control is an ideal FIL activity. Better management of PLB disease will benefit farmers through reduced input costs while maintaining or increasing yield.

Soil pH

Potatoes are considered more tolerant of acid soils than most other vegetables (Maynard and Hochmuth 2007). Al, Fe and Mn concentrations in soil normally increase as pH declines as shown in (Table 7.7) with Al and Fe but not Mn. It has been assumed therefore that potatoes possess some tolerance to high concentrations of these elements but we found otherwise. For example lower tuber yield of Granola was associated with high Al in soil (pre-planting) (Table 7.8) and petioles (Table 7.9) in CJ and WJ. The increased yield of Granola in response to applied lime on an acid soil in Ciwidey WJ was assumed to be due to reduced Al toxicity as soil pH increased (Subhan and Sumarna 1998). There was no information for NTB and SS as Al was not measured in the soil or petioles in those provinces. Concentrations of exchangeable Al > 0.90 cmol (+)per kg (or 81 mgper kg dry soil, pre-planting) were associated with lower tuber yields of the potato variety Kennebec grown on eight coarse textured soils typical of potato production areas in Canada (van Lierop *et al*. 1982). Results showed 79% of the sites in CJ and 96% of the sites in WJ had exchangeable soil Al levels above 81 mgper kg dry soil, pre-planting (Figure 7.4) and so reduced tuber yield could be expected. This Al value in the soil corresponds to a pH (H_20) in CJ of 6.7 and in WJ of >7.0, considerably higher than the pH below which potato yield is normally expected to be reduced (i.e. 5.0, van Lierop *et al.* 1982). Therefore high soil Al may lower tuber yields in Indonesia more than in Canada and so high soil Al is more important than pH by itself. This is borne out by survey results where low soil pH was not significantly associated with lower yield in Java (Appendix 1, Table 6.4b) even though soil Al was in CJ (Table 7.8) and soil Al increased at lower pH (Figure 7.4).

Table 7.7. Soil micro nutrient concentration and linear regression response with soil pH. (A1 T6.3a).

Nutrient (mgper kg)	Province	Significance# of regression	Response of regression
Al	CJ	****	negative
	NTB	-	
	SS	-	
	WJ	**	negative
Fe	CJ	**	negative
	NTB	ns	
	SS	ns	
	WJ	**	negative
Mn	CJ	ns	
	NTB	ns	
	SS	ns	
	WJ	ns	

# *P < 0.10, **P < 0.05, ***P < 0.01, ****P < 0.001 and ns not significant.

Table 7.8. Linear regression between soil micro nutrient concentration and tuber yield. (A1 T6.4a).

Nutrient	Province	Regression	R^2	P
Al	CJ	y = 24.10 - 0.03x	0.16	**
	NTB	-	-	-
	SS	-	-	-
	WJ	y = 21.54 + 0.006x	-	ns
Fe	CJ	y = 22.21 - 0.6x	0.10	*
	NTB	y = 34.08 + 0.04x	-	ns
	SS	y = 22.49 - 0.102x	-	ns
	WJ	y = 21.08 + 0.22x	-	ns

*<0.10, **<0.05, ***<0.01, ****<0.001 and ns not significant.

Table 7.9. Petiole micro-nutrients (avg) and yield. Petiole concentration was average of 3 samples at 10 mm tuber stage and 2 and 4 weeks after. (A1 T6.5a).

Nutrient	Province	Mean (mgper kg) (+/-SE)	Range	Regression	R^2	P
Al	CJ	1173 +/-157	383-3610	y = 23.6-0.005x	0.11	*
	NTB	-	-	-	-	-
	SS	-	-	-	-	-
	WJ	1062 +/-128	213-2790	y = 27.3-0.004x	0.07	*
Fe	CJ	572 +/-82	200-1817	y = 23.01-0.009x	0.10	*
	NTB	1022 +/-50	690-1590	y = 44.6-0.008x	-	ns
	SS	335 +/-37	99-633	y = 13.9+0.022x	-	ns
	WJ	528 +/-68	121-1324	y = 26.81-0.007x	-	ns

*<0.10, **<0.05, ***<0.01 and ns not significant

There are no published critical concentrations for petiole Al above which reduced yield is expected for potatoes (Huett *el al*. 1997). However it is reasonable to use the critical concentrations for Mn, an essential micro-nutrient, of 200 mgper kg dry weight as guide (Gupta *et al.* 1995) at the 10 mm tuber stage, for Al, a non-essential micro-nutrient. Using this value all crops from CJ and WJ had petiole Al concentrations that may contribute to reduced yield (Table 7.9).

Lower yield was associated with high soil and petiole Fe in CJ only (Tables 7.8 and 7.9).

In contrast to Al, Fe and Mn, concentrations of exchangeable Ca, Mg and K (the bases) in the soil, pre-planting, usually increases as soil pH increases and this was shown here in all provinces except NTB for Ca and Mg and for K in Java but not NTB and SS (Appendix 1, Table 6.3b). In contrast to Al and Fe, higher yield was associated with higher concentrations of Ca in both the petiole and soil (exchangeable) in CJ and WJ but not NTB and SS (Appendix 1, Table 6.4b and Figure 6.25). Higher yield was associated with petiole Ca concentrations above levels that are usually considered adequate for maximum yield at the 10 mm tuber stage (i.e. 0.5% dry weight, Huett *et al.* 1997). It is possible that in Indonesia higher plant Ca is needed to counteract the negative effects of high plant Al.

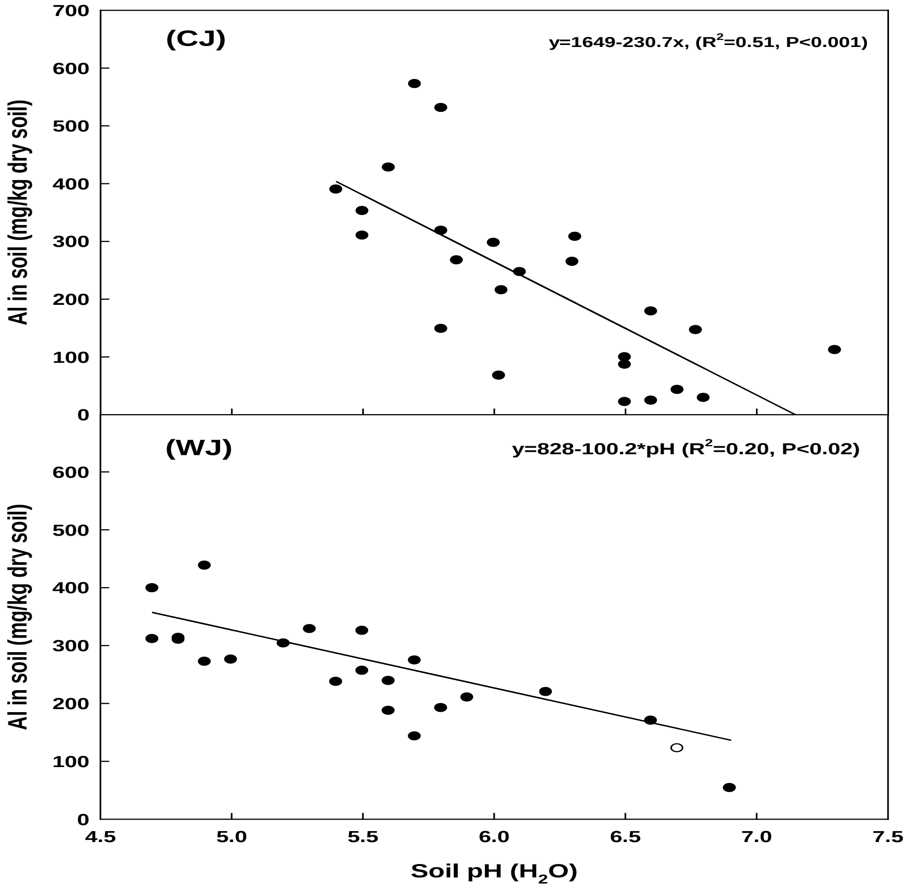

Figure 7.4. Linear regression between Al concentration versus pH in topsoil in CJ and WJ. (A1 F6.21).

By contrast exchangeable Mg in the soil was not related to yield in any province (Appendix 1, Table 6.4b) and low yield was associated with high concentrations of Mg in the petiole in CJ and NTB (Appendix 1, Figure 6.26).

The identification of soil acidity and associated crop nutrition issues of high soil and plant Al and low Ca is important for sustainable potato production. These issues may be easily solved through soil testing and liming of acid sites. Soil pH should be a focus of FIL learning-by-doing plots in the next phase of the project.

Leafminer fly

LMF was consistently recorded although there were differences between the incidence recorded by the farmers and enumerators. This may indicate a lack of knowledge of the symptoms caused by LMF or of the fly itself which was first identified in Indonesia in 1994 (van de Fliert *et al.* 1999). This may explain how in NTB the absence of LMF was associated with higher yields (Appendix 1, Figure 6.52). NTB farmers have not been growing potatoes as long as farmers in Java or SS. It has been noted that the importance of LMF varies a lot between years and location (de Vries 2004). Farmers mention that LMF is more of a problem in the dry season than the wet season in Indonesia. However this survey found LMF was a constant issue in both wet and dry growing seasons.

Control of LMF is similar to that of PLB in Indonesia with frequent applications of sprays. Only a small percentage of farmers in Java and NTB used yellow sticky traps, an indication of familiarity with IPM methods, and NTB users produced significantly lower yield. Similar low proportions of farmers using management techniques besides pesticides were recorded by van de Fliert *et al*. (1999). It is estimated that total pesticide application for potatoes costs US $378/ha (van de Fliert *et al*. 1999), a third of which, USD126, is spent on insecticides (Fuglie *et al*. 2005), mainly for the control of LMF. The baseline economic survey shows that the average costs of insecticides across the provinces was USD206/ha (calculated from Table 7.5 using an exchange rate of 8,714 Rp/USD). Numbers of natural beneficial predators are low due to the over-use of broad spectrum insecticides (van de Fliert *et al*. 1999).

The baseline economic survey of potatoes found a negative correlation in CJ between insecticide expenditure (including labour to apply the insecticide) and yield (Figure 7.5). The additional expenditure on insecticides and their application is ineffective in raising yields

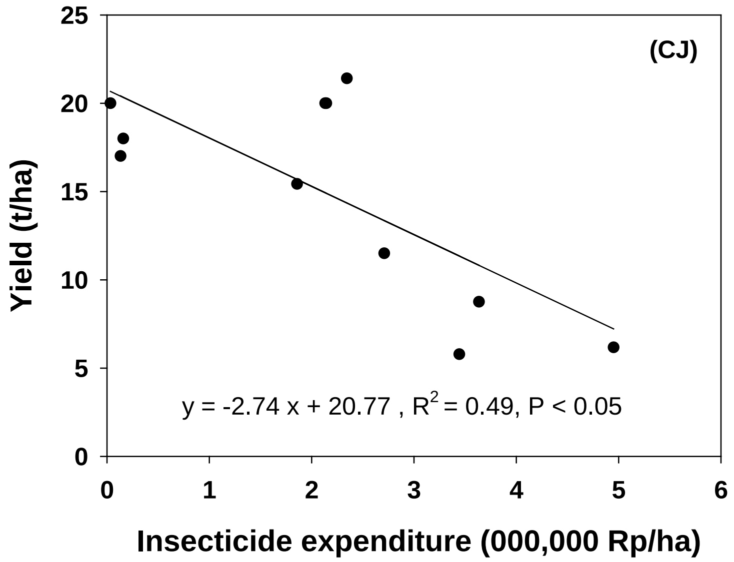

Figure 7.5. Linear regression of yield with insecticide expenditure (including labour to apply) in Central Java. (A2 F6.7).

CJ also had a negative correlation at $P < 0.05$ between insecticide expenditure (including labour costs to apply the insecticide) and gross margin. The additional expenditure on insecticides is ineffective in raising yields and income while increasing expenditure (Figure 7.6).

In SS there is a positive correlation at $P < 0.05$ between insecticide expenditure and gross margin (Figure 7.6). SS with an average expenditure on insecticides of 3% of total cost spends much less than the other three provinces. There was no significant correlation between yields and insecticide expenditure in SS.

There is no significant correlation between insecticide expenditure and average price received for any of the provinces.

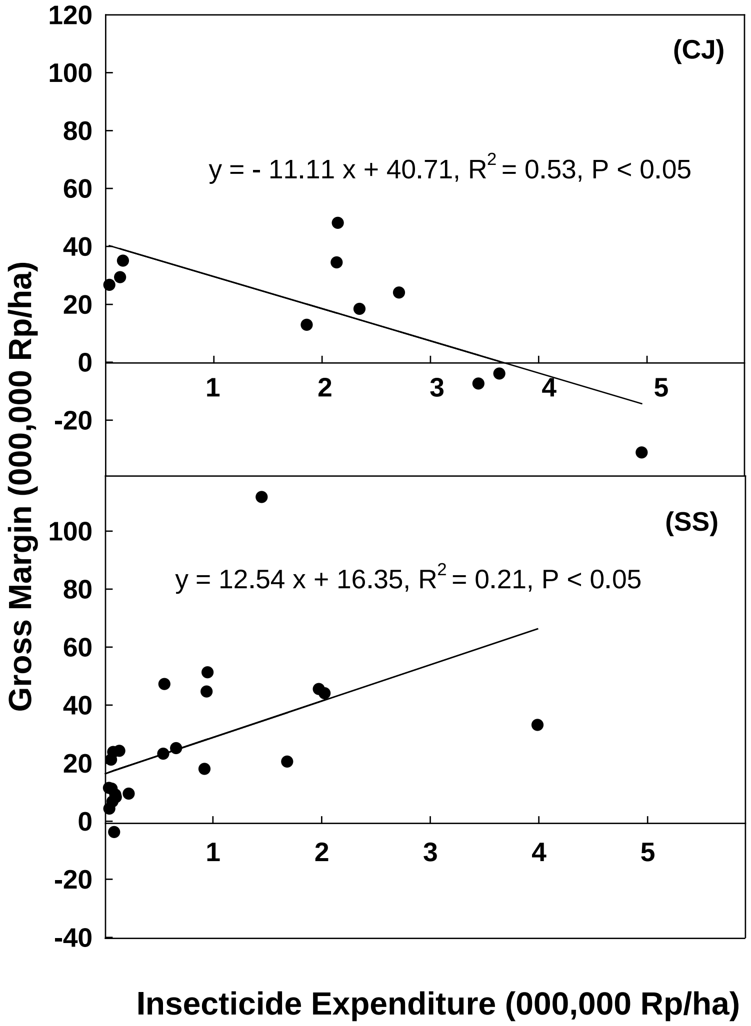

Figure 7.6. Linear regression of gross with insecticide expenditure (including labour to apply) in CJ. (A2 F6.8).

The control of LMF is a major issue for farmers and insecticides represent between 3% and 11% of average costs across the provinces (Appendix 2 Table 6.2). There was often no correlation between these inputs and yields and gross margins. Farmers are over-applying agro-chemicals in the hope of controlling pest such as LMF. In WJ there was a negative correlation between insecticide expenditure and yield and insecticide expenditure and gross margin. WJ farmers are over-using insecticides and not achieving returns for this additional expenditure. This supports the findings of the ACIAR funded "*Liriomyza huidobrensis* leafminer: developing effective pest management strategies for Indonesia and Australia" (Ridland *et al.* 2000) project that showed 90% of the pesticides applied to potatoes for LMF management did not control the pest so it was an expense with no benefit.

Fertiliser management

The economic baseline survey of potatoes showed that fertiliser expenditure is the second most important input cost impacting on gross margins (Figure 7.23) after seed expenditure. Improved efficiency in fertiliser use will improve the gross margins of potato farmers.

Nitrogen

Higher tuber yield was associated with higher rates of applied N in NTB (Figure 7.7) and SS (Figure 7.8) but not CJ and WJ. Rates of applied N in NTB ranged from 145 to 180 kg N/ha and from 39 to 245 kg N/ha in SS. Rates of applied N recommended for high yields of Indonesian potatoes ranged from 170 to 237 kg /ha (Duriat *et al.* 2006). This suggests potato crops in SS and NTB receiving the lower rates of applied N may be short of N and have reduced yield. High yield was not predicted by high concentrations of total N nor extractable nitrate or ammonium N in the soil before planting or % N in the petioles in NTB and SS. For example there was no evidence of N deficiency based on petiole N at the 10 mm tuber stage in any province, especially NTB and SS (Appendix 1, Annex 2, Figure 11).

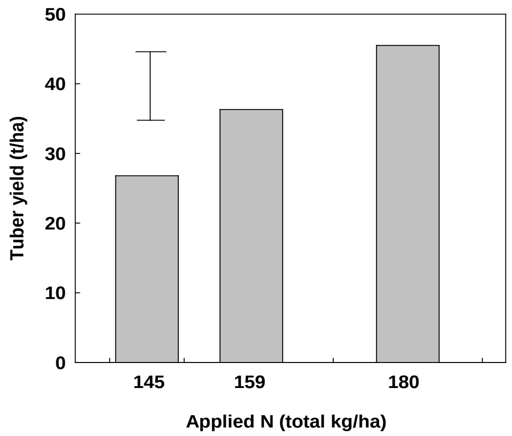

Figure 7.7. Tuber yield with rate of applied N in NTB. Bar is LSD for differences (P < 0.10) in yield between Kg N/ha from the ANOVA. (A1 F6.15).

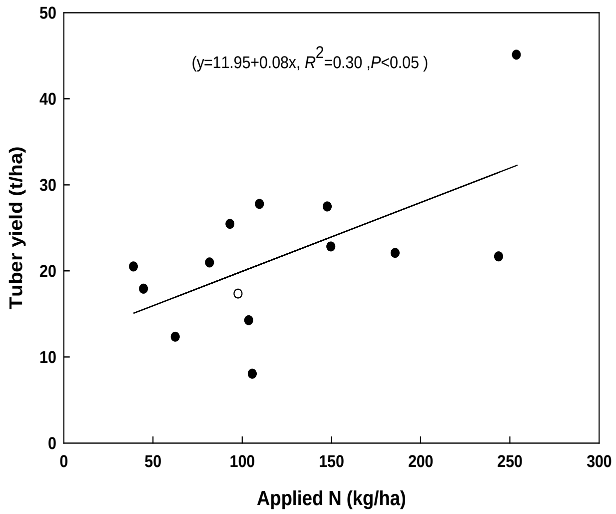

Figure 7.8. Linear regression between tuber yield and rate of applied N in SS. (A1 F6.18).

Phosphorus

Higher tuber yield was associated with higher rates of applied P in SS (Figure 7.9) but not CJ and WJ. In NTB higher yields were associated with medium and high rates of P compared to low rates (Figure 7.10). Rates of applied P in NTB ranged from 45 to 136 kg P/ha and from 7 to 56 kg P/ha in SS. Rates of applied P recommended for high yields of potatoes in Indonesia ranged from 44 to 70 kg P/ha (Duriat *et al.* 2006) suggesting the lowest rates of P applied in NTB and especially in SS could be restricting yield. In NTB petiole P at the 10 mm tuber stage appeared to be deficient across all sites according to both Australian and International Standards (Maier and Shepherd 1998, Huett *et al*. 1997). The significantly higher yield with higher petiole P at the 10 mm tuber stage in NTB supports the proposal the P fertilisation may have been inadequate (Appendix 1, Annex 2, Figure 13). By contrast high yield was not predicted by high concentrations of extractable P in the soil before planting in NTB (not measured in SS).

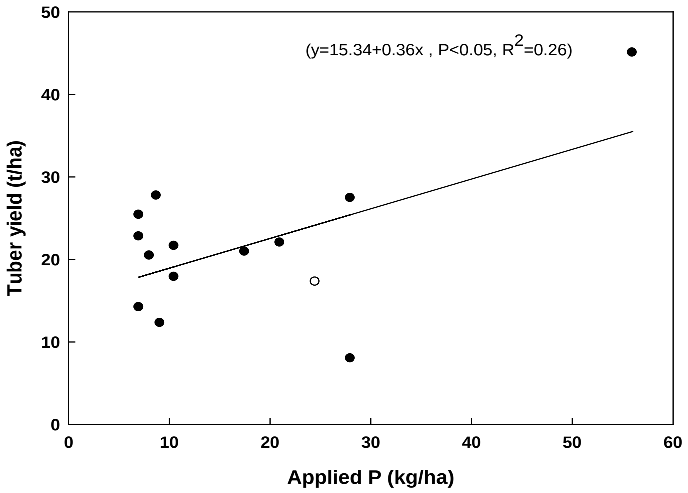

Figure 7.9. Linear regression between tuber yield and rate of applied P in SS. (A1 F6.19).

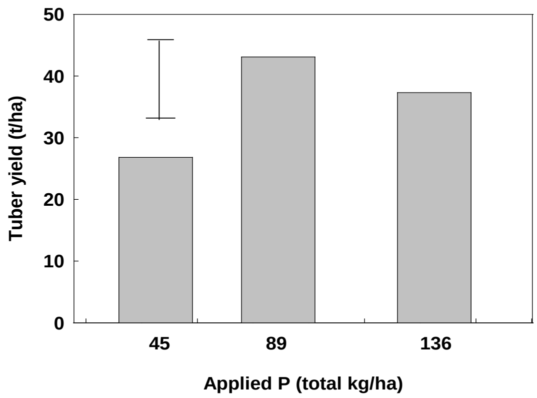

Figure 7.10. Tuber yield with rate of applied P in NTB. Bar is LSD for differences ($P < 0.05$) in yield between Kg P/ha from the ANOVA. (A1 F6.16).

Potassium

Higher tuber yield was associated with higher rates of applied K in SS (Figure 7.11) but not CJ and WJ. In NTB higher yields were associated with lower rather than higher rates of applied K as yield was higher with 83 compared with 129 kg K/ha (Figure 7.12). Applied K in NTB ranged from 83 to 129 kg K/ha and from 13 to 106 kg K/ha in SS. Rates of applied K recommended for high yields of potatoes in Indonesia ranged from 113 to 163 kg K /ha (Duriat *et al.* 2006) suggesting even the highest rates of applied K used in SS could be limiting yield. It is not clear why lower yields were associated with 129 versus 89 kg K/ha in NTB as this rate is unlikely to cause K toxicity. The concentrations of extractable/exchangeable K in the soil prior to planting appeared to be deficient across all NTB sites (Maier 1986). Despite the higher rates of K applied in NTB to other provinces petiole data that indicated K concentrations were deficient for maximum yield on most sites. The apparent contradictory result between applied K and K in the soil and petioles was considered an ideal opportunity to develop a potassium FIL activity to resolve whether K fertiliser management is an issue in NTB.

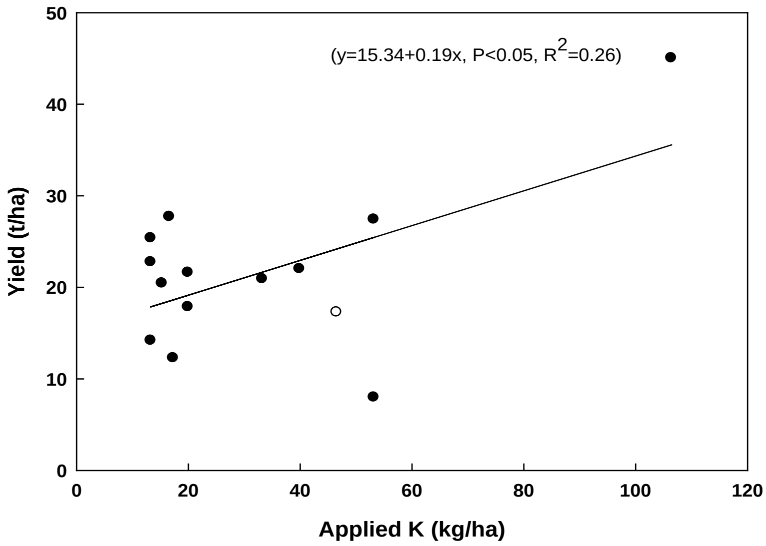

Figure 7.11. Linear regression between tuber yield and rate of applied K in SS. (A1 F6.20).

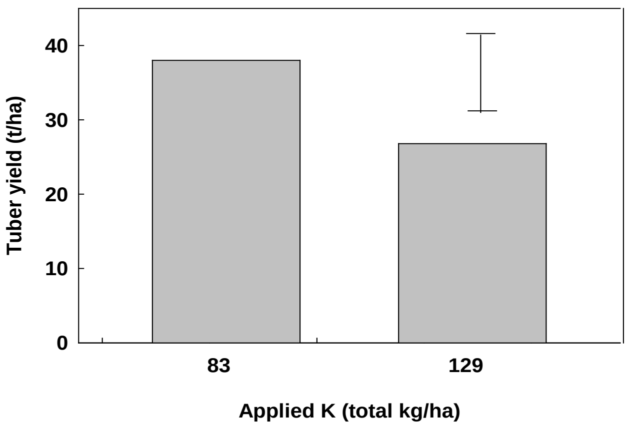

Figure 7.12. Tuber yield with rate of applied K in NTB. LSD bar shown is for differences ($P < 0.05$) in yield between Kg K/ha although the ANOVA showed differences were significant at $P = 0.001$. (A1 F6.17).

Potato cyst nematode

Few farmers in Indonesia believed that nematodes were present in their crops yet many still used nematicides. It is unlikely that the farmers performed soil tests for nematodes prior to planting and were using nematicides as an insurance policy or felt that the nematicides were controlling the nematodes present. Of particular concern is that only one respondent from Java identified PCN as being present on their property. PCN was first identified in East Java in 2003 (Indarti *et al*. 2004) and is now endemic in potato growing areas of highland CJ causing significant yield reductions. Despite government regulations on growing potatoes on land known to have PCN these are poorly regulated and enforced whilst soil is spread easily through movement on and between farms and erosion. If left to continue unabated this will lead to significant problems for the potato industry of Indonesia in the future. In Australia where PCN is closely monitored and the severity much lower than in Indonesia, any spread of PCN is estimated to cost the industry approximately $18.7 million annually and a total cost of $370 million over 20 years (Hodda & Cook 2009). Therefore PCN represents a significant problem for both the Indonesian farmers and government now and in the future.

7.1.3 Potato ICM Farmer initiated learning, 2nd cycle

Modification of FFS methodology to FIL

After the first cycle of FFS farmers reported that they wanted to investigate improved pest and disease management; and how to increase yield. For farmer's learning requirements to be met a change of FFS methodology was required that allowed specific crop management techniques to be tested.

By the second cycle of FFS specific management techniques likely to benefit potato farmers had been identified through the baseline surveys. These management techniques were:

- Improved PLB management to reduce input costs while maintaining or increasing yield;
- Improving soil pH through liming to prevent low pH reducing fertiliser efficiency and potato yields in Indonesia and to combat high soil levels of Al;
- Adoption of IPM to prevent the ineffective expenditure on insecticides with LMF as the major target; and
- For NTB to test whether K fertiliser management is an issue.

A modification to the methodology of FFS was made that allowed the impact of single management changes to be measured by farmers. Previously the FFS had compared an ICM plot versus a conventional plot. This resulted in a range of management changes between the plots which meant that the identification of the cause of improvements in profits between the treatments was not possible. Our aim was to instigate LBD demonstration plots that allowed the impact of single management changes to be measured by farmers. We called the new methodology Farmer Initiated Learning (FIL) or Pembela**jar**an Peta**ni** Pelo**por** or Jarnipor or PP for short in Indonesian.

Individual LBD demonstration plots for the wet season potato crop in WJ 2008/09 were designed to test a single management technique at the project review meeting in Lembang in August 2008. Factors identified by the baseline survey were examined. The final design for all sites was:

- LBD 1; 3 sources of seed (imported G4 certified, Indonesian G4 certified and local (uncertified) seed);
- LBD 2; source and rate of lime (none, 2 rates of calcium carbonate and 2 rates of dolomite);
- LBD 3; PLB management comparing conventional control with the *systemic-contact-systemic* method (after Cáceres *et al.* 2007).

Collaboration between groups by pooling results was encouraged to enable more rigorous comparisons of the results to be made using statistical analysis.

A series of PowerPoint presentations were developed to provide Master Trainers with information about seed sources, soil acidity and PLB management.

2008/09 FIL activities results not involving seed are reported below. Results of FIL activities which investigated seed in this season can be found in Section 7.2.

FIL lime West Java 2008/2009

The response to applied 'limes' either as dolomite or calcium carbonate to LBD plots in 2008/2009 was variable between sites and plots within sites and not significant overall. However the pH value of plots before planting and after lime application was only reported for 2 sites and only one of these was lime responsive. The sole acidic site of the Warga Mandiri FIL group showed an increase in soil pH after lime application and had a positive yield and gross margin response to applied calcium carbonate at 3 t/ha (Table 7.10). The yield response to the 6 t/ha rate was not obvious due to this plot's lower initial acidity of

4.0 which, as the pH scale is logarithmic, is 4.0 times more acidic than the 3 t/ha plot's initial pH of 4.6 and 3.3 times more acidic than the control plot's pH of 4.5 (Table 7.10). This meant that the soil pH in the 6 t/ha lime rate plot would have increased more slowly than the pH level of the 3 t/ha plot meaning that the plants in this plot would have grown under more acid conditions. On other sites the variable response to the limes may have been due to non-responsive (non acid) soils. The lack of pH testing before and after the lime tests shows that the farmer groups and their guides must thoroughly understand the topic being investigated. The response from the sole acidic site backs up the findings of a potato yield response to lime in Granola crops in Ciwidey on a soil of similar acidity (pH 4.1) to the Warga Mandiri site (Subhan and Sumarna 1998). New information of high concentration of extractable Al in the potato soils of Java revealed by this project combined with the known sensitivity of potatoes to high soil Al means that further FIL lime LBD activities on sites with low pH (< 5.0) are needed.

Table 7.10. Yield, income, cost and gross margin (GM) for Granola crops with different sources and rates of application of lime on the Warga Mandiri acid site in WJ in 2008/2009. (A1 T6.8).

Lime added (t/ha)	Soil pH		Yield (t/ha)	Revenue	Cost*	GM
	Before	After		(Rp 000 000 /ha)		
0	4.5	5.2	23.8	58.0	44.8	13.2
3.1	4.6	5.5	25.3	61.6	45.4	16.2
6	4.0	5.3	20.0	48.8	45.9	2.9

* Assume cost of lime at 3 and 6 t/ha is 0.58 and 1.07 million Rp/ha in addition to standard operating cost of 44.8 million Rp/ha. The effect of lime is assumed to last for 3 years (6 crops) so 17% of cost is attributed to the first crop.

Potato late blight West Java 2008/09

The PLB LBD plots were not successful as the FIL sites were not large enough to compare lime, seed and PLB treatments. To allow all treatments to be applied the PLB plot was planted without sufficient buffer area to isolate the two treatments. Consequently edge effects of uncontrolled inoculum interfered with these plots and no results were reported. This shows that the FIL method must be kept simple with only one LBD planned for each farmer group. It's better to complete one LBD well rather than several poorly.

Superphosphate and compost NTB 2009

At Sembalun 6 farmer groups compared rates of superphosphate and rates of compost. Their LBD plot results are presented in Table 7.11. The results from each farmer group were used as replicates with the combined results being analysed using ANOVA.

For superphosphate there was no significant difference between rates of 300 and 600 kg/ha. Superphosphate costs Rp 2000 per kg (BPTP NTB 2009a) and the average farmer uses 433 kg/ha. The finding that 300 kg of superphosphate is sufficient for potato production in the paddy areas of Sembalun means that there can be a saving of 133 kg of superphosphate or Rp 266,000 per ha which will improve farmer income because of reduced input costs.

For compost there was no significant difference between rates of 5,000 and 3,000 kg/ha. Manure costs Rp 497 per kg (BPTP NTB 2009a) and the average farmer uses 3,192 kg/ha. The finding that 3,000 kg of compost is sufficient for potato production in the paddy areas of Sembalun means that there can be a saving of 192 kg of compost or Rp 95,425 per ha for the average farmer which will also improve farmer income because of reduced input costs. For farmers who use above average organic manure the savings will be greater. For example if a farmer who previously used 5,000 kg/ha of compost reduces this input to 3,000 kg/ha the savings would be Rp 994,000 per ha.

A complete report of the activities was prepared by BPTP NTB (2009b) and a translation can be found in Appendix 10, Annex 1. BPTP NTB (2009b) noted that the FIL treatment plots produced an average yield of 33.1 t/ha. The Farmer treatment here refers to the rate of phosphate applied. All other management was according to the Standard Operational Procedure (SOP) developed for the Potato Technical Toolkit (see next Section). Farmers and AIAT staff were surprised to see that the 33.1 t/ha yield in the Farmers treatment plot was much higher than the 20 t/ha that farmers usually produce in this area.

Table 7.11. Results of 6 Farmer Initiated Learning LBD plots investigating superphosphate and compost rates – NTB 2009. (A10 T6.3.1).

Treatment		Yield (t/ha)
Super phosphate	300 kg/ha	33.0
	600 kg/ha	33.1
Significance		ns
LSD		1.4
Compost	3,000 kg/ha	33.0
	5,000 kg/ha	32.7
Significance		ns
LSD		2.8

Potassium NTB 2009

The agronomic baseline survey of potatoes in NTB indicated that potassium may be a limiting factor for potato production (Figure 7.12). This was tested in LBD demonstration plot which looked at 5 rates of potassium. This was repeated at 3 sites. Yield from this potassium demonstration shows no difference between potassium rates (Table 7.12). At two sites yields were far lower than the first site and this was caused by late planting of these sites which coincided with foggy, cloudy weather 40 days after planting. This weather caused a PLB outbreak that affected 20-30% of the plant population despite control measure being applied. This weather disruption means that the potassium activity should be repeated ensuring that the sites are planted during the main growing season.

Table 7.12. Yield produced by the potassium fertilisation plots. (A10 T 6.3.2).

Treatment				Yield
#	Amount K_2SO_4 applied (kg/ha)			
	Basal	Side dressing	Total#	(t/ha)
K1	0	0	0	21.5
K2	61	61	122	21.2
K3	122	122	244	21.8
K4	244	244	488	24.1
K5	488	488	976	23.5
n				3
Significance				ns
LSD P < 0.05				4.2

\# corresponds to 0, 50, 100, 200 and 400 kg K/ha for treatments K1 to K5 respectively

7.1.4 Potato ICM Farmer initiated learning, 3rd cycle

The 2nd cycle of FIL showed that further improvement could be gained through simplification. The previous season's FIL plots were successful in comparing just two of the three proposed treatments of lime, seed and PLB management with the PLB treatment failing (See *PLB West Java 2008/09* in previous section). It would be better to have a farmer group focus on just one LBD activity rather than several.

Further improvement could also be made with improved information for trainers. In the previous season PowerPoint presentation were prepared for Master Trainers. However this information did not always reach the farmer groups. An example was the lime FIL plots of the second cycle which were executed well but the vital step of selecting and acidic site through preliminary soil testing was mostly not done (Section 7.1.3). Improved training manuals were developed to ensure that the risk of poor site selection for lime experiments will be reduced.

Updating training manuals, and develop extension materials

Technical Toolkits

A Potato Technical Toolkit (PTT) (DAFWA 2010a) and a Cabbage Technical Toolkit (CTT) (DAWFA 2010b) were developed to provide information to support FIL activities. These technical toolkits were aimed at FIL guides. They describe how farmers can undertake rigorous but simple experiments to test new management techniques. For example in the PTT five experiments appropriate for farmers to undertake were described. These experiments were designed to test: a new fungicide program for PLB control, the performance of different seed potato sources; IPM management of LMF; the effect of lime on acid soils; and the requirement for potassium fertiliser in NTB. The PTT and CTT contain supporting information about how simple experiments can be set up, SOP (= GAP) for the crops, background information on the topics suggested for experimentation, tally sheets required for the collection of crop growth, yield and profit data. A companion field pocket booklet *Buku Catatan: Mengejar Keuntungan* was also produced to record inputs that were applied to the treatments in the LBD plots to be recorded so the profitability of the treatments could be later determined.

Instructional DVDs

LPTP produced three DVDs showing practical management techniques recommended by the project. One DVD discusses potato profitability through improved management of PLB and insect pests. A second DVD is about preventing and controlling the spread of clubroot of cabbage. The third presents information about preventing PCN spread through use of PCN free seed and biosecurity.

Factsheets and posters

Factsheets and posters were prepared to provide improved technical information to farmers. For cabbage, factsheets and posters were prepared for cabbage head caterpillar, diamondback moth, natural predators, clubroot disease, black rot and the soil pH requirement of the crop. For potatoes, factsheets and posters addressed seed selection, PCN, PLB, the soil pH requirement of potatoes and natural predators of LMF. A pictorial instruction manual was produced to show techniques for improved handling, storage and distribution of potatoes. Relevant to both crops was a factsheet on calibrating knapsack sprayers and a poster on the FIL methodology.

Website

An Indonesian website was established at www.indopetani.com to enable easily access to the above training materials. The website would also allow access to other project information like research findings.

Details of the extension publications produced are given in Section 10.2.

FIL NTB 2010

Potato late blight

These PLB LBD plots followed the design presented in the PTT. They were planted in the wet season of 2010. It rained almost every day when the crops were growing. The high rainfall even damaged the local paddy rice crop. Five farmer groups planted LBD plots; two groups planted in paddy fields and these LBD plots were severely affected by the wet weather, the third was damaged by herbicide. Results from the two remaining sites, Koang Londe and Mentagi, where crops grew well, are examined below.

Yields for both PLB treatments were similar with the farmers' management producing 17.97 t/ha while the ACIAR recommended treatment yielded significantly higher with 19.47 t/ha (Figure 7.13). This shows that the new ACIAR PLB control method may have had better efficacy than the farmers' usual method. PLB infection data backs this up with the farmers' management plot recording 17% of plants infected at flowering while the ACIAR recommended treatment only had 10% of plants infected. This was significant at $P < 0.10$ (Figure 7.13). The PLB also differed in profitability as shown by gross margin. The farmers' management included average pesticide costs of Rp 10.95 million per ha while the ACIAR method was slightly lower at Rp 10.56 million per ha. This expenditure is 39% higher than found in the economic baseline survey where average pesticide expenditure for NTB was Rp 7.9 million per ha (Table 7.5). The fungicide component of costs under farmers' management was Rp 8.9 million per ha while the ACIAR method was slightly lower at Rp 8.5 million per ha. Farmers' management fungicide costs were 59% higher than shown in the baseline survey probably because of the very wet season. The ACIAR treatment produced a gross margin of Rp 10.83 million per ha which was significantly greater, by Rp 4.04 million per ha, than the farmers' treatment gross margin (Figure 7.13).

These results show that the FIL methodology of LBD demonstration plots is an effective way for farmer groups to do their own research on crop management. The results also show that the ACIAR recommendations for PLB management are effective and produce greater profits than the farmers' usual disease management whilst reducing the risk of PLB resistance from developing.

Two FIL PLB activities failed due to flooding. The season was so unusually wet that even the paddy rice crops failed. However the failure of the two FIL activities shows the importance of reducing risk of failure by careful site selection. With experience in FIL activities guides and farmer groups should be able to increase the success rate of these activities.

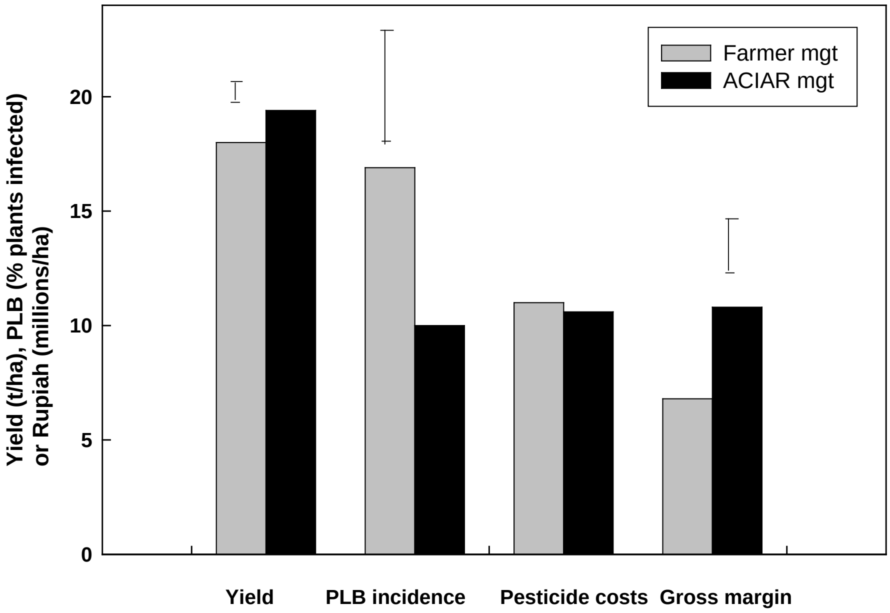

Figure 7.13. Effects of improved PLB management at Sembalun, Lombok. Yield was significantly higher for the ACIAR management (LSD P < 0.05 = 0.4 t/ha), % plants infected by PLB was significantly lower for the ACIAR management (LSD P < 0.1 = 4.9%) and gross margin was significantly higher for the ACIAR management (LSD P < 0.05 = 2 million Rp/ha). (A10 F6.4).

7.1.5 Baseline surveys of cabbage

The cabbage baseline agronomic and economic surveys were completed during the second year of the project. These surveys aimed to identify constraints to production and technical solutions which could be tested by farmer groups.

Gross margins

CJ has a higher average yield (34.1 t/ha) than WJ (30.8 t/ha) which when combined with CJ's much higher average price (Rp 1,011 per kg compared to Rp 476 per kg) provides a higher income, gross margin and BCA (Table 7.13). Average costs per ha are similar for both provinces at Rp 9.1–9.5 million. The largest cost for both WJ and CJ was fertiliser followed by either insecticides or labour-other (primarily harvest labour) and seedlings (Table 7.13). Both provinces spend similar amounts on fertiliser. CJ's farmers spend less on insecticide, herbicide and fungicide than their WJ counterparts. CJ's farmers plant on average 19,000 seedlings per ha compared to 24,000 seedlings per ha, however including labour costs and nursery costs (chicken manure and fungicides) the total expenditure on seedlings is similar.

Table 7.13. Average cabbage gross margins for West and Central Java. (A4 T6.1).

Item	West Java	Central Java
Crop size (ha)	0.45	0.39
Yield (t/ha)	30.8	34.1
Price (Rpper kg)	476	1,031
Income (Rp/ha)	14,670,284	35,163,006
Costs (Rp/ha)		
Cost of Seedlings	1,042,042	992,051
Fertiliser	4,011,419	4,493,621
Insecticide	1,136,950	918,077
Fungicide	285,483	88,564
Herbicide	32,381	7,231
Planting	161,899	235,513
Weeding	315,727	472,359
Labour-other	715,238	1,692,385
Equipment	260,841	368,983
Other	1,094,059	244,555
Total	9,056,039	9,513,338
Gross Margin (Rp/ha)	5,614,245	25,649,667
Benefit:cost analysis (Income/expense)	1.62	3.70

Results of the Excel input cost sensitivity analysis that was conducted on the CJ data is shown in the spider chart in Figure 7.14. Using the Sensit Add-in in Excel a sensitivity analysis was conducted to gauge the impact of percentage changes in input costs on the gross margin returns. This helps to identify inputs that should be investigated for correlation. On this spider chart, lines that are nearly horizontal generally indicate an input variable where small percentage changes do not have much effect on the gross margin. Lines that are more vertical indicate an input variable where small percentage changes have a greater affect on the gross margin. The slope downwards from left to right indicates a negative relationship. The inputs are listed in the legend in Figure 7.14 in decreasing order of impact on gross margin. The graph clearly shows that if fertiliser use efficiency can be increased then gross margins should increase.

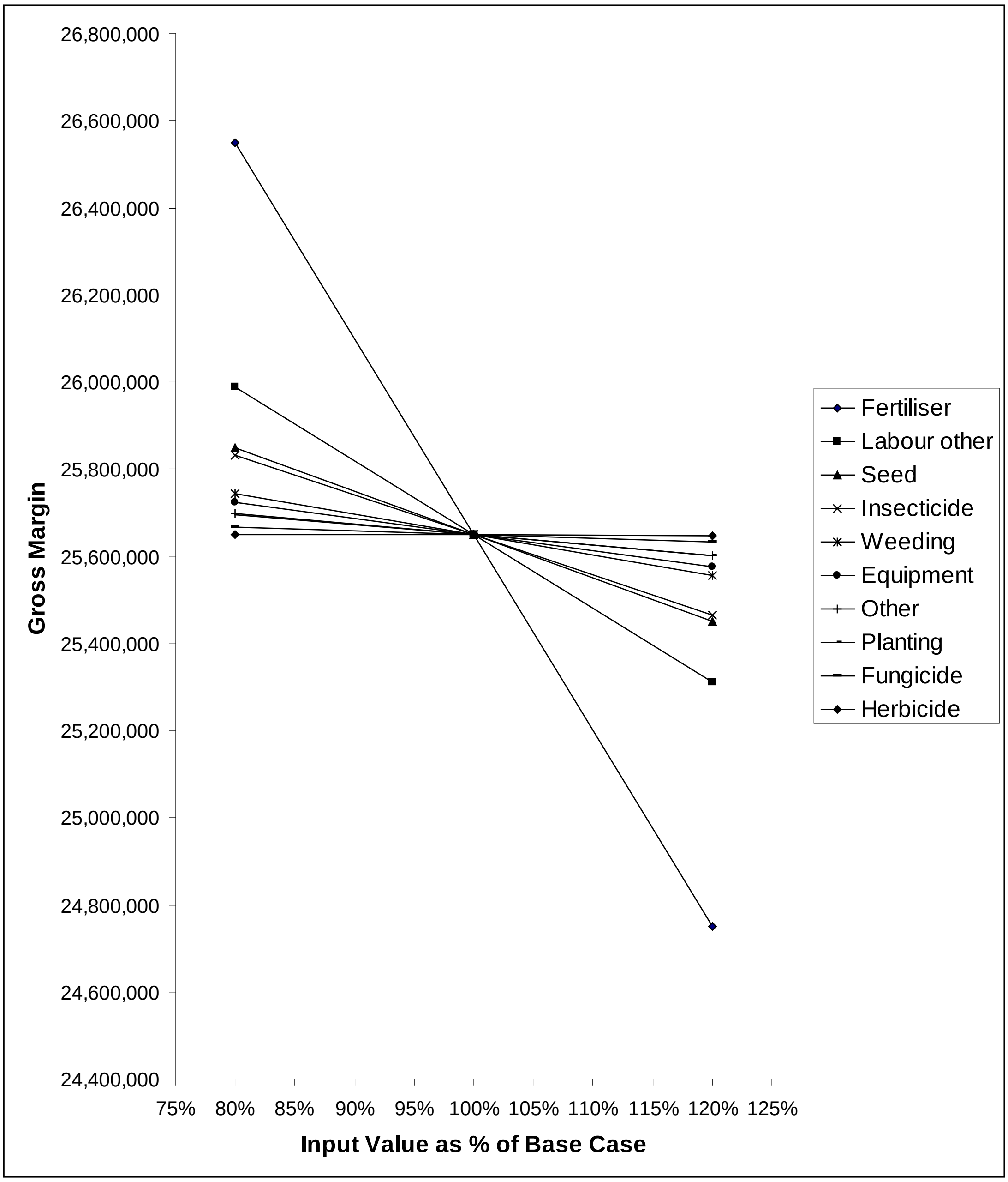

Figure 7.14. Gross margin sensitivity analysis (spider chart) for cabbage in Central Java. (A4 F6.1).

Most agricultural enterprises are highly sensitive to factors affecting returns – prices received, gross yield and waste. A sensitivity analysis was conducted using price and yield to measure their impact on the gross margin for CJ (Table 7.14). Large fluctuations in gross margins result from 10% or 20% changes in yield and price. A 10% increase in yield and 10% increase in price leads to a 28% increase in gross margin; from Rp 25 million per ha to Rp 32 million per ha. Accordingly it is worth investigating the effect of various inputs and practices on yields, average prices and gross margin.

The sensitivity analysis showed that cabbage is a low risk crop because even at low yields and prices in the sensitivity analysis the gross margin remains positive.

Table 7.14. Sensitivity analysis for price and yield for cabbage grown in CJ. (A4 T6.3).

			Yield (tonnes/ha)				
			- 20%	**- 10%**	**0%**	**+ 10%**	**+ 20%**
			27.29	**30.71**	**34.12**	**37.53**	**40.94**
Price (Rpper kg)	- 20%	825	13,329,462	15,973,264	18,617,066	21,260,868	23,904,670
	- 10%	928	16,142,503	19,137,935	22,133,367	25,128,799	28,124,231
	0%	1,031	18,955,543	22,302,605	25,649,667	28,996,729	32,343,791
	+ 10%	1,134	21,768,583	25,467,276	29,165,968	32,864,660	36,563,352
	+ 20%	1,237	24,581,624	28,631,946	32,682,268	36,732,591	40,782,913

Gross margin regression analysis

Both provinces saw a correlation at $P < 0.05$ between yield and gross margin (Figure 7.15). Correlations between gross margin and yield for WJ and CJ showed gross margin continued to increase directly with yield. The correlation between yield and gross margin is stronger in WJ than CJ. CJ has a higher indicative break-even yield at 18.4 t/ha than WJ's 13.1 t/ha according to the x-intercepts in Figure 7.15. This initially appears unusual as the averages provided in Table 6.1 indicate that both provinces have similar costs and with higher returns generated by higher prices it would be expected that farmers with lower yields in CJ would still break-even. However the average figure for CJ masks a wide spread of input costs and returns. The two farmers that returned losses growing cabbage in CJ had an average price of Rp 200 per kg, well below the Rp 1,031 per kg average.

The correlations between gross margin and yield for WJ and CJ shows that there is scope to increase profitability of cabbage farmers through improved agronomic efficiency as gross margin continues to increase directly with yield.

Most of the farmers produce a positive gross margin from their cabbage crops e.g. 10 out of 13 farmers in CJ and 5 out of 6 farmers in WJ.

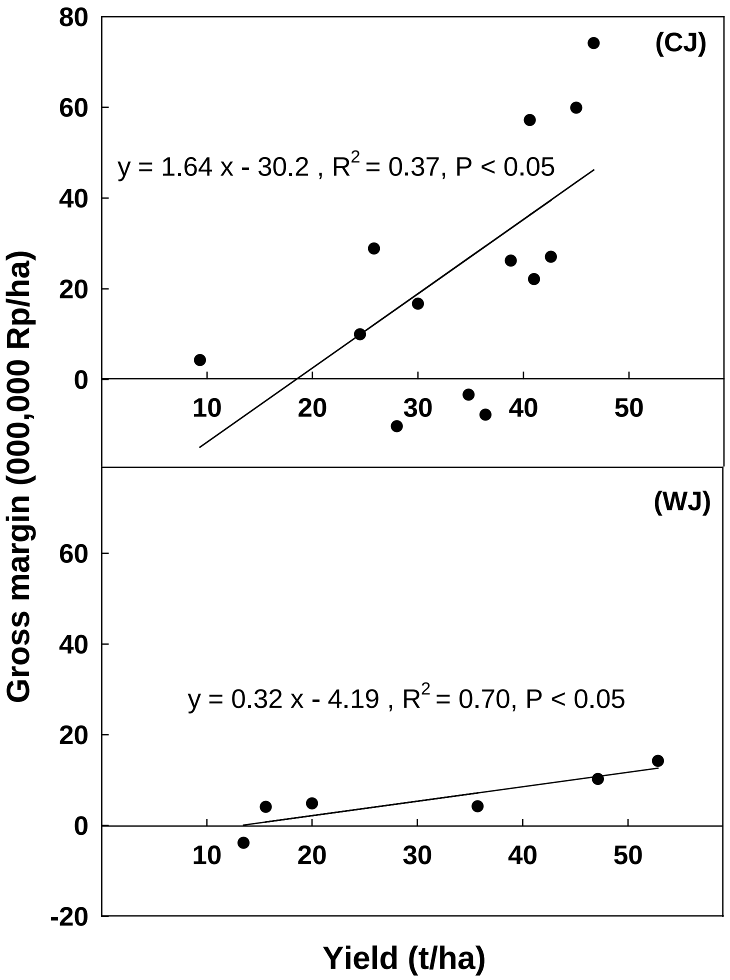

Figure 7.15. Linear regression of cabbage yield with gross margin in WJ and CJ, ($P < 0.05$). (A4 F6.2).

Fertiliser expenditure and average price regression

There is a negative correlation between fertiliser expenditure and average price received in CJ at $P < 0.05$ (Figure 7.16). However fertiliser expenditure did not have any statistically significant association with yield or gross margin. Fertiliser has the greatest effect on gross margin with increasing fertiliser costs reducing gross margin steeply (Figure 7.14). Fertilisers represent the largest input cost in both WJ (44%) and CJ (47% of inputs). However there was no significant correlation in either province between fertiliser expenditure and yields, average prices or gross margin returns. This indicates the fertiliser expenditure is inefficient. The baseline agronomic survey of cabbage (Appendix 3) found that the disease clubroot was an important constraint to production as was low soil pH. Clubroot could be expected to impair nutrient uptake by impairing root function while low soil pH impairs nutrient uptake by reducing the availability to plants of nutrients. At pH below 5 the major nutrients N, P, K, Ca and Mg become markedly less available to plants (Maynard and Hochmuth 2007). Farmers may be trying to overcome poor crop performance caused by low soil pH and clubroot by applying high rates of fertiliser. This may explain the relationship between average price and fertiliser. Here the cause of the low price is the poor quality cabbage from low pH and clubroot infested sites, not the associated high cost of fertiliser used in an attempt to overcome these problems (Figure 7.16). Farmers in CJ and WJ should investigate management of clubroot and soil pH with the aim of capturing the significant potential to reduce fertiliser costs to improve profitability.

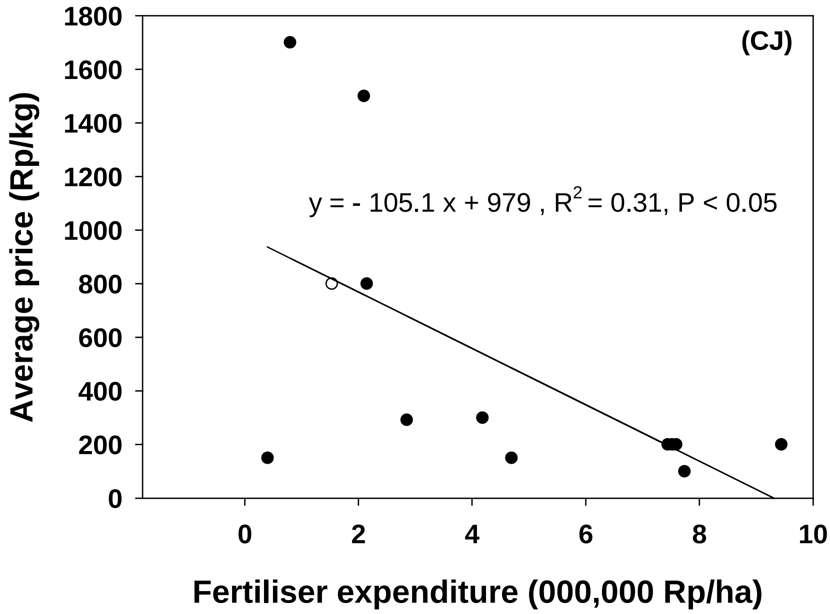

Figure 7.16. Linear regression of fertiliser expenditure (including labour to apply fertilisers) with average cabbage price per kg in Central Java. (A4 F6.4).

Insecticide and average price regression

CJ had a negative correlation between pesticide expenditure and average price of produce at $P < 0.05$ (Figure 7.17). Possible explanations for this are:

- The use of broad spectrum insecticides may be reducing the population of beneficial insects and leading to increased pest problems which then affect produce quality,
- Pest populations are resistant to insecticides,
- Inefficient insecticide use, for example targeting adults of diamondback moth rather than its caterpillars.

Insecticide costs were the fourth steepest line in the Excel Sensit analysis (Figure 7.14). Insecticide expenditure is a large input cost in WJ (13% of inputs) and CJ (10% of inputs) yet there was a negative correlation between insecticide costs and price. Farmers in CJ and WJ should investigate optimising insecticide use by testing the efficacy of IPM. If insect control is improved it will reduce input costs and improve product price and so increase gross margin.

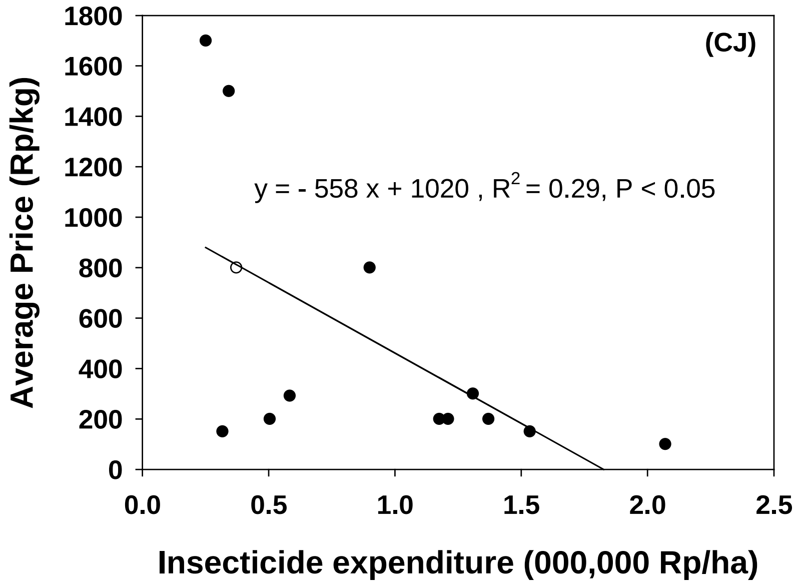

Figure 7.17. Linear regression of insecticide expenditure (including labour to apply insecticides) with average cabbage price received in Central Java. (A4 F6.7).

Clubroot incidence

Clubroot (*Plasmodiophora brassicae*) was identified as the most important disease limiting yield, based on incidence, from both farmer response and crop monitoring in both provinces (Table 7.15). Due to its widespread incidence and difficulty in obtaining accurate assessments of severity at each site it was not possible to obtain statistical relationships with yield. Assessments of severity were difficult due to differences between the criteria used for severity in each district and missing data.

Table 7.15. Incidence of disease (% of sites) in the field in West and Central Java. (A3 T6.5)

Disease	WJ	CJ	Average
Clubroot	88	57	73
Black rot	64	22	43
Ring spot	24	9	17
Damping off	16	0	8
Nematode	68	30	49

The high incidence of clubroot is not surprising with in-field crop losses worldwide caused by clubroot ranging from 10 - 15% with a mean loss of 11% (Dixon 2009). Clubroot severity and symptom expression increases with the intensity and frequency of crop production (Dixon 2009), with high moisture content and soil temperatures above 20°C (Rimmer *et al*. 2007). Indonesian vegetable production revolves around short crop rotations with average mountain air temperatures around 22°C (Darmawan and Pasandaran 2000).

The major role of clubroot in limiting the yield of cabbage needs to be viewed in light of other agronomic factors. Worldwide, several techniques are used to manage clubroot, including resistant varieties, liming, long crop rotations, trap cropping, soil solarisation and fungicide application (Rimmer *et al.* 2007, Donald *et al*. 2006). Currently in Indonesia the favoured cabbage varieties show no resistance to clubroot and given the ability of clubroot spores to survive in the soil for up to 20 years (Rimmer *et al*. 2007) there is a constant build up of inoculum leading to greater crop loss. Chemicals used in Indonesia for clubroot are dominated by bio-pesticides that are promoted by chemical resellers and have not been proven to work in scientific studies. These bio-pesticides add significant production costs to the farmers without providing any increase in yield or quality.

Soil condition is a major factor in the ability of clubroot to develop and spread with the disease favouring acidic soils (Rimmer *et al.* 2007). Raising soil pH through liming has been practiced for many years as one of the main techniques for managing clubroot (Donald and Porter 2009). The mean pH for both CJ and WJ soils were acidic with WJ farms being more acidic than those from CJ. The more acidic WJ soils may have lead to the higher incidence of clubroot in that province compared with that of CJ. Despite what appeared to be general awareness amongst farmers of the importance of managing acid soils for Brassica production there was little use of lime reported in the agronomic baseline survey with only 6% using it (Appendix 3). Where it was used it was as dolomite applied at rates from 0.4 to 1.0 t/ha. These rates are most likely too low to raise pH adequately to counteract soil acidity and minimise clubroot. Also there was no use of the more reactive forms of lime such as calcium hydroxide reported in the agronomic baseline survey.

Pests

Diamondback moth (DBM) (*Plutella xylostella*) is considered the most important pest of crucifers in Indonesia (Sastrosiswojo and Setiawati 1992) and the results from the agronomic survey confirmed that it is widespread across all growing regions. The use of synthetic insecticides is still the most commonly used strategy for controlling insect pests of cabbage, particularly DBM, with applications beginning within one week after planting and total per crop season ranging from 4 (Rauf *et al*. 2005) to 26 applications (Shepard & Schellhorn 1997). The number of pesticide applications recorded in the survey, 2 to 15 per crop, was of a similar range. IPM programs have previously been developed in Indonesia but have not been widely adopted by farmers. Farmer's use of biological control agents such as *Bacillus thuringiensis* have increased over time but their beneficial effects have been overcome by the farmers' use of broad spectrum insecticides.

Research into the impact of natural enemies on the showed that:

- DBM was the most significant pest in the early part of the year
- Heavy rainfall can significantly reduce pest numbers
- *Diadegma semiclausum* can be an extremely effective natural enemy of diamondback moth in WJ
- The predator complex of foliar and soil dwelling spiders and beetles causes significant pest mortality
- The natural enemy complex investigated has the potential to form the cornerstone of an IPM programme but current insecticide use patterns disrupt natural enemy populations.

Soil factors and fertiliser management

Java soils were shown to be acidic with WJ more acidic than CJ. Lower yields were significantly related with high concentrations of extractable Al (Figure 7.18) and Mn in the soil. The concentration of both these elements increases as soils become more acidic.

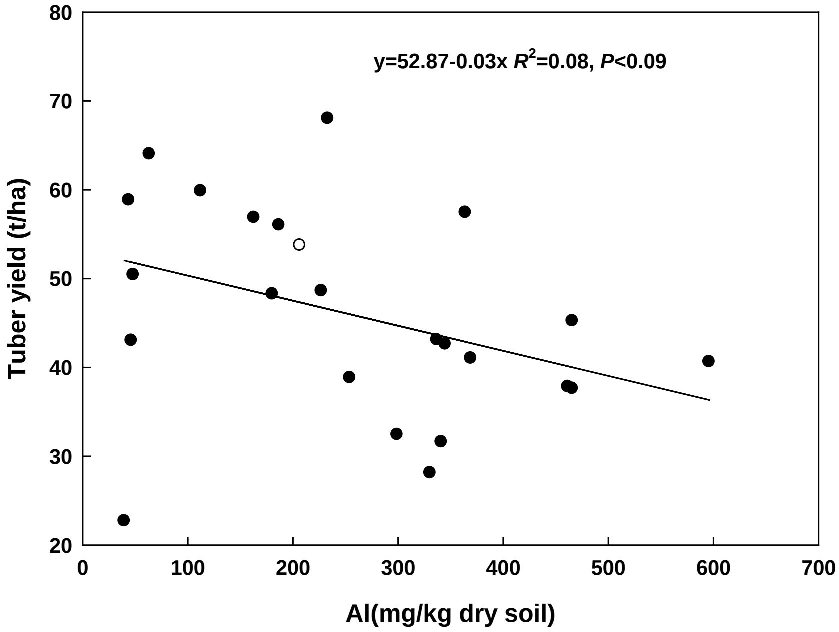

Figure 7.18 Relationship between head yield of cabbage and extractable Al in the soil from a baseline survey of crops in CJ in 2006/2007 (A3 F6.7).

Related to this was the finding that higher yields were correlated with higher concentrations of Ca in the soil (Figure 7.19) and petioles and Mg in the petioles, the concentration of which increases in the soil with pH i.e. as soils become less acid.

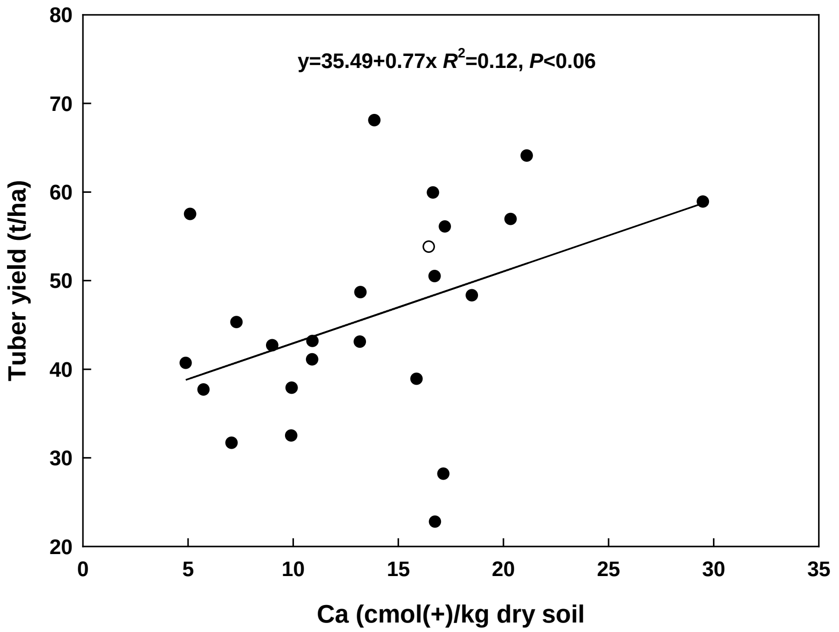

Figure 7.19 Relationship between head yield of cabbage and exchangeable Ca in the soil from a baseline survey of crops in CJ in 2006/2007 (A3 F6.9).

7.1.6 Cabbage ICM farmer initiated learning, 1st cycle

By the time of the first cycle of cabbage FFS specific management techniques likely to benefit cabbage farmers had been identified through the baseline surveys. These management techniques were:

- clubroot;
- non-response to fertiliser probably due to low soil pH.

Cabbage FFS activities built of the experience gained from the first cycle of potato FFS change of methodology by undertaking a FIL LBD lime activity.

Central Java 2009

A 2008/09 FIL LBD plot of the Sekar Tani farmer group compared the effect of different agricultural limes on clubroot incidence and severity. The LBD plot served three purposes; first to determine the amount and type of lime required to increase pH in the acidic soils of Indonesia. Second to determine the effect liming has on the level of clubroot seen on crops and finally to introduce farmers to a more detailed scientific method through hands on training. Initial soil pH was acidic 5.5 and it was aimed to increase this to pH of 6.5 by using conventional recommendations of 5.2 t/ha dolomite and 4.2 t/ha $Ca(OH)_2$ and 'ACIAR' recommendation based on soil organic content (SOC) and % clay of 8.5 t/ha dolomite and 6.8 t/ha $Ca(OH)_2$. The use of lime had an obvious effect on plant growth (Figure 7.19) and a significant effect on marketable yield with the $Ca(OH)_2$ having the highest yields (Table 7.16). There was no significant effect on the percentage of plants with clubroot between individual lime treatments or of the combined lime treatments (Table 7.16). There was no significant differences between the ACIAR and the conventional lime recommendations for both yield and clubroot percentage.

Table 7.16 Effect of lime application and two crop management regimes on yield and clubroot infection of cabbage. (A11 T6.2.2f).

Treatment	Amount (t/ha)	Yield (kg/ plot)	Plants with clubroot (%)
Dolomite conventional	5.2	0.5	92
$Ca(OH)_2$ conventional	4.2	10.0	58
Dolomite ACIAR	8.5	2.5	58
$Ca(OH)_2$ ACIAR	6.8	10.8	65
Un-limed control		0	100
Significance #		**	ns
LSD		5.6	91
Lime			
No lime applied		0.0	100
Lime applied		5.9	68
Significance #		ns	ns
LSD		10.9	34

ns = not significant or '*' = P < 0.1, '**' = P < 0.05,'***' = P <0.01

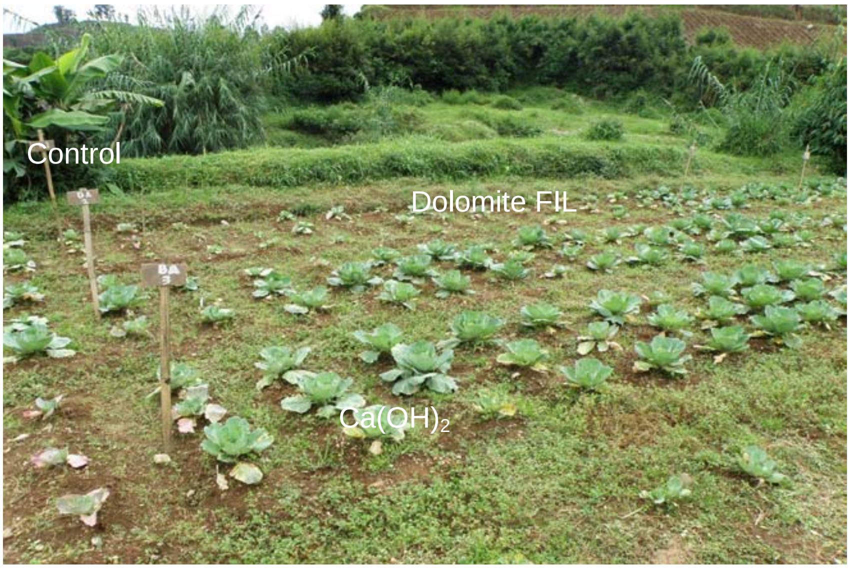

Figure 7.20 The learning-by-doing plots of the Sekar Tani cabbage trial with different lime treatments and rates. Photo taken in Feb 2009. (A11 F6.2).

Raising soil pH by using lime is one of the oldest and most widely practised techniques to control clubroot with incidence and severity generally reduced at pH 7.2 (Donald & Porter 2009). It is likely that the liming did have an effect on reducing clubroot severity as shown by the difference in health of plants in Figure 7.20. The clubroot assessment in Table 7.16 is incidence, not severity. A severity assessment method is now provided in the CTT (DAFWA 2010b, Results-Table 9) to enable FIL groups to make this improved assessment. Also the lime effect may have been reduced due to the lime being applied within a month of planting which is too late. Poor mixing with the soil and the short interval before planting does not allow enough time for the lime to increase pH to the levels which control clubroot. A number of variables are known to influence the effect of liming and clubroot control including soil preparation, moisture and texture, particle size and quantity of lime and the incubation interval between application and planting (Donald & Porter 2009).

The higher yield when $Ca(OH)_2$ was used to increase pH compared with dolomite ($MgCO_3.CaCO_3$) suggests that the form of the lime is important in clubroot control. Calcium hydroxide has a higher neutralising value and reacts more rapidly with the soil and will change pH more rapidly than dolomite at comparable rates required to change the soil pH the same amount. This is important when it is difficult to allow sufficient time between lime application and planting for pH to change. However it has been suggested that particle size and proper mixing of lime in the root zone of the soil is as or more important than form of lime (Dobson *et al*. 1983).

7.1.7 Cabbage ICM Farmer initiated learning, 2nd cycle

Central Java and South Sulawesi 2010

The new round of the cabbage LBD plots were planted with at least 2 replications per treatment and a control plot that included either a standard growing variety or standard liming practice.

The application of lime at Bukit Madu (CJ) and Pemuda Tani Vetran (SS) groups also showed increased yields, with a significant increase at the Bukit Madu site (Table 7.17), and reduced clubroot incidence, significant at Pemuda Tani Vetran (Table 7.18).

Surprisingly although lime reduced clubroot incidence in several sites, although not always significantly, at the Bukit Madu site the Greenfrosh variety with lime produced lower yields than the un-limed plots (Table 7.17). It is possible that another factor or variable besides clubroot, such as black rot disease or an insect pest, reduced the yields of these plots as the clubroot incidence was reduced with liming.

Soil pH increased from 4.5 to 6.0 - 6.5 by the end of the Pemuda Tani Vetran FIL activity. There was a significant difference in yield and clubroot incidence between varieties with Maxfield producing higher yields and lower clubroot percentage. Liming had no significant effect on both yield and clubroot incidence. When combined, variety and liming had no significant effect on yield but did have a significant effect on clubroot incidence with Maxfield and liming having significantly lower clubroot incidence.

Table 7.17 Effect of variety and lime on clubroot infection of cabbage in plots set up by the Bukit Madu Farmer Group 2010. (A11 T6.2.2h).

Treatment		**Yield (t/ha)**	**Plants with clubroot (%)**
Variety			
Greenfrosh		13.6	31.4
Maxfield		28.3	0.0
Significance #		***	**
LSD		1.7	19.5
Lime			
No lime		21.9	13.5
Lime		19.9	17.9
Significance #		*	ns
LSD		1.7	19.5
Variety x lime			
Greenfrosh	No lime	15.8	35.8
	Lime	11.3	27.1
Maxfield	No lime	24.0	0.0
	Lime	32.5	0.0
Significance #		***	ns
LSD		2.4	27.6

ns = not significant or '*' = P < 0.1, '**' = P <0.05,'***' = P < 0.01

The Pemuda Tani Vetran group showed that liming was an affordable treatment (Table 7.18). The cost of liming is considerable with the cost of lime 1,000,000 Rp/tonne and application labour costs of 300,000 Rp per ha. Lime has a residual effect and is thought to last for 5 years in the tropics (Perry Dolling personal communication). Gross margins for the Pemuda Tani Vetran treatments were determined using cabbage gross margins developed in CJ (Table 7.13). The cost of the lime applied was divided by six to apportion this cost over the six consecutive crops which would benefit from the improved soil pH. We believe that this is a conservative estimate of the longevity of the effect of this lime. The costs for the application of the lime were fully costed to this crop where it was applied. Seed costs for Maxfield were assumed to be twice the cost of local seed. The result is that the gross margins for the lime treatments are higher than for the no lime treatments (Table 7.17). This shows that liming is an economical treatment to increase yield and reduce clubroot infection on low pH soils of SS. The gross margin for the Maxfield and lime treatment was Rp 9.5 million per ha, over twice the Rp 4.6 million per ha gross margin of the local variety without lime treatment. The gross margin calculations are shown in Appendix 11, Section 6.2.4, Table 6.2.2j.

Table 7.18 Effect of variety and lime on clubroot infection of cabbage in plots set up by the Pemuda Tani Vetran Farmer Group 2010. (A11 T6.2.2i).

Treatment		**Soil pH**		**Yield**	**% plants**	**Gross**
		Before treatment	**After harvest**	**(t/ha)**	**with clubroot**	**margin (Rp/ha)**
Variety						
Local variety				15.5	28.5	
Maxfield				21.2	2.5	
Significance #				0.06	**	
LSD				6.1	10.8	
Lime						
No lime				17.5	22.5	
Lime				19.2	8.5	
Significance #				ns	*	
LSD				6.1	10.8	
Variety x lime						
Local variety	No lime	4.5	4.5	14.8	40	4,629,051
	Lime	4.5	6.25	16.2	17	5,025,985
Maxfield	No lime	4.5	4.5	20.2	0	8,623,512
	Lime	4.5	6.25	22.2	0	9,507,276
Significance #				ns	0.08	
LSD				8.7	15.3	

ns = not significant or '*' = P < 0.1, '**' = P < 0.05,'***'= P < 0.01

Both the Bukit Madu (CJ) and Pemuda Tani Vetran (SS) farmer groups compared a local variety against that of Maxfield (synonym Tekila). Maxfield is a cabbage variety developed by Syngenta Seeds that has shown high levels of resistance to clubroot in Australia. A large number of virulent combinations of *Plasmodiophora brassicae* are known to exist (Rimmer *et al*. 2007) and it was not certain whether the resistance seen in Australia would be maintained in the high disease pressure environment that Indonesia represents.

The results from both FIL plots indicate that Maxfield produces a higher yield and is less affected by clubroot compared with local varieties. As these two FIL plots were planted in two different locations on sites known to be highly infested it is encouraging to see that resistance may hold in Indonesia. Maxfield and lime produced the highest yields and had no loss to clubroot in both trials and so this combination should become a recommendation for the clubroot integrated disease management program. These results are summarised in Figures 7.21 and 7.22 below.

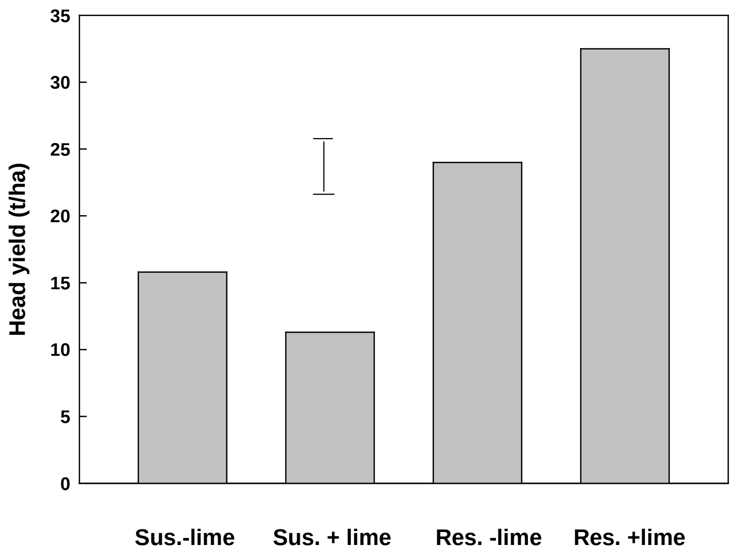

Figure 7.21 Yield of two cabbage varieties on the clubroot infected site of the Bukit Madu farmer FIL group in CJ. The susceptible (Sus) and resistant (Res) varieties were Greenfrosh and Maxfield. The vertical bar is LSD ($P < 0.05$) for yield differences between varieties and lime treatments. Maxfield had significantly greater yield than Greenfrosh. Maxfield with applied lime also had a significantly higher yield than the Greenfrosh without lime. It is not known why Greenfrosh with lime had a significantly lower yield than without lime. (A11 T6.2.2h).

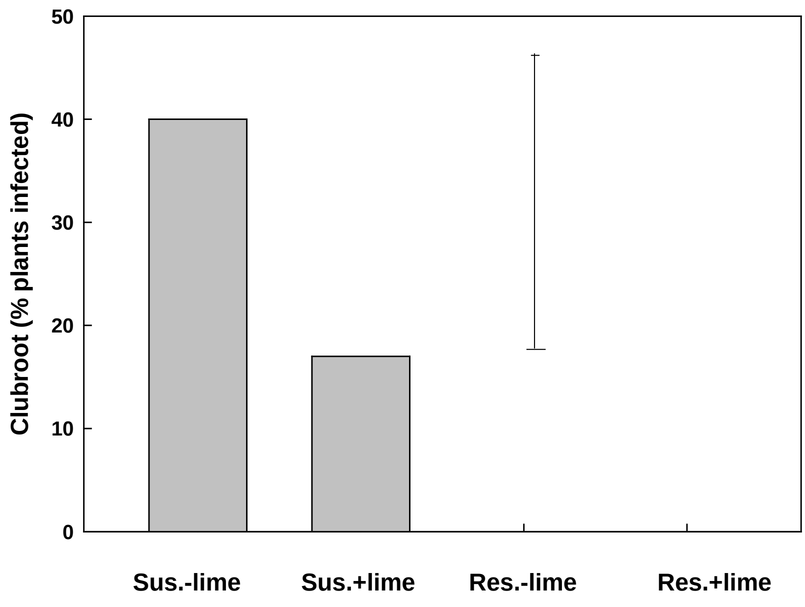

Figure 7.22 Percentage of cabbage plants of 2 varieties infected with clubroot in the Pemuda Tani Vetran farmer group FIL plots in SS on an infected site either un-limed (-) or limed (+). The susceptible (Sus.) and resistant (Res.) varieties were an unnamed local variety and Maxfield respectively. The vertical bar is the LSD ($P < 0.05$) for yield differences between varieties and lime treatments. The number of plants of the susceptible variety infected with clubroot was significantly lower with lime than without lime. No Maxfield plants appeared to be infected with clubroot. (A11 T6.2.2i).

7.1.8 Cabbage post-harvest studies Indonesia

A post harvest specialist visited members of the potato and vegetable supply chain to ask their opinions about post-harvest handling and to observe current practices. For cabbage farmers received little feedback on the quality of their product and there is little incentive for them to provide improved quality. Vegetable packers lack refrigeration. An intervention that may help is modified atmosphere packaging (MAP). At ambient temperatures MAP can act like refrigeration in slowing quality loss allowing broccoli to be kept in good condition for 10 days at 25°C in Australian experiments. The use of MAP for cabbages should be tested in Indonesia.

7.2 Low cost scheme that significantly improves the access of Indonesian farmers to quality potato seed

7.2.1 Baseline surveys of seed potatoes

Seed cost sensitivity analysis

Using the Sensit Add-in in Excel a sensitivity analysis was conducted to gauge the impact of percentage changes in input costs on the gross margin in SS (Figure 7.23). In this graph the higher the gradient for each input the greater the impact it has on gross margin returns. The slope downwards from left to right indicates a negative relationship. In SS seed represents the largest cost at 34% and so the gross margin is most sensitive to changes in the cost of seed (price or volume of seed used). A 20% increase in seed costs from the base case sees the gross margin fall from Rp 25.1 million per ha to Rp 23.6 million per ha. In the other provinces seed costs amounted to 53% of costs in NTB, 45% in CJ and 40% in WJ (Appendix 2, Table 6.2). Fertiliser costs are the next most important in terms of impact on gross margin returns. This was also true for CJ and WJ but in NTB fungicide costs were the second highest input cost after seed (Appendix 2, Table 6.2). Improvements in efficiency of seed and fertiliser use will improve farmer’s returns and should be a focus of FIL farmer group activities.

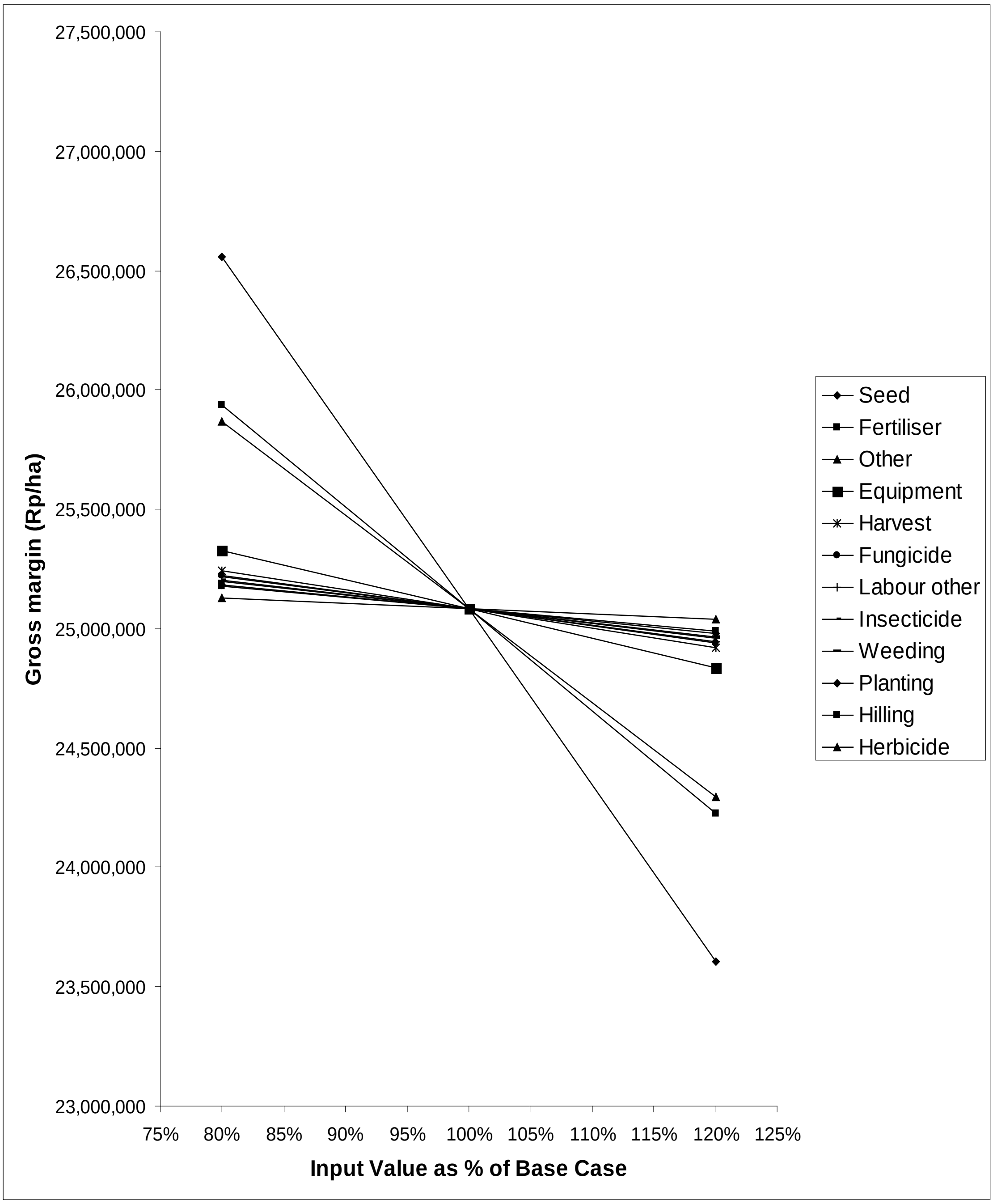

Figure 7.23 Sensitivity Analysis for South Sulawesi of potato gross margin returns to changes in input values. (A2 F 6.1).

Seed quality

Higher yield was significantly associated with higher seed price (Figure 7.24). This suggests farmers are skilled at purchasing higher quality seed from off-farm sources. Higher yield was also associated with the use of purchased versus own seed, selection on size and appearance and weight or diameter. This suggests farmers are also skilled at selecting higher (sanitary) quality seed from their own crops.

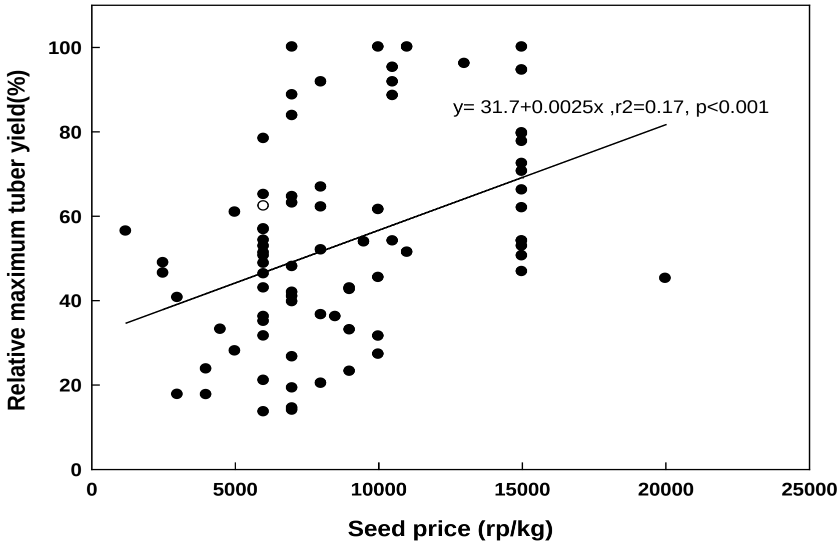

Figure 7.24 Linear regression of tuber yield (relative maximum %) with price (Rpper kg). Relative maximum yield (%) is highest tuber yield in each province/actual yield at each site x 100. (A1 F6.10).

There was a significant relationship between the higher incidence of PLRV and lower yield in WJ (Figure 7.25). This shows the important role of seed schemes in ensuring seed of low virus infection is produced. Figure 7.25 shows that 4 sites out of the 24 tested had PLRV infection levels of 15 to 30% which would be reducing yields by 5 to 10% (Struik and Wiersema 1999).

Counter intuitively higher yield was associated with higher field generation (G) number in CJ but not the other provinces. Lower G number doesn't guarantee higher yield as on low yielding sites factors other than seed health may be over-riding constraints. For example in WA, experiments comparing different generation seed sources did not produce significant differences except at the higher yielding sites over 30 t/ha (Floyd 1986). Lower G number also doesn't in itself guarantee higher seed quality as it depends on the effectiveness and standards of the relevant seed certification scheme.

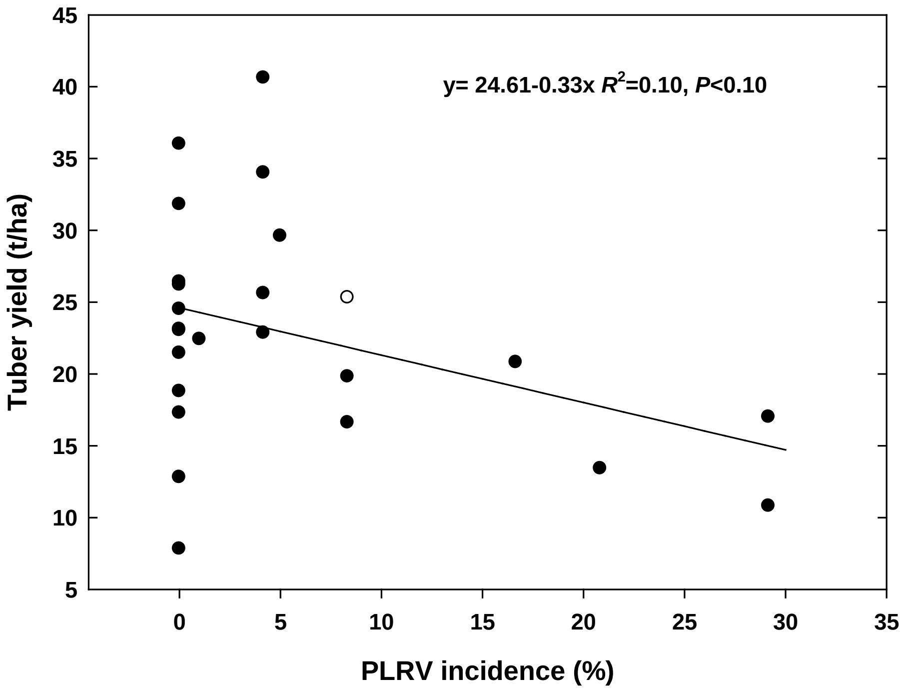

Figure 7.25 Linear regression between incidence of potato leafroll virus (PLRV, %) and tuber yields in WJ. (A1 F6.45).

In WJ higher yield was associated with shorter sprouts over the range 0.5 to 7.5 cm (Figure 7.26). Similarly in NTB higher yield was associated with shorter sprouts. A more detailed ANOVA ($P < 0.10$) showed yields of 40 t/ha from seed with sprouts of about 3.0 cm to 27 t/ha with 7.5 cm sprouts in NTB. The association of higher yield with shorter sprout length in some cases suggests physiological, as distinct from sanitary, quality maybe an issue as well. Shorter sprout length and lower number suggests younger physiological age and lower tuber number per plant in the subsequent crop (Struik and Weirsema 1999). It may be better in tropical environments to use physiologically younger seed so that crops produce a fewer tubers per plant resulting in a high proportion of large marketable tubers at harvest. Using ‘older’ seed may lead to a high proportion of small unmarketable tubers that will not ‘fill out’ if for example the crop growth cycle is shortened by disease.

The many seed factors associated with yield indicate that seed is an important factor in potato production and should be a focus for FIL LBD plots in the next phase of the project.

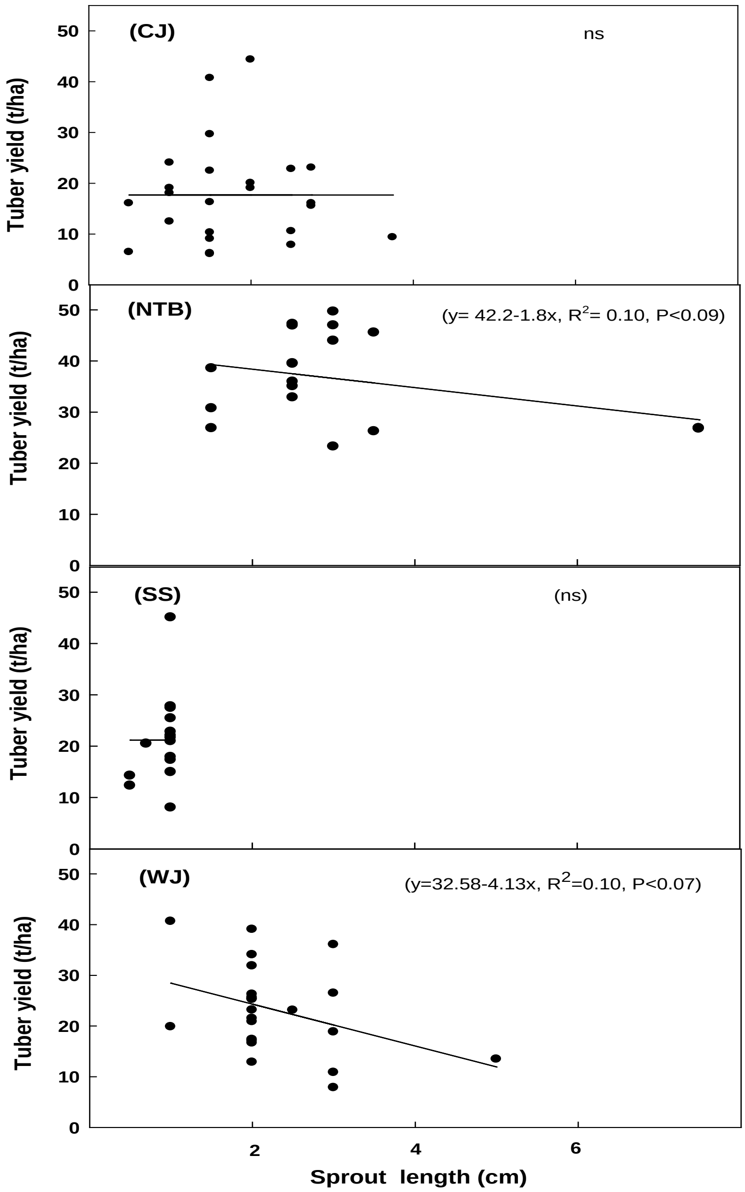

Figure 7.26 Linear regression of tuber yield with sprout length in 4 provinces. (A1 F6.9).

7.2.2 Potato seed farmer initiated learning, 2nd cycle

The agronomic baseline survey showed that many seed factors were associated with yield. It also found there was a significant relationship between the higher incidence of PLRV and lower yield in WJ (Figure 7.25). The economic baseline survey showed seed costs had a great impact on the gross margin. These findings show that seed is an important factor in potato production and should be a focus for FIL LBD plots in the next cycle of participatory technology transfer.

West Java 08/09

The 2008/09 FIL activities in WJ were successful with the introduction of the FIL method which allowed the rigorous comparison of a limited number of management techniques against control techniques. This was an advance on the previous season where many management changes were tested against conventional management but the effects of the individual management changes could not be measured as shown at Barokah Tani Farmers' Group and Taruna Tani Sauyunan farmer group (See section 7.1.1 or Table 7.3).

There was no significant difference in average yield from ten sites grown with Local, Indo G4 or Aust G4 seed in 2008/2009 (Figure 7.27). The quality of Aust seed was adversely affected during a long period of storage (over 5 weeks) in hot and humid ambient conditions from time of arrival in Indonesia to planting. During this period the seed became infested with PTM and it was difficult to supply all farmer groups with good quality seed for the LBD. This has helped to identify the need for improved seed storage knowledge and infrastructure in Indonesia. Despite the poor condition of the Aust G4 seed some sites such as Warga Mandiri and Mekar Sari reported yields of Aust G4 seed as high as Indo G4 seed. Presumably the seed used on these sites was of better quality or better graded than other sites and good agronomic practices were employed. High potato yield requires both high quality seed and appropriate agronomy as was shown in best management practice evaluations in Vietnam (McPharlin *et al.* 2003). On 3 WJ FIL sites where an economic analysis of seed sources was completed yield from Aust G4 seed was on average as high as Indo G4 seed and higher than the Local seed crops. This resulted in better economic return from the use of Aust G4 seed with on average higher income, gross margin and BCA. The better performance of Aust G4 seed in these 3 LBDs compared with the entire 10 sites and is presumably due to a combination of seed selection which ensured better quality seed as well as superior management practices.

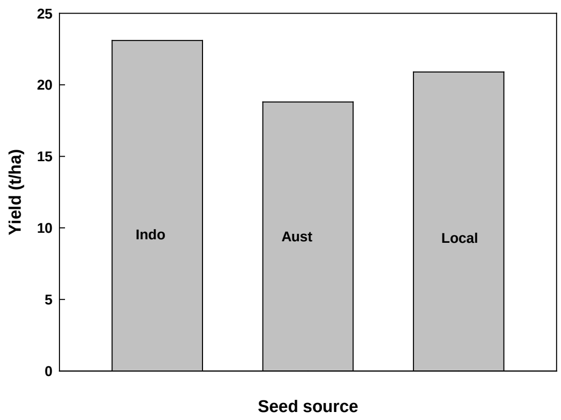

Figure 7.27 Mean potato tuber yield from different sources of Granola seed in the LBD plots in WJ in 2008/2009. 'Indo, 'Aust or 'Local' refers to certified Indonesian G4, certified imported WA G4 or local seed (G unknown) respectively. There was no significant difference between the means. (A8 F6.3).

7.2.3 Potato seed Farmer initiated learning, 3rd cycle

West Java seed sources 09/10

Mean tuber yield ranged from 14.8 t/ha for crops using local seed to 19.4 t/ha for crops using Indo G4 seed (Fig.7.28). The yield of crops using Aust G4 seed, 17.7 t/ha, was comparable to crops using Indo G4 seed as there was no significant difference in yields between seed sources.

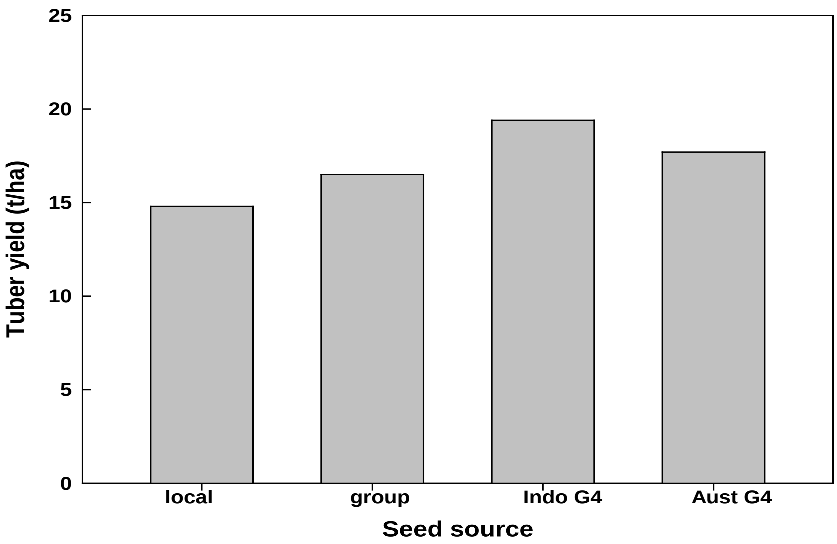

Figure 7.28 Mean tuber yield (t/ha) of Granola crops grown by four farmer groups from different seed sources in LDB plots in WJ 2009/2010. There was no significant difference between means. (A8 F6.5).

Similarly there was no significant difference in income from the seed sources (Table 7.19). However as the price used to calculate income varied from site to site the performance of the seed is probably best assessed from the yield results.

There was a significant difference between the costs of the seed treatments with local farmer seed costs significantly lower than the costs for the Aust G4 and Indo G4 seed treatments (Table 7.19). However this did not translate to improved gross margins for these cheaper treatments as statistical analysis showed no significant difference between seed treatment gross margins. Gross margins varied greatly; each seed treatment producing both positive and negative gross margins.

Table 7.19 Yield, income and costs from four potato seed sources tested by farmer groups in WJ during the wet season of 2009-10. (A8 T6.20).

Seed treatment	Yield range (t/ha)	Yield (t/ha)	Income	Costs	Gross margin
			(Rp 000 000/ha)		
Local farmer seed	5.2 – 19.0	14.8	34.7	37.8	-3.1
Group seed	9.5 – 18.9	16.5	43.0	39.9	3.1
Indo G4	17.7 – 20.9	19.4	46.5	43.0	3.5
Aust G4	15.4 – 20.9	17.7	44.4	44.8	-0.5
Significance		ns	ns	**	ns
LSD (P = 0.05)		4.5	12.1	3.1	12.7
Not certified (Local & Group seed)		15.7			
Certified (Aust G4 + Indo G4)		18.6			
Significance		ns‡			
LSD (P = 0.05)		3.0			

‡ ns P<0.10

In the 2009/2010 LBDs there did not appear to be any significant difference in the physiological state of the seed as expressed in terms of sprout number and length at planting and stems/plant after emergence (Appendix 8, Tables 6.12, 6.13, 6.17). Sprout length and number can be used as indicators of the physiological age of seed before planting as seeds with more and longer sprouts are assumed to be physiological older and produce more stems/plant (Struik and Wiersema 1999). Also the larger size of local and group yield did not appear to influence stem number/plant or yield. The yields in the 2009/10 LBDs were moderate and constraints other than seed probably limited yield. In WA, experiments comparing different quality seed sources did not produce significant differences except at the higher yielding sites over 30 t/ha (Floyd 1986). PLB was monitored as it was the most significant factor limiting yield across all sites. Linear regression showed a significant decline in yield with % incidence of PLB at flowering, but not other crop stages, across all sites. However despite the guaranteed PLB freedom of Aust G4 seed (due to the absence of this disease in WA) the % incidence and severity measured in the growing crop from 30 cm height to flowering was not significantly lower than other seed sources. This shows that infection (incidence and severity) from PLB in the growing crop may be extensive enough to mask the effects of PLB status of the seed and that all sources of seed are equally susceptible to attack.

There was no data presented to compare the effect of the different spray regimes, ACIAR and conventional on the LBD plots. Despite this being the case the ACIAR regime was used on all the seed plots and the % incidence did not exceed 4% per plot for any of the seed sources. Similarly the highest severity recorded was 8 that equates to a scale of 50 lesions per plant on the scale used (Results-Table 7 PTT, DAFWA 2010a). This indicates that the ACIAR regime is successful in maintaining low levels of PLB infection throughout the life of the crop.

The supply of Indonesian Certified G4 seed does not meet farmers' demand (Fuglie *et al.* 2005). This means that inferior quality seed is used instead. This non-certified seed increases the risk of spread of pests and diseases. This has probably already happened in the case of PCN. PCN's wide distribution in CJ and the findings of PCN in other provinces of Indonesia is most likely due to spread through non-certified seed. These results show that Australian seed can be used to provide an alternative, safe source of high quality seed. Aust G4 seed comes from an area known to be free of PCN (Collins *et al.* 2010) and other important pathogens like bacterial wilt and PLB (Holland and Spencer 2009). The conditions under which Australian seed potatoes are produced are considered to be the best in the world according to the International Potato Center (Dawson *et al.* 2003). The quality of seed from Australia is even further enhanced due to the low number of generations used. The maximum generation used in WA is G5 which makes it equivalent to Class SE (Netherlands), Pre-basic 4 (Scotland) or G5 Elite 4 (Canada) (Dawson 2008). The use of imported seed will help Indonesia protect potato production areas that are currently free of PCN by increasing the availability of high quality seed. These characteristics of WA potato seed make it suitable for the basis for a partial seed scheme for Indonesia to augment its own government certified seed (see Section 7.2.7).

NTB seed sources 2010

One NTB farmer group planted an LBD seed source plot at Lendang Luar in the wet season of 2010. Both seed sources grew vigorously, the newly imported WA seed had 64 stems from 40 plants/row compared with the 69 stems of the once-grown seed. This indicates that the two seed sources probably had similar physiological age. The newly imported seed produced more than double the number of tubers compared with the once-grown seed (Table 7.20). The tubers filled out which meant that yield of the newly imported Australian seed was 18.3 t/ha while for the once-grown dry season bulked Australian seed was 9.1 t/ha (Table 7.20).

Table 7.20 Yield, income and costs from two potato seed sources tested by a FIL group at Lendang Luar in East Lombok in the wet season of 2010. (A10 T6.4.2).

Atlantic seed source	**Tuber number by grade (tubers/50 m^2)**				
	< 30 mm	**30 - 50 mm**	**> 50 mm**	**Reject**	**Marketable (No rejects)**
Australian import	160	685	590	13	1,435
Once-grown Aust seed	95	324	241	54	660
	Yield by grade (t/ha)				
	< 30 mm	30 - 50 mm	> 50 mm	Reject	Marketable (No rejects)
Australian import	2.5	10.2	5.6	0.1	18.3
Once-grown Aust seed	1.2	4.9	3.0	0.8	9.1

The once-grown seed had about 12% of plants with visible secondary (seed-borne) virus symptoms (14/120 plants). This level is probably not high enough to affect yield but it could have affected tuber set. In WA, experiments comparing different quality seed sources showed lower generation seed set more tubers than older generation seed (Floyd 1986). The virus levels of 12% in once-grown seed are a good finding in an Indonesian context. In Java farmers report that it is difficult to grow Atlantic seed because of virus problems. The first generation of plants show 0.5% symptoms of “mosaic” virus, while the next generation consistently shows 60% (Appendix 12, Section 6.2.6). This may indicate that the degeneration rates of Atlantic at Sembalun are less than in Java. The 12% virus level found would not have affected yield greatly because even severe PVY strains which may cause 50% yield loss in a plant only cause about 4% crop loss when 12% of plants are infected (Struik & Wiersema 1999 Appendix 2).

This 12% virus level found in once-grown imported seed in NTB could be reduced with the following interventions:

- farmers are trained in seed potato virus management, e.g. roguing,
- Granola is grown instead of Atlantic (reported to be less susceptible to virus degradation),
- aphid management appropriate for seed crops is introduced.

The results of this FIL plot should provide evidence that once-grown WA seed from Sembalun can be used to complement the existing Indonesian seed supply system. This evidence will help to gain entry of WA Granola seed potatoes to Indonesia.

7.2.4 PCN NTB

Status

The PCN survey in the Sembalun areas undertaken from July to November 2008 examined 454 soil samples. No cysts of PCN were found in the potato cropping area of Sembalun (Table 7.21). Based on the survey results it can be concluded that the Sembalun was free from PCN at that time, November 2008. This situation means that the Sembalun region has good potential to become a centre of potato seed production to fill the potato seed needs of other areas of Indonesia.

Table 7.21 Results of the Potato Cyst Nematode Survey at Sembalun July – November 2008. (A5 T6.1).

Site No.	Farmer's name	No. soil tests	Results	Site No	Farmer's name	No. soil tests	Results
1	Musnaeli	16	No PCN	23	Amaq Lepi	3	No PCN
2	Haji Sayuti	12	No PCN	24	Haji Sayuti	8	No PCN
3	Sukirno	6	No PCN	25	Amaq Fika	8	No PCN
4	Sukirno	32	No PCN	26	Fery	3	No PCN
5	Haji Hairil	6	No PCN	27	Haji Jun	8	No PCN
6	Haji Dia	12	No PCN	28	Haji Wir	4	No PCN
7	Haji Muhlisin	4	No PCN	29	Haji Ros	6	No PCN
8	HM Kartif	37	No PCN	30	Haji Upin	4	No PCN
9	Sayuti	19	No PCN	31	Samirih	4	No PCN
10	Musnaeli	4	No PCN	32	H. Suhilwadi	14	No PCN
11	Suandi	11	No PCN	33	Amaq Deri	6	No PCN
12	Haji Nidia	5	No PCN	34	Amaq Dia	7	No PCN
13	Musnaeli (Mentagi)	8	No PCN	35	Amaq Leli	8	No PCN
14	H. Anwar (D. Blek)	14	No PCN	36	H. Atahar	7	No PCN
15	H. Wildan	6	No PCN	37	Amaq Joi	4	No PCN
16	Am. Peni (Dorit)	6	No PCN	38	Amaq Exl	12	No PCN
17	Bp. Izah (D. Blek)	16	No PCN	39	Musnaeli	13	No PCN
18	H. Amir (Dorit)	26	No PCN	40	H M Idris	14	No PCN
19	H. Muspaidi	22	No PCN	41	H. Ayup	9	No PCN
20	Amaq Filad	21	No PCN	42	Amaq Susi	4	No PCN
21	Amaq Pino	7	No PCN	43	Amaq Dwi	5	No PCN
22	Minardi	13	No PCN				
Total samples examined						454	

PCN species identification

Based on morphological characters especially stylet of the larvae/juveniles of PCN and perenial pattern of PCN cysts, only *G. rostochiensis* was found in all of the soil samples from East, CJ, and WJ (Table 7.22). PCR provided consistent results on electrophoresis gels (Mulyadi *et al.* 2008) and these are summarised in Table 7.22.

Table 7.22 Number of cysts of PCN in East, Central and West Java and the species of PCN found based on morphological characteristics and molecular identification. (A5 T6.4).

Province & site	Altitude	Number of cysts/20 g soil				PCN
	(m asl)	1*	2*	3*	4*	sp†
East Java, Bumiaji						
Brakseng	± 1,700-1,800	14.30	10.30			Ro
Tunggangan	± 1,600	13.15	6.00			Ro
Kembangan	± 1,500-1,600	2.25				Ro
Watu Tumpuk	± 1,500	0				
Bon XV	± 1,200	0				
Central Java, Wonosobo						
Patak Banteng	± 800	2.0	22.60	19.30	4.60	Ro
Kejajar	± 1,500	5.00	3.30	0.30		Ro
Central Java, Banjarnegara						
Dieng Wetan	± 1,800	46.30				Ro
Dieng Kulon	± 1,800	1.30				Ro
Karang Tengah	± 1,900	44.40	44.00			Ro
Karang Bakal	± 1,900	6.00				Ro
Batur	1,900	10.00				Ro
Dieng Gapura	± 1,500	18.30				Ro
Pasurenan	± 1,900	14.00	4.30	0.30		Ro
Sumberejo	± 1,900	0.30	16.30			Ro
West Java, Pangalengan	± 1,400				13.67	Ro

1*; 2*; 3* and 4 *: at first, second, third, and fourth soil sampling
†: Ro = *Globodera rostochiensis* from both morphology and PCR tests.

PCN pathotype identification

Three collections of PCN were tested using indicator species differential screening tests (Table 7.23). The fourth collection from Banjarnegara did not hatch and therefore was unable to be tests. Good reproduction took place when the populations were grown with *S. andigena* and the susceptible potato variety, Desiree. This combination indicates the pathotype was Ro2, Ro3 or Ro5. *S. kurtzianum* and *S. vernei* restricted cyst multiplication which indicates that the pathotypes were not Ro3 or Ro5. Therefore it is concluded that the pathotype is Ro2. Had there been G. pallida then high multiplication would have been observed on all of the potato clones.

In addition the original populations and those multiplied on the susceptible hosts were tested by AFBI using PCR and all of the results indicated pure populations of *G. rostochiensis* which confirmed the results reported in the previous section.

Table 7.23 Results of differential indicator test to determine pathotypes of four Indonesian populations of potato cyst nematode. (A5 T6.5).

Indicator species or variety	Allows reproduction of pathotype*: Ro1	Ro2	Ro3	Ro5	Sample	Wonosobo Indo 1	Banjarnegara† Indo 2	Kota Batu Indo 3	Pangalengan Indo 4	Interpretation
						(Number of cysts produced on indicator plant)				
Desiree					1/5	232	-	1288	657	High numbers of cysts here indicate pathotype
					2/5	1260	-	2492	980	is one of Ro1, Ro2, Ro3 or Ro5.
	✓	✓	✓	✓	3/5	612	-	1256	406	It is not *Globodera pallida* as there would be high
					4/5	860	-	2000		numbers of cysts produced on all the indicators.
					5/5	1660	-	988		
S. vernei					1/5	16	-	20		High numbers of cysts here indicate pathotype
58.1642/4					2/5	21	-	41		Ro5. No sample was considered to be Ro5
	×	×	×	✓	3/5	3	-	22		due to the low numbers of cysts produced
					4/5	6	-	62		on this indicator.
					5/5	2	-	18		
S. kurzianum					1/5	10	-	24	8	High numbers of cysts here indicate either
60.21.19					2/5	9	-	44	7	pathotype Ro3 or Ro5. No sample was
	×	×	✓	✓	3/5	4	-	35		considered to be Ro3 due to the low numbers
					4/5	15	-	47		of cysts produced here.
					5/5	5	-	24		
S. andigena					1/3	409	-	42	1358	The high numbers of cysts here indicate pathotype
(MP)	×	✓	✓	✓	2/3	1021	-	3200	621	Ro2, Ro3 or Ro5. As Ro3 & Ro5 have already
CPC 1673					3/3	493	-	512		been eliminated the high number of cysts
										show the pathotype of all samples is Ro2.

* According to the International Pathotype Scheme
* Not tested as not enough cysts could be produced.

The finding that the pathotype of three collections of PCN from Batu, (WJ), Wonosobo (CJ) and Pangalengan (WJ) is important information for managing PCN as it now allows resistant potato varieties that may be appropriate for testing in Indonesia to be identified. There is a potato breeding program in New York State of USA that has been breeding potatoes for resistance to this pathotype. These include crisp processing varieties that could be suitable for Indofood. One hurdle is that many of these Ro2 resistant potato varieties will have plant breeders' right and Indonesia as at 22/10/2009 was not a member of the International Union for the Protection of New Varieties of Plants (UPOV).

PCN decline studies

The number of PCN cysts drastically decreased by 99% at 30 days and reached zero at 60 days after burying bags containing the cysts in paddy soil. Whereas the number of the cysts in terrace soil had drastically decreased by approximately 87% within the first 30 days then the rate of decline decreased after this time. The cysts and eggs seem to be very susceptible to breakdown and death under flooded paddy soil conditions (Table 7.24). The number of PCN viable eggs in paddy soil was also drastically decreased with 16% remaining after 30 days and with none detectable after 60 days after burying the bags containing the cysts. Eggs in the terrace soil were still detectable at 180 days when the experiment ended (Table 7.24). The different population decline trends of PCN cysts and viable eggs in paddy and terrace soils (in Banjarnegara) can be seen more clearly in Figures 7.29 to 7.32.

Table 7.24 The average number of cysts and viable eggs at 30; 60; 90; 120; 150; 180 days after burial (DAB) the bags in paddy and terrace soil. (A5 T6.9).

Treatments	Initial population	Days after burial					
		30	60	90	120	150	180
Cysts							
In paddy soil	140	0.8	0	0	0	0	0
In terrace soil	160	20	44	27	12	15	21
Eggs							
In paddy soil	464	72	0	0	0	0	0
In terrace soil	426	204	237	187	190	163	176

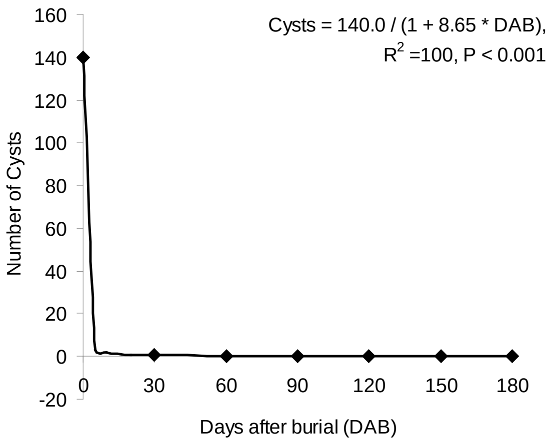

Figure 7.29 Decline equation for PCN cysts buried in highland paddy soils on the Dieng Plateau, CJ, in the absence of a host. (A5 F6.3.2).

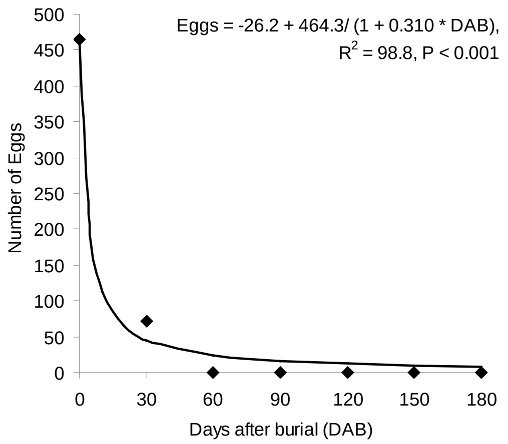

Figure 7.30 Decline equation for PCN eggs buried in highland paddy soils on the Dieng Plateau, CJ, in the absence of a host. (A5 F6.3.3).

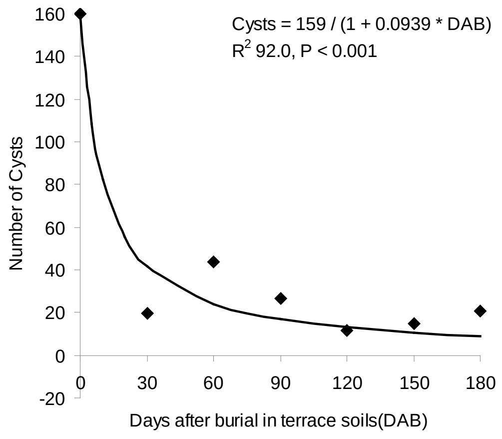

Figure 7.31 Decline equations for PCN cysts buried in highland terrace soils on the Dieng Plateau, CJ, in the absence of a host. (A5 F6.3.4).

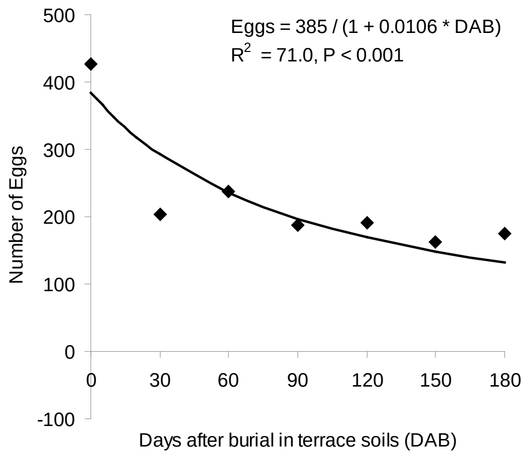

Figure 7.32 Decline equations for PCN eggs buried in highland terrace soils on the Dieng Plateau, CJ, in the absence of a host. (A5 F6.3.5).

7.2.5 Potato post-harvest studies Indonesia

A post harvest specialist visited members of the potato and vegetable supply chain to ask their opinions about post-harvest handling and to observe current practices.

For seed potatoes there was a gap in the knowledge of physiological aging of the seed tubers. Extension information was prepared to fill this knowledge gap.

Potato stores inspected were all ambient temperature stores open during the day which allowed warm air to enter. Temperatures measured of tubers in stores were 28 to 31°C. The storage conditions could be easily improved with management changes. Better management would have the stores closed during the day and opened at night with fans used to ventilate the stores with cool night air. Structural changes would benefit many stores. Vents should be closed during the day and open at night. Ideally inflow vents in stores should be placed low to allow cool night air to replace the warm air which should escape through fan assisted roof ventilators. The tubers should be stored in trays on racks to allow improved ventilation and access for grading and sorting. They should allow filtered (diffuse) light in. A plan for a simple but improved cool store was provided in the extension material prepared.

Imported seed should be not be kept in an ambient store as this seed has previously been cool stored and will commence sprouting when warm. The rapid growth of shoots in the dark stores leads to rapid dehydration and physiological aging of this seed. Suitable cool store facilities were identified.

Table potatoes were observed to be harvested immature before their skins had hardened. They are then packed and transported in 65 - 70 kg sacks. Traders reported rots and damage to be a problem. Improved out-turns should result from harvesting the potatoes when they are mature, keep them as cool as possible and transport them to markets in rigid plastic crates.

7.2.6 Potato post-harvest studies Australia

Varietal differences in bruising response to impacts

Bruising response of varieties to drop height and the IS G force calibration to drop height was determined (Appendix 6, Figures 6.1 to 6.3). This allowed the relationships between the G force recorded by the IS and tuber damage of Atlantic and Granola to be determined (Figures 7.33 and 7.34). These relationships show that Atlantic is more susceptible to bruising with tuber damage occurring above 50 G while Granola was more tolerant with tuber damage only occurring after impacts of 200 G were reached.

Crop harvest and post-harvest measurements

Atlantic

Combined data for Atlantic harvests shows an average of 18 harvest runs and 15 bunker drops were measured per farmer (Table 7.25). The average temperature was 11.7 °C. The bruising of the Atlantic tubers can be predicted from these results using the equations shown in Figure 7.33. Predicted percentage of tubers bruised was 4.0% with a range from 1.9 to 6.7%.

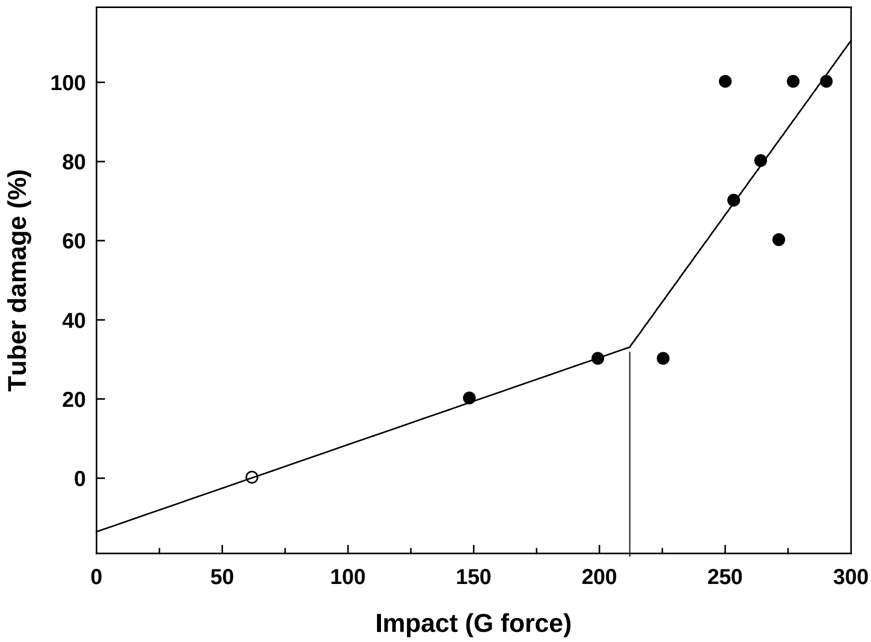

Figure 7.33 Relationship (2 split lines) between tuber impact (G force) and % bruising in Atlantic tubers with a pulp temperature of 15°C. The vertical line intercepts the x axis at the level of impact (212 G) above which significant tuber damage is first observed (threshold). Equations:

for line 1; $y = 33.1 + 0.22 (x - 212)$ where $x < 212$ and

for line 2; $y = 33.1 + 0.88 (x - 212)$ where $x > 212$ ($R^2 = 0.7$). (A6 F6.4)

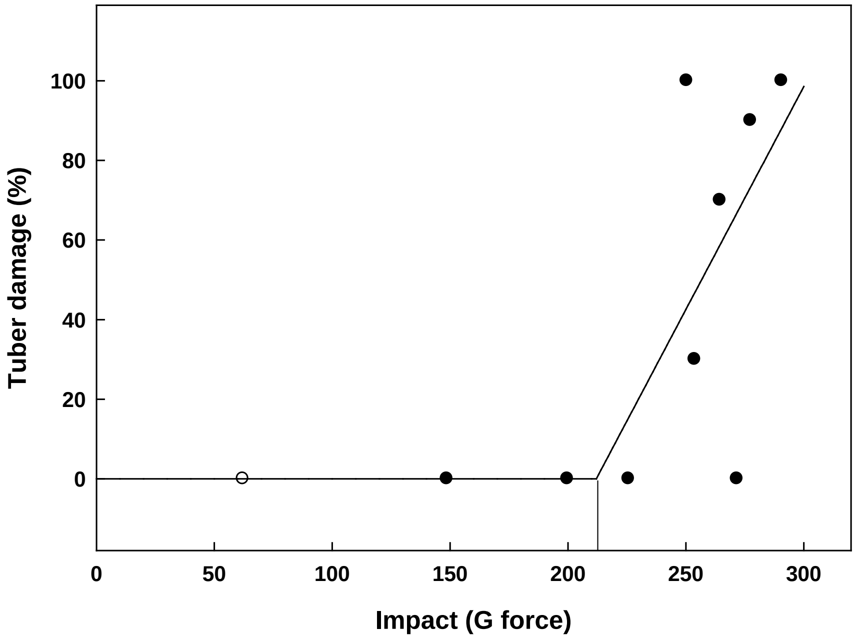

Figure 7.34 Relationship (2 split lines) between tuber impact (G force) and % bruising in Granola tubers with a pulp temperature of 15°C. The vertical line intercepts the x axis at the level of impact (212 G) above which tuber damage is first observed (threshold). Equations:

for line 1; y = 0 where x < 212 and

for line 2; y = 1.12 (x - 212) where x > 212 (R^2= 0.30). (A6 F6.5)

Table 7.25 Instrumented sphere harvesting measurements of 5 individual Atlantic crop plus mean values during harvesting. The average acceleration is used to predict the percentage of tubers bruised using the equations shown in Figure 7.33. (A6 T6.3a)

Measurement	**Crop**					**Mean**
	1	**2**	**5a**	**5b**	**6**	
Harvester						
No. runs	20	23	12	16	20	18
No. impacts > 50 G	16	22	6	9	42	15
No. imp > 50 G/run	0.8	1.0	0.5	0.6	2.1	0.8
Bunker						
No. runs	21	17	22	15		15
No. impacts > 50 G	42	20	20	10		10
No. imp > 50 G/run	2.0	1.2	0.9	0.7		1.2
Combined Harvester and bunker						
No. impacts > 50 G	58	42	26	19	42	37
No. imp > 50 G/run	1.4	1.1	0.8	0.7	2.1	1.2
Average impact (G)	81	82	74	77	92	81
Predicted bruise % (From Fig 7.32)	4.3	4.5	2.7	1.9	6.7	4.0
Tuber harvest temp (°C)	18.4	12.4	8.4	8.4	11.1	11.7

Granola

The Granola data shows of the 22 harvest runs (Table 7.26) the average time taken for the IS to travel through the harvester was 52 seconds and the temperature was 11.1 °C. The bruising of Granola tubers can be predicted using the equations shown in Figure 7.34. Predicted percentage of tubers bruised was 0%.

Table 7.26 Instrumental sphere harvesting measurements of one Granola crop during harvesting. The average acceleration is used to predict the percentage of tubers bruised using the equations shown in Figure 7.34. (A6 T6.3b)

Measurement	**Crop 4**
Harvester	
No. runs	22
No. impacts > 200 G	0
No. imp > 200 G/run	0
Bunker	
No. runs	
No. impacts > 200 G	0
No. imp > 200 G/run	0
Combined Harvester and bunker	
No. impacts > 200 G	0
No. imp > 200 G/run	0
Bruising of sample (%)	60
Predicted bruise % (From Fig 7.33)	0
Tuber harvest temp (°C)	11.1

Crop verse G force > 50

There were significant differences between farmers and the combined number of impacts greater than 50 G per run for the harvester and bunker drops (P = 0.001) (Figure 7.35). Crop 6 had significantly higher number of impacts > 50 G than any other crop with 2.1 impacts, followed by crops 1 (1.4 impacts) and 2 (1.1 impacts). Crops 3 (0.4 impacts), 4 (0.4 impacts) and 5 (0.8 and 0.7) impacts were not significantly different to one another but were significantly lower than crops 6, 1 and 2. Crop 5b used the same machinery as crop 5a; the difference was a faster harvester driver. The predicted bruising for these crops was 1.9% and 2.7% respectively showing that the operator is a major factor in bruise incidence.

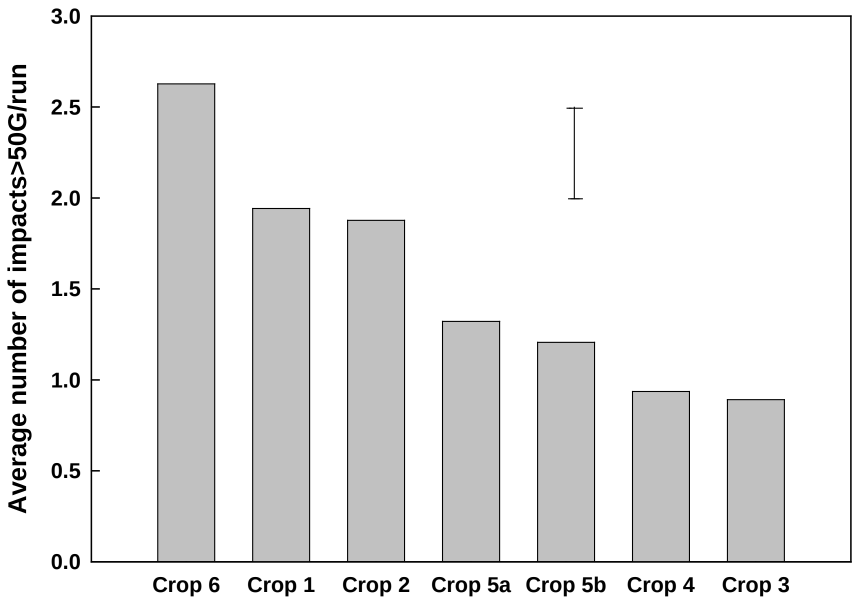

Figure 7.35 The average number of combined impacts > 50 G per run for all crops. LSD = 0.53. Average number of impacts > 50 G was significantly lower in crops 5, 4 and 3 compared with crops 6, 1 and 2. (A6 F6.7)

Bunker versus harvest.

There is a significant difference between the number of impact events greater than 50 G at the bunker drop compared with the harvester impacts for all crops (P = 0.039) (Appendix 6, Figure 6.8). The bunker to bin drop averaged 1.2 impacts of > 50 G every drop whereas the harvester only averaged 0.89 impacts > 50 G every run.

Actions to reduce bruising

Seed potato farmers in WA have several options available to minimise the bruising seen on tubers. The first is to assess impacts by using an IS and to make adjustments to machinery to reduce the size and number of these impacts through physical modifications to their machinery or through refinement of the operating settings. We found an IS assessment of a harvester takes approximately 3 hours. Other ways to minimise damage include removing as much soil as possible on the primary chain and loading the rear cross, elevator and boom chains to capacity so that tubers cushion each other (Blaesing and Kirkwood 2004). Removal of soil on the primary chain is a plausible option for seed potato farmers in WA using any one of the three machines examined in this study; it would just require the machine operator to be closely aware of soil moisture content, soil texture and weeds. A more difficult task would be to ensure the chain capacity of tubers as this requires training harvester operators, many of whom are casual backpacker workers, in maintaining chain speed in the harvester whilst determining the optimum level of tubers on the chains and continuing to sort the tubers.

7.2.7 Partial seed system to augment Indonesian certified seed

Indonesian farmers obtain seed from the following sources:

- government certified seed potato system,
- imported seed,
- private sector tissue culture seed and
- informal seed where the tubers produced by farmers outside the formal regulated seed production sector are saved for their own seed use

A review of Indonesian seed sources was prepared (Appendix 7) and it found the following important short comings.

1. Only the informal seed meets demand. The government certified seed and the private tissue cultured seed require field bulking. In Indonesia the certified seed is produced in major potato production centres. There is no protective isolation from other potato and Solanaceous crops and rotations. Suitable land is scarce and rotations are of insufficient length to reduce pest and disease build up. Imported seed cannot meet demand because importers cannot obtain import permits for Granola seed (Iwan Gunawan, personal communication).
2. The government certified seed and the private sector tissue culture seed do not provide adequate protection against the spread of PCN. Although fields are tested for PCN before seed can be accepted for certification by the Agency for Seed Control and Certification (BPSB), the test for PCN will only detect this pest after it has built up to relatively high levels. By this time the pest would have been spread via the seed produced from previous crops in the field when the pest was present but undetectable. The rotations used in seed production in Indonesia are too short to protect against the build up of PCN if it is inadvertently introduced to the seed areas. Imported seed from areas known to be free of PCN and which have long rotations will provide seed with the lowest risk of introducing and spreading PCN. Imported seed may also be the only short term source of varieties resistant to the strain of PCN found in Indonesia. Three populations of PCN have been identified to species and race) and they were found to be *Globodera rostochiensis* Ro2 (Tables 7.22 and 7.23). This pathotype is uncommon but has been found in New York State in the United States of America (Halseth 2006) and there is a potato breeding program developing resistant varieties to PCN Ro2 at Cornell University in New York.
3. In “1’ above it was noted that there is no protective isolation from other potato and Solanaceous crops like chilli and tomato and that rotations are of insufficient length to reduce pest and disease build up. This means that the degeneration rates of field multiplied seed in Indonesia are high.
4. The cost of seed is high. Imported seed was the most expensive at Rp 6,000 to 13,000 per kg but government certified seed was also costly at around Rp 7,000 to 8,000 per kg even though it is subsidised.

The short comings in the seed sources are due to the adoption of systems not suited to Indonesian conditions rather than to the execution of these systems. The government certified seed system has been based on a system developed for temperate areas with isolation and long rotations between potato crops and low vector levels to ensure low seed degeneration rates. To supply quality seed from areas with high degeneration rates the number of field multiplications must be limited. It is also beneficial to reduce degeneration rates with careful site selection and the production of varieties resistant to the main causes of degeneration.

There is an opportunity to increase the supply of high quality potato seed in Indonesian by augmenting the Indonesian government certified seed supply system with a partial seed program. Partial seed programs have been devised to overcome the problems of seed production in areas of high degeneration where 3 to 4 field generations are not possible without seed degradation (Struik & Wiersema 1999). Partial seed schemes are based on imported seed which is multiplied for a limited number of generations in isolated areas where seed quality can be kept at a reasonable level. The requirements of a partial seed system are described by Struik & Wiersema (1999). They are:

- good farmers’ organisations to multiply the seed,
- selection of an appropriate imported seed class according to number of in-country multiplications required,

- physiological age of the imported seed must suit planting time,
- field multiplications need to be supervised under a quality control system,
- one field generation only until seed farmers have gained experience in the production of good quality seed,
- monitoring of customers'(ware farmers') response to seed produced,
- modification made to the system after considering the experience of seed farmers and seed buyers.

These requirements for a partial seed program can be met in Indonesia if the partial seed system is based in the Sembalun Valley of NTB imported seed from PCN free areas of Australia. Imported Granola seed would be cool stored after arrival in Indonesia to prevent deterioration while quarantine checks are carried out. The seed would then be multiplied once in the Sembalun Valley which has medium seed degeneration rates compared to the high degeneration rates found in Java (See Section 7.2.3 sub section NTB s*eed sources 2010*). PCN has also not been found in the Sembalun Valley (Table 7.21). The once-grown seed would be used to supply PCN free areas of eastern Indonesia. This additional supply of PCN free seed will help to stop the spread of PCN and so prolong the use of the susceptible varieties Granola and Atlantic. It is expected that this partial scheme could provide lower priced seed compared to imported seed with only slightly reduced quality. It will increase the supply of PCN free high quality seed to Indonesian potato farmers.

Currently the Sembalun Valley produces Atlantic potatoes for Indofood-Fritolay with crops grown on highland paddy soils from May to October. This is done through a partnership between the company and the farmers' group Kelompok Horsela. Indofood-Fritolay supply some cropping inputs, like Atlantic potato seed from Canada and Australia, and capital to buy chemical fertiliser and pesticides through Kelompok Horsela management group, the costs of which are repaid by the farmers after harvest. The Horsela Farmers' Group management guarantee in return the quality target that's requested by PT Indofood. Kelompok Horsela is a well organised group that has successfully supplied Indofood-Fritolay for four years.

Seed production could be carried out in conjunction with the processing crop. There is sufficient area as there are 1,105 ha of paddy soils with only 15% used for potato production in 2010. The processing crop would have to be grown to seed standards but as this crop already uses imported seed this requirement should be easily met.

More detailed explanation of aspects of this partial seed scheme follows.

PCN protection

This partial seed scheme will provide better protection against the spread of PCN than other schemes operating in Indonesia. The relatively new potato area of the Sembalun Valley only produced small amounts of potatoes up to 2006; for example just 131 ha was grown in 2001 and production ranged from 28 to 44 ha in the four years to 2005. Since then farmers have started growing the potato variety Atlantic on a larger scale for Indofood-Fritolay. The Atlantic crops have been planted with imported seed from PCN free areas supplied by Indofood-Fritolay. The small size of the Sembalun Valley means that it is feasible for a partial seed program to be based there as all seed could be replenished annually from a clean imported source.

PCN has not been found in the highland Sembalun Valley on the Island of Lombok in NTB. Evidence for this came from a PCN soil survey which was undertaken from July to November 2008. Soil samples were taken on an intensive 3 x 3 pace grid. From a total of 454 samples examined, no cysts of PCN were found in the potato cropping area of Sembalun (Table 7.21).

The Sembalun Valley is characterised by the production of dry season potatoes in paddy fields following the wet season highland rice crop harvest. This is a key feature because this cropping system gives good protection against PCN because the flooding rapidly kills cysts with none being detected after 60 days (Table 7.24, Figure 7.29). The cysts and eggs seem to be very susceptible to breakdown and death in flooded condition. In comparison the number of the cysts in terrace soil did not decline as rapidly with eggs in the terrace soil still detectable after 180 days (Table 7.24, Figure 7.32). The preceding rice crop which is flooded for 3 months will therefore provide good protection against PCN because any cysts or eggs introduced to the site will be killed. If only seed from PCN free areas is introduced to the Sembalun Valley the area will remain free of the pest. An annual potato cropping program on these soils will have low risk of spreading PCN.

Reduced degeneration

If the partial seed scheme is based on one field bulking in the Sembalun Valley then the seed produced will have less degeneration than the G4 government certified seed which is in short supply. The imported seed would be grown in WA where G4 infection rates are less than 1% (Holland & Spencer 2009) and where conditions have been recognised as being the best in the world for disease free seed bulking (Schmiediche quoted in Dawson *et al.* 2003). This seed is once-grown at Sembalun where degeneration rate is moderate compared with Java. Evidence for this is that Atlantic farmers in Java report degeneration rates are high with virus levels increasing from 0.5% to 60% of plants in one season (Appendix 11, Section 6.2.6). In the Sembalun Valley degeneration rates for Atlantic are moderate with 12% infection in once-grown seed (See Section 7.2.3 sub section *NTB seed sources 2010*). Also in the Sembalun Valley only 11% of the sites had aphids compared with 53% in CJ and 44% in WJ. (Appendix 1, Table 6.8).

The likely outcome is illustrated in Figure 7.36. Under the high degeneration rates of Java one field generation planted with G2 government certified seed with 0.5% virus infection will end up as G3 with 60% infection. Whereas imported seed bulked once in the Sembalun Valley which has a moderate degeneration the seed will end up as G5 with 12% infection. The degeneration rate in the Sembalun Valley could be expected to drop once its processing farmers were trained in seed production techniques.

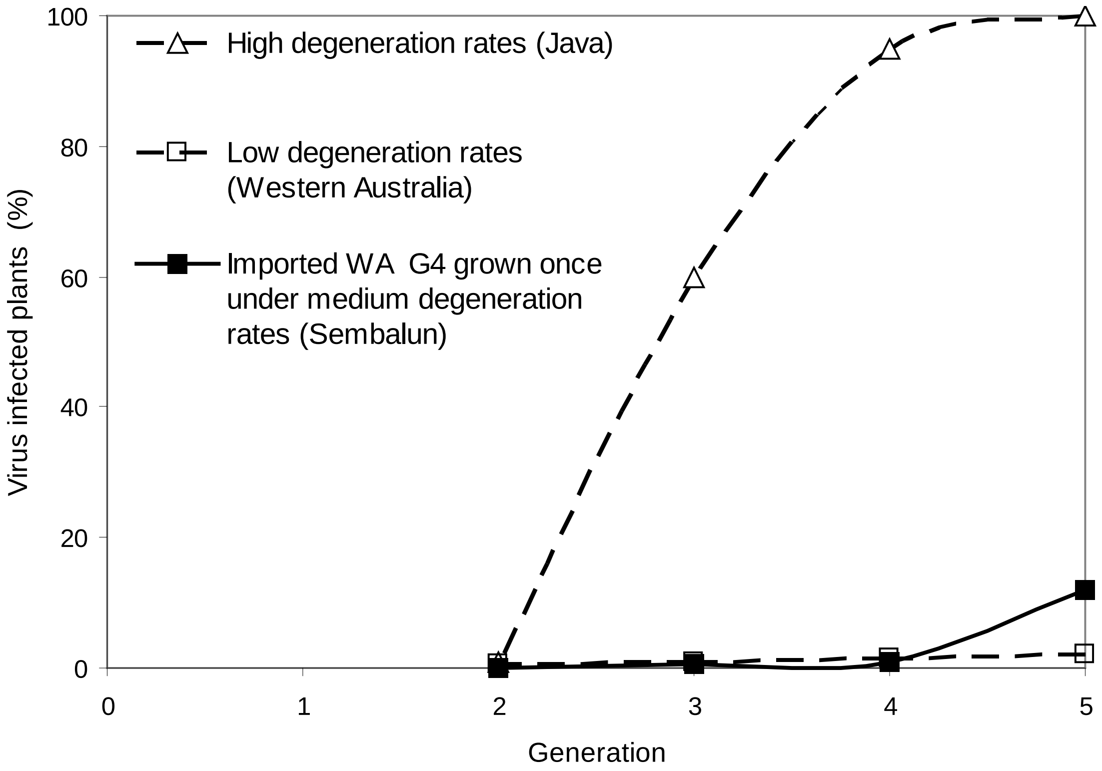

Figure 7.36 Estimated virus infection of Atlantic seed sources grown under different degeneration conditions. Under high degeneration conditions of Java the virus infection of Atlantic reaches over 60% in G3, the first field generation. If the Atlantic is grown from imported G4 seed where the infection is less than 1% and then under a medium degeneration rate of 12% as found at Sembalun then the G5 will have 12% infection. This is better quality than the G3 Indonesian seed which is already at 60% infection. (A7 F1).

Reduced cost

A partial seed program should be able to provide seed at a lower price than imported seed. An average gross margin for Atlantic processing crop grown at Sembalun from imported seed was compiled for the economic baseline survey (Table 7.5). This gross margin has been used to develop gross margins for hypothetical once-grown imported Granola seed production at Sembalun (Table 7.27). It is assumed that half the Granola production will be seed size and sold at seed price while the remainder will be sold as wares. Granola production costs are assumed to be similar to Atlantic. However cool storage costs for holding seed before planting and for storing one third of the seed produced are included for the Granola enterprise. Seed price is set at twice the Indofood-Fritolay price of Rp 2,700 per kg. To ensure that the once-grown seed is available for a range of planting times the budget allows for the cool storage of one third of the seed produced. These costs would be passed on to the seed buyer and amount to Rp 7,300 per kg for 6 months storage. This may mean that seed cool stored for 6 months may have to be sold at the high price of Rp 12,700 per kg. This price is more expensive than freshly imported seed but cool storage will supply seed ready for planting in March and April when imported Granola seed from Australia is not available and when alternative Indonesian seed supplies have a risk of introducing PCN.

The gross margin for the Atlantic processing crop is Rp 16.1 million per ha based on a sale price of Rp 2,700 per kg. The Granola seed/ware crop based on a seed price of Rp 5,400 per kg (twice the ware price of Rp 2,700per kg) with 50% of sales as wares at Rp 2,700per kg produces a gross margins of Rp 44.1 million per ha which is nearly three times higher than the Atlantic gross margin.

Table 7.27 Gross margins for Granola once-grown imported seed production at Sembalun based on Table 7.5). It is assumed that half the Granola production will be seed size. The yield and costs of Granola are assumed to be similar to Atlantic. However cool storage costs for holding seed before planting and for storing 1/3 of seed produced after harvest are included for the Granola enterprise. Seed price is set at twice the Indofood price of Rp 2,700per kg. (A7 T5).

Budget item	Atlantic for Indofood	Granola 50:50 ware & seed & 1/3 seed cool stored
	(Sale prices shown in bold)	
Yield (t/ha) – processing or ware	21.02	10.5
Price (Rpper kg)	**2,700**	**2,700**
Income (Rp/ha)	56,757,817	28,378,909
Yield (t/ha) – seed shed stored	0	7.0
Price (Rpper kg) (2 x 2,700)		**5,400**
Income (Rp/ha)		37,838,545
Yield (t/ha) – seed cool stored	0	3.5
Price (Rpper kg) (2 x 2700 + 7,300 cool store cost)		**12,700**
Income (Rp/ha)		44,495,326
Total income (Rp/ha)	56,754,000	110,712,779
Costs (Rp/ha unless shown otherwise)		
Seed (cost per kg)*	10,500	9,450
Seed	21,564,471	19,408,024
Seed cool storage (imported seed before planting)	0	2,464,511
Fertiliser	3,716,338	3,716,338
Pesticide	7,940,392	7,940,392
Labour	6,258,650	6,258,650
Other	1,203,761	1,203,761
Cool storage 1/3 seed produced (Rp 7,300 kg for 6 months)	0	25,576,053
Total costs	40,683,612	66,567,729
Gross Margin (Rp/ha)	16,074,205	44,145,050
(AUD/ha) (Rp 8990 = AUD1.00, 2 Mar 2011)	1,788	4,910

* Cool stored seed price is reduced as there will be less waste.

This partial seed method is a way to improve quality seed supply at a lower cost to freshly imported seed which has already been shown to work in Indonesia (Dawson *et al.* 2004). Sembalun offers several other advantages in that it is small and isolated and its whole area can be planted with fresh imported seed every year. However the potato farmers in the Sembalun Valley are new to seed potato production and there needs to be development and training to enable them to reap the full potential of their situation.

Development required for the Sembalun Valley to host a partial seed program

The Sembalun Valley was shown to be free of PCN in November 2008 and its paddy soils were shown to be able to prevent the establishment of PCN (Table 7.24, Mulyadi *et al.* 2010) so the area has the potential to become PCN free seed production area. The interest in potato production at Sembalun has led to a minority of farmers, maybe 15 out of 220, bringing in uncertified seed from Java in 2009 and planting it in the wet season away from the paddy fields on sites that will be susceptible to PCN. There needs to be measures introduced to prevent this happening and to maintain the Sembalun Valley's freedom from PCN. In addition a seed potato scheme needs to be introduced. Actions required to support the development of a partial seed scheme in the Sembalun valley are:

- Introduction of seed production rules. Dinas Pertanian NTB and Kelompok (Tani) Horsela (Horticulture Sembalun Lawang) need support to develop seed production regulations for Sembalun. These must include appropriate rotation times, locations (periodically flooded soils) and ongoing testing to ensure claim of PCN freedom can be justified.
- Planned seed production to ensure local seed supply meets demand. This strategy is recognised to be a more practical defence than quarantine laws against the spread of disease (Crissman 1989). AIAT NTB should help Kelompok Horsela ensure demand for seed potatoes can be met from local certified seed potato production. This must include improved storage for both imported and locally produced seed potatoes.
- Improved storage to assist with maintaining quality of local seed so that it is available from February to October.
- Obtain Ministry of Agriculture support for the scheme to enable import permits for Granola seed to be obtained.
- Development of provincial regulations restricting the movement of potatoes into the Sembalun Valley other than official seed potatoes from PCN free areas.
- Assistance with marketing of seed to PCN free areas with planting times that suit the p-age of the seed produced. Assist farmers obtain credit to support the partial seed scheme.
- Monitor the performance of the seed crops in the Sembalun Valley and the performance of this once-grown seed in other regions to determine the efficacy and success of the partial scheme.

Partial seed scheme conclusions

The unique conditions of the Sembalun Valley make it a suitable candidate to be the base for a partial seed scheme to augment the Indonesian government's certified potato seed supply scheme for the following reasons:

- The area has been surveyed for PCN and none was found;
- The major potato production takes place in the dry season on paddy soils. These periodically flooded soils provide protection against the establishment of PCN;
- The area has moderate degeneration rates which are an advantage over the high degeneration rates found in Java;
- The area grows processing potatoes using freshly imported seed every year;
- The area has additional capacity to produce potatoes on the paddy soils. A partial seed scheme would complement the current processing production;
- The costs of the seed will be lower than for imported seed while the Sembalun seed farmers will increase their income compared with their processing crops.

However the horticulturist group will need:

- training in seed potato production and seed marketing;
- government permits to import Granola into NTB, and
- assistance in obtaining credit to support the venture.

This opportunity offers a feasible means to increase the supply of high quality potato seed at a lower cost than freshly imported seed. If successful this model could be used as a model to expand the partial seed scheme to other areas of Indonesia.

8 Impacts

Farming, social, and community impacts of the project were assessed by farmers themselves at the Farmer Conference (Appendix 13) and by LPTP through their social impact study (Appendix 14). Economic impacts were also assessed by estimating the economic benefits that could be derived from outcomes of FIL activities. Results of these assessments are summarised below. First the impact of scientific findings from the results section is presented.

8.1 Scientific impacts – now and in 5 years

The species of PCN sampled from East Java, CJ, and WJ was identified as *Globodera rostochiensis* pathotype Ro2. This is the first time that we know of that this pest has been identified to pathotype in Indonesia. The identification of pathotype is important for managing PCN as it allows resistant potato varieties to be identified. The Ro2 pathotype is uncommon but has been found in New York State in the United States of America (Halseth 2006) where there is a potato breeding program developing resistant varieties to PCN Ro2 at Cornell University.

The rapid decline of PCN cysts and eggs under the flooded conditions of highland paddy soils shows that these situations will protect against the introduction and establishment of PCN. These highland rice areas may therefore be valuable sites for dry season seed potato production.

The rapid decline of PCN cysts and eggs under the flooded conditions of highland paddy soils may not be solely due to abiotic factors such anaerobic conditions. There could be biotic factors contributing to the decline of cysts and eggs, the elucidation of which could provide new methods of managing this pest.

The DBM natural enemy complex investigated has the potential to form the cornerstone of an IPM program. Research showed that: *Diadegma semiclausum* can be an extremely effective natural enemy of DBM; the predator complex of foliar and soil dwelling spiders and beetles causes significant pest mortality; current insecticide use patterns disrupt natural enemy populations.

8.2 Capacity impacts – now and in 5 years

8.2.1 Farming knowledge and skills

The LPTP Social Impact Study (Appendix 14) concluded that the presence of ICM FFSs since 2007 followed by FIL has been beneficial to group members and nearby villagers, not only in terms of increased knowledge and experience, but also in improving potato and cabbage farming production yield. FIL member farmers' knowledge has increased significantly; all of the respondents interviewed said their farming knowledge had increased.

Many farmers admitted that before taking part in FIL they used pesticides excessively including mixing different pesticides together. They did not monitor pest levels but sprayed at first signs of pest infestation. Some farmers would always spray pesticides even though there were no pests or diseases on their crops for prevention. Each season, farmers would use an average of 50 - 60 kg/ha with a spraying interval of 2 - 3 days. Excessive pesticide use was documented in the baseline surveys (Figures 7.3, 7.5, 7.6 upper, 7.16).

Knowledge of pest management increased through the life of the project, particularly in pesticide use. Farmers reported that pest and disease control decisions were now based on the results of monitoring the crop for pests and diseases so pesticides are now used more selectively and carefully. Before the project farmers would mix several pesticides together in the hope of obtaining better control. They now understand that one carefully selected active ingredient that is effective against the target gives better and cheaper control than *ad hoc* mixtures of on-hand pesticides. Farmer's knowledge of applying the correct dose with a properly calibrated sprayer also improved during the project. Mixing of agricultural chemical was reduced with the understanding of the active ingredients and the knowledge that rotating different active ingredients was better. Now pesticides use is reduced to 20 - 25 kg/ha in a season. Almost all FIL member farmers in all four provinces said their earnings had increased with reduced outlay for pesticides. Pesticide expenditure on average has fallen from Rp 15 million per ha to a current average of Rp 8 million per ha, meaning a reduction of Rp 7 million due to fewer and more directed pesticide applications. Pest savings were confirmed by at the Farmer Conference (Section 8.3.1 below) with one farmer group quantifying cost savings as Rp 3.2 million per ha.

Farmers' knowledge of fertiliser application has also improved. Farmers were now aware of the benefits of using composted organic fertilisers. It was reported that some groups now used increased amounts of organic fertiliser and more regular applications of chemical fertiliser. Now they can produce their own PGPR. In their opinion, PGPR can increase plant growth and control diseases, resulting in slightly less expenditure for pesticides and fertilisers.

Increased knowledge of the importance of correct soil pH for vegetable production meant that farmers now measured soil pH before planting and applied lime if needed.

Seed selection skills have improved. Farmers usually bought seed potatoes from the market or from other farmers, which then would be planted repeatedly. When they got good seed, their harvest yield would increase, but it was not uncommon for yield to fall due to diseased seed also being planted. Farmers can now select seed by themselves. They recognise the characteristics of good seed and now sort before planting. Farmers reported that the use of certified seed had increased as their knowledge of its benefits grew. Benefits were; reduced risk of introducing pests like PCN, reduced virus levels and more vigorous growth.

Two groups reported that planting density had been reduced. One group reported planting density had been reduced from 25 x 75 cm (53,333 plants per ha) to 35 x 60 cm (35,714 plants per ha). This change was made to allow for better PLB control through having a more open canopy which allowed faster drying after rain and better fungicide penetration and coverage. The change also meant that the cost of seed was reduced.

Farmers were more aware of PCN and now considered the risk posed by this pest. Farmers were more aware of on-farm biosecurity measures that can be taken to reduce the risk of introducing this pest.

Adoption of simple FIL experimental methodology will increase the capacity of farmers to assess the value of management changes. During the field school processes, farmers were taught how to conduct simple experiments that they could apply in their own fields. Though not all FIL member farmers conducted experiments, others have developed experiments of their own. The emergence of researcher farmers in the program regions will certainly be a positive influence on neighbouring farmers. Simple trials developed by farmers include variety trials, fertiliser application trials, natural pesticides trials, etc. Indirectly, farmers' capacity to carry out simple research is increasing. They no longer believe others who offer farming products without trials to prove their effectiveness. Many farmer researchers have emerged in all four provinces.

Farmers were able to do their own enterprise management. This meant that they could make better decisions on management inputs as well as having an understanding of the costs and returns and what level on investment was appropriate for their crop inputs. There have been changes in the way villagers use the proceeds from their harvest yield. The proceeds of harvest production sales were usually used to meet families' everyday needs. However, since participating in FIL, some families put aside a certain amount as farming capital for the following season.

FFS members' initial apathy has gone after gaining knowledge from participating in the project's potato and cabbage FIL. Capacity impacts however are not restricted to members of FIL as many non FIL farmers now ask for members' opinions on certain matters. FIL members report that many other farmers want to copy what they have learned from FIL. Farmers usually learn from what they see from others around them, so farmers participating in FIL could become examples and direct them towards profitable potato and cabbage farming in their communities.

8.2.2 Changing FFS methodology to FIL

A modification to the methodology of FFS was implemented. The aim was to enable farmers to assess the impact of a single management change. Previously the highland vegetable FFS had compared an ICM plot versus a conventional plot which resulted in a range of management differences between plots which made identifying the cause of improvements in profits between the treatments difficult.

The new method focussed on the development of simple but robust experiments designed to allow farmers to test new management techniques. Information to support the implementation of these experiments was contained in publications called Technical Toolkits which were produced for both potatoes and cabbage (DAFWA 2010a & b). These were aimed at FFS guides or facilitators. The PTT and CTT contain supporting information about how simple experiments can be set up, standard operation procedures (GAP) for the crops, background information on the topics suggested for experimentation, tally sheets required for the collection of crop growth, yield and profit data. The standardisation of simple experiments as detailed in the Technical Toolkits meant that collaborating farmer groups could add rigor to their results by pooling data to allow statistical analysis of their results. This was achieved by the most successful groups.

The new methodology was called FIL to identify this different, simpler method of participatory learning. FIL provides, for the first time, a valuable tool for Indonesian highland vegetable farmer groups to independently assess new management techniques. This was recognised by farmers at a FIL review meeting where one group stated that the benefit of FIL was "Menciptakan petani yang mahir dan mandiri" (the creation of self-reliant expert farmers).

8.2.3 Crop management

Farmers from SS, WJ and CJ have reported they are already adopting the project's PLB management recommendations of alternative applications of appropriate systemic then contact fungicides, with better disease control and reduced input costs.

Farmers have also reported that they are now measuring soil pH to decide whether lime application is required.

8.2.4 New seed production plan

The unique conditions of the Sembalun Valley of NTB make it a suitable candidate to be the base for a partial seed scheme to augment the Indonesian government's certified potato seed supply scheme for the following reasons:

- The area has been surveyed for PCN and none was found;
- The major potato production takes place in the dry season on paddy soils. These periodically flooded soils provide protection against the establishment of PCN;
- The area has moderate degeneration rates which are an advantage over the high degeneration rates found in the potato seed growing areas of Java;
- The area grows processing potatoes using freshly imported seed every year;
- The area has additional capacity to produce potatoes on the paddy soils. A partial seed scheme would complement the current processing production;

- The costs of the seed will be lower than for imported seed while the Sembalun Valley seed farmers will increase their income compared with their processing crops.

However the horticulturist farmer group will need:

- training in seed potato production and seed marketing; and
- assistance in obtaining credit to support the venture.

This opportunity offers a feasible means to increase the supply of high quality potato seed at a lower cost than freshly imported seed. If successful this scheme could be used as a model to expand the partial seed scheme to other areas of Indonesia.

8.2.5 Seed handling in Australia

Seed potato farmers in WA can now assess harvest impacts to seed potatoes by using an IS. This will enable them to test whether adjustments to machinery and operating settings to reduce the size and number of impacts.

8.2.6 Integrated pest management

Through her research Bu Rini Murtiningsih has acquired ecological experimental skills which have improved IVEGRI's capacity to investigate the impact of natural enemies on Brassica pests. She is further investigating the impact of natural enemies as a PhD candidate at University of Queensland supported by a John Allwright fellowship.

8.2.7 PCN

New methods were used in PCN cyst population experiments which have increased the capacity of UGM to do applied research of direct benefit to the Indonesian potato industry.

The identification of the Ro2 pathotype of PCN should build the capacity of the Indonesian potato variety evaluation and breeding project by enabling them to target sources of resistance to this pest.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

Yield

At the Farmer Conference it was reported that yields had improved after adoption of project methodology. The example presented was an increase in yield from 8 t/ha to 26 t/ha. There was a concomitant increase of costs from Rp 25 million per ha to Rp 38 million per ha. This gave a before-project gross margin of negative Rp 5 million per ha while the post-project gross margin was positive Rp 27 million per ha. Assumptions used to arrive at these figures were that the potatoes were sold for Rp 2,500 per kg and the costs presented were the total variable costs. The net gain from this increased yield due to increased inputs was Rp 33 million per ha.

Input costs

Farmers reported that insecticide input costs were decreasing as a result of reduced pesticide use due to spraying decisions now being based on the results of crop monitoring rather than calendar spraying as occurred previously. One group was able to quantify the cost savings as Rp 3.2 million per ha. Before project methodology was adopted Rp 9.4 million per ha was spent and with project methodology this was reduced to Rp 6.2 million per ha. This echoes the findings of the LPTP Social Impact Study above where pesticide use has more than halved down to 20 - 25 kg/ha in a year with almost all farmers reporting their earnings had increased with reduced outlay for pesticides. Pesticide expenditure on average had almost halved to an average of Rp 8 million per ha, meaning a reduction of Rp 7 million due to fewer and more directed pesticide applications. However at the Farmer Conference one group reported spraying frequency had increased to 20 sprays compared with 18 previously but that the number of pesticides applied had reduced as farmers were no longer mixing several pesticides together every time they went to spray their crops.

Some farmer groups were reported to have begun making group purchases of agricultural inputs in order to increase their bargaining power with the suppliers. These group purchases had led to reduced input costs.

Marketing

It was reported that when farmers acted as a group to market their product they obtained better prices and conditions from their agents than when they acted alone. This was due to the increased marketing power enabled by their large amount of produce.

FIL groups have done a number of things to build better relationships with other organisations, including working with financial institutions to secure capital. They have worked with Bank Indonesia, to secure credit. So, indirectly, farmers have established networks with other parties.

Improved clubroot control

A project recommendation for clubroot control was the use of the resistant variety Maxfield with the application of lime to raise soil pH to 7.0 - 7.5. Experimental yields achieved by the Pemuda Tani Vetran farmer group of SS (Table 7.18) were applied to gross margins prepared for SS (Appendix 11, Table 6.2.2j), CJ and WJ (Table 7.13). The adoption for this management was estimated for 10 years into the future under both “with project” and “without project” scenarios. This allowed the annual value of project benefits to be calculated (Appendix 4, Tables 7.1 – 7.3). These annual benefits were used to calculate the PV of the benefits of the work. The analysis used an elasticity of demand of -2.5. The PV of project benefits from improved clubroot control in cabbage for SS, CJ and WJ area shown in Table 8.1. The PV was Rp 756 billion or AUD86 million (Table 8.1). When price elasticity was considered these values fell to Rp 89 billion or AUD10 million (Table 8.1). The benefits are large because the recommended treatment increased yield of cabbage by 150% (Table 7.18).

Table 8.1 Present value of project clubroot management recommendations of use of lime with the resistant variety Maxfield in South Sulawesi, Central Java and West Java. Present values with the current price and with a price elasticity of demand of -2.5 are shown. (A4 T8.1)

Province	Measurement and currency	Present value of benefits	
		Current price	Price elasticity of demand of -2.5.
SS	Present value of benefits Rp	19,704,393,166	4,041,768,851
	Present value of benefits AUD	2,251,931	461,916
CJ	Present value of benefits Rp	647,100,406,313	69,690,166,699
	Present value of benefits AUD	73,954,332	7,964,590
WJ	Present value of benefits Rp	89,271,390,218	15,715,216,519
	Present value of benefits AUD	10,202,445	1,796,025
Total	Present value of benefits Rp	756,076,189,698	89,447,152,069
	Present value of benefits AUD	86,408,707	10,222,532

PCN free seed supply for South Sulawesi

A key recommendation of the project is the establishment of a partial seed potato scheme system based in the Sembalun Valley of NTB. This system will provide a source of PCN free seed that could help to prevent the spread and introduction of PCN to areas where currently the pest is not found. The bulk of domestic seed comes from Java which has PCN and so there is a risk of PCN spread on potato seed from Java. If the project recommendations regarding establishing seed production in NTB are implemented and NTB seed is used by SS farmers, then this province may remain free of the pest. The PV of benefits of maintaining SS's freedom from PCN was calculated (Appendix 2, Section 7.1.3). The analysis compared two scenarios – the without the project scenario "PCN infestation" has PCN infesting SS and the with project scenario "PCN freedom" has SS remaining free from PCN due to use of clean seed from NTB. The rate of spread of PCN in the "PCN infestation" scenario is shown in Table 8.2. Likelihood of success for the project (chance of keeping PCN out of SS) is 90% while the attribution of benefits to the project are 80%. The discount rate is 7%. The present value of the project is gained through avoiding yield losses. A yield loss of 55% resulting from the spread of PCN leads to farmers only breaking even. The protection of SS from PCN provides a PV of benefits of Rp 33,566,061,230 or AUD3,836,121 (Table 8.2).

Table 8.2 Value of project PCN free seed supply for South Sulawesi. With the project adoption of PCN free seed from NTB commences in year 1 and the current gross margin of Rp 25 million per ha is maintained. Without the project South Sulawesi becomes infected with PCN via informal seed from Java. The rate of infestation is shown in columns 2 and 3. Infested areas have only a break-even gross margin of Rp -0.05 million per ha. The annual benefits due to the project are shown in the last column. These are applied to the NPV function in Excel with the discount rate shown to determine the discounted benefits. These are adjusted for project attribution and chance of success in the lower section of the table. (A2 T7.1)

Assumptions and constants:			
Yield before PCN (t/ha)	12.45	Yield loss	55%
Area of potato production (ha)	1,433	Discount interest rate	7%
GM without PCN (Rp/ha)	25,081,555	Ex rate (Rp/AUD)	8750
GM with PCN (Rp/ha)	-57,798		

Year	PCN infestation			PCN freedom		Project benefits
	Area affected		Gross margin A	Area affected	Gross margin B	= B - A
	%	ha	Rp/1,433 ha	%	Rp/1,433 ha	Rp
1	0	0	35,941,868,315	0	35,941,868,315	0
2	0	1	35,905,843,622	0	35,941,868,315	36,024,693
3	0	2	35,887,831,275	0	35,941,868,315	54,037,040
4	0	3	35,860,812,755	0	35,941,868,315	81,055,560
5	0	5	35,820,284,975	0	35,941,868,315	121,583,340
6	1	7	35,759,493,306	0	35,941,868,315	182,375,009
7	1	11	35,668,305,801	0	35,941,868,315	273,562,514
8	1	16	35,531,524,544	0	35,941,868,315	410,343,771
9	2	25	35,326,352,658	0	35,941,868,315	615,515,657
10	3	37	35,018,594,830	0	35,941,868,315	923,273,485
11	4	55	34,556,958,088	0	35,941,868,315	1,384,910,227
12	6	83	33,864,502,974	0	35,941,868,315	2,077,365,341
13	9	124	32,825,820,303	0	35,941,868,315	3,116,048,012
14	13	186	31,267,796,298	0	35,941,868,315	4,674,072,017
15	19	279	28,930,760,289	0	35,941,868,315	7,011,108,026
16	29	418	25,425,206,276	0	35,941,868,315	10,516,662,039
17	44	628	20,166,875,257	0	35,941,868,315	15,774,993,058
18	66	941	12,279,378,728	0	35,941,868,315	23,662,489,587
19	99	1412	0	0	35,941,868,315	35,941,868,315
20	99	1412	0	0	35,941,868,315	35,941,868,315
PV						Rp 46,619,529,487
PV with attribution 80%						Rp 37,295,623,589
PV with chance success 90%						Rp 33,566,061,230
PV AUD						$3,836,121

Improved potato late blight management

The value of the projects *systemic-contact-systemic* recommendations for PLB control was assessed for WJ and CJ. The analysis is based on benefits gained from wet season PLB control. The analysis focuses on the benefits of reduced costs to control PLB rather than increased yields. Assumptions are described in Section 5.10.3 *Benefit of improved potato late blight management*. Calculations are shown in Appendix 2, Table 7.2. The present value of project benefits for improved efficiency in PLB control was Rp 18.1 billion

AUD2 million) for both provinces. For CJ the PV was Rp 10.4 billion (AUD1,183,022) while for WJ it was Rp 7.7 billion (AUD883,795) (Table 7.2, Appendix 2).

8.3.2 Social impacts

Half of all other respondents interviewed also said that by taking part in FIL they had become more confident to voice their opinions. This courage to speak in public has led villagers to entrust various things to FIL members. Many farmer participants have felt that where previously they had been regular villagers, now they are often invited to take part in village planning:

- become committee members in village activities,
- Rumah Wilayah (small administrative unit) heads,
- Family Welfare Movement (PKK) heads,
- work team members in village conservation efforts,
- Rukun Tetangga heads (RT, lurah level),
- at least two farmers in each FIL group have become local facilitators, and have become more motivated to develop and progress their groups,
- Chair of the Farmer Water Users' Association (P3A), part of village administration in charge of regulating water use.

Some groups are now working together with village governments, as with their support, all group activities are more easily accepted. In some FIL locations, village officials have also become FIL participants. This helps the groups to use village facilities such as village halls and village land, etc.

The farmers reported that the ACIAR project had made farmers better appreciate the benefits that FIL groups could give them. Consequently they noted that attendance at FIL groups was better attended than previously.

They reported that the FIL groups strengthened relationships between farmers. This led the group decisions being made where previously individuals would have acted after only considering their own interests.

The success of the FIL groups had led to the establishment of independent (from the ACIAR project) FIL groups which are adopting FIL technology through diffusion of information through community and religious affiliations. Potato seed producing groups have emerged, for instance: the Bukit Madu, Trubus, Sekar Tani and Ngudi Luhur farmer groups in Banjarnegara District, and the independent study group in Tedunan Hamlet, Mlandi Village, Garung Subdistrict in Wonosobo. These seed potato production enterprises have succeeded in providing seed for their own members and other groups in the villages, and one in Gumelem Village, Petungkriyono Subdistrict, Batang District has even been supplying seed to others outside the district.

Independent groups have even emerged for farming inputs, such as the Manunggal farmer group in Tieng Village, Kejajar Subdistrict, Wonosobo, which provides and sells farming inputs and acts as a credit union for its members. Now it is looking into marketing both fresh and processed potato products.

In WJ, a number of independent groups have emerged, whose activities focus on FIL principles, i.e. the Jaya farmer group in Cisurupan Subdistrict in Garut District, and the Wargi Mandiri group in Bandung District. These farmer groups adopted technologies and learning processes in FILs before developing them into group activities.

Gender - Men's and women's roles

The majority of female farmers only help their husbands, and are only considered everyday homemakers, despite playing a significant role in farming. Generally, the levels of participation and capacity to secure work opportunities are still low for women. Men's and women's roles are clearly defined in farming management. Wives play a role in selecting seed, planting, harvesting and maintaining potato crops. Other roles are as homemakers, so in addition to working in the fields, they must also cook, prepare food and deliver it to their husbands working in the fields. Families usually teach their sons about farming; digging, planting, spraying etc. from an early age, and they become involved when they become adults. After following FILs, they also teach them to observe crops to detect signs of pest or disease infestations. Daughters' involvement in farming is usually at planting, weeding and harvesting times. The differences in men's and women's involvement in farming began when they were still small, and this has affected the knowledge passed down from parents to sons and daughters. A daughter will not be taught how to use a mattock or spray crops as those are a man's jobs. Women are only involved in the lighter jobs in farming. Men usually work much longer hours in the fields, departing in the morning and returning home at midday. Women, meanwhile, only work half days from 08:00 to 11:30 as they also have to work in their households, and cleaning their homes, preparing food, and looking after the children requires a lot of energy. The burden for farming women ultimately increases.

Gender - Men's and women's decision making

Interviews during the impacts study revealed that women have yet to become more involved in decision-making, and female farmers are rarely involved in making decisions relating to farming. Almost all respondents said that men made the decisions on when to spray, the types of crops, fertiliser application, etc. Nevertheless, in some places in Banjarnegara District, women are involved in discussions relating to farming, but ultimately, men make the final decisions. Decisions relating to harvest yield management and sales before FILs were always made by men. There have been some changes since FILs with men and women making decisions together in accordance with common considerations and agreements. However, this is only the case with a small percentage of FIL participants.

The proceeds of harvest production sales are usually used to meet families' everyday needs. Here women are the most dominant in determining how these proceeds are spent. However, since participating in FILs, some families put aside a certain amount as farming capital for the following season. There have been changes in the way villagers use the proceeds from their harvest yield.

Sprayer health and safety

It was reported that before the project the farmers were not concerned about the spray operators health and safety. During the project they become aware of the risks of applying pesticides and what steps could be taken to protect spray operators.

8.3.3 Environmental impacts

Farmers reported that they were more aware of environmental impacts of their farming activities as a result of project activities than they had been at the start of the project.

The lower, more selective and careful use of pesticides will indirectly improve environmental quality and of course influence the health of the farmers themselves. This will have a flow on effect to the environment as there should be a net reduction in the amount of pesticides applied.

8.4 Communication and dissemination activities

The main aim of the project was to increase the profitability of the potato and cabbage system through participatory technology transfer of appropriate market focussed crop management techniques. Consequently much of the project activity concerned technology transfer. These activities have already been described in the Results section under

Sections 7.1.1, 7.1.3, 7.1.4, 7.1.6 and 7.1.7. The highlight was the change the project brought to participatory technology transfer where the old paradigm of ICM FFS was replaced by FIL which focussed on standardised single factor management investigations by farmer groups whose guides were supported by Technical Toolkits in Indonesian. The most successful groups were able to pool data and their results were able to be statistically analysed. This gives Indonesian vegetable farmer groups, for the first time, a tool to independently assess new management techniques.

Other major communications and dissemination efforts were the production of short publications in Indonesian aimed at farmers. These are listed in Section 10.2. Three DVDs aimed at providing key project findings were also produced in Indonesian language on the topics of: Preventing and controlling the spread of clubroot of cabbage; Increasing Potato Profitability In Indonesia by sustainable management of late blight & insect pests; and PCN prevention.

Suggestions for post-harvest improvements for potatoes were provided to farmers in a pictorial format which identified both the best and least desirable current practices. Farmers can immediately see how their own practices rate and use the best suggestions to improve the handling of their product.

Extension material published by the project as well as the Technical Toolkits aimed at farmer group guides and trainers can be accessed at the website dedicated to this project www.indopetani.com

9 Conclusions and recommendations

9.1 Conclusions

The main aims of the project were to:

1. Adapt and apply robust ICM systems for potato and cabbage.
2. Develop and implement low-cost schemes that significantly improve the access of smallholder vegetable producers to quality potato seed.
3. Develop the capacity of project partners to use adaptive research and development strategies.
4. Assess the potential to develop a potato seed producing area in eastern Indonesia.

All aims were achieved.

Adapt and apply integrated crop management systems for potato and cabbage

The baseline surveys were able to identify potential constraints to production of both cabbages and potatoes. The identification of low soil pH as a major constraint was unexpected. Correcting soil pH will help farmers to obtain the full potential from their potato and cabbage crops as well as other crops in the rotation. Correct soil pH will also mean that fertiliser inputs will be used more efficiently by the crops.

The modification of ICM FFS participatory technology transfer method to the FIL method allowed new ICM techniques to be tested by farmers. FIL focuses on single management changes tested in a standardised way by several cooperating farmer groups. Farmers tested new management techniques to overcome the constraints of low soil pH, PLB, low availability of quality seed and clubroot. Farmer FIL experiments showed that clubroot management using resistant varieties and lime gave much improved yields and gross margins. Economic evaluation of this clubroot management determined project benefits to farmers for the next decade to be Rp 756 billion or AUD86 million. Other farmer experiments showed that: lime application was effective in raising soil pH and potato yield on acid sites; imported Australian potato seed, despite debilitating pre-planting storage conditions, performed as well as Indonesian certified seed which is in short supply; and the systemic-contact-systemic fungicide program for PLB management was effective and saved costs.

Develop low-cost schemes that improve the access to quality potato seed

This project has identified and tested the components of a partial seed scheme can supply increased quantities of PCN free seed at an affordable price to the areas in Indonesia that are currently free from the pest. The scheme will use imported Granola seed from PCN free areas of Australia. This seed will be bulked once only in the Sembalun Valley of NTB which has been surveyed for PCN with none found. This area has lower degeneration rates than Java. The seed potato production will occur in the dry season on paddy soils. These periodically flooded soils provide protection against the establishment of PCN. The area has additional capacity to produce potatoes on these paddy soils. Budgets prepared show that the costs of the seed will be lower than for imported seed while the Sembalun seed farmers will increase their income compared with their processing crops. This opportunity offers a feasible means to increase the supply of high quality potato seed at a lower cost than freshly imported seed. If successful this model could be used as a model to expand the partial seed scheme to other areas of Indonesia.

Develop partners capacity to use adaptive research and development strategies

The new methodology of FIL provides, for the first time, a valuable tool for Indonesian vegetable farmer groups to independently assess new management techniques. This gives them the capacity for adaptive research and development. This was recognised by farmers who stated that the benefit of FIL was “Menciptakan petani yang mahir dan mandiri” (the creation of self-reliant expert farmers).

Assess the potential to develop a potato seed producing area in eastern Indonesia.

The Sembalun Valley in NTB in eastern Indonesia was shown to be a vital part of the proposed partial seed scheme described above. We believe this area has the potential to produce high quality seed potatoes that are protected against PCN.

9.2 Recommendations

9.2.1 Farmers’ recommendations

Recommendations from the Farmer Conference about the current and future ACIAR projects were that:

- information should be made available on the internet,
- additional farmer groups should be developed
- farmers be given the opportunity to develop their knowledge
- facilitators should be given the opportunity to develop their skills and knowledge,
- FIL activities should use bigger plots
- Farmers need information and training an how to improve their access to capital
- Farmers need more information and training on post-harvest care and processing of their product
- Farmers need more information and training on marketing their product
- Delays that occurred in seed supply through the project need to be overcome.

9.2.2 Other recommendations

A model needs to be developed to enable farmer groups to self fund FIL groups.

The guidance for these FIL groups should come from senior farmers and guides who are trained in the FIL technique. Training is vital to ensure the success of FIL. Some FIL activities failed, for example farmer groups investigating the efficacy of lime for improving soil pH missed the vital preliminary step of taking soil pH tests to select lime responsive sites. These failures can be overcome as farmers and guides gain experience. The Technical Toolkits should be a major part of the curricula for this TOT training. Additional experiments designed for farmers to test more management techniques should be developed and added to the Technical Toolkits.

PCN is a major challenge for which the Indonesian potato industry must be prepared.

The partial seed scheme developed by the project will provide protection against this pest. This alternative seed scheme needs the support of government at both provincial and national levels if it is to make an impact. For this scheme to become a commercial success the farmers of the Sembalun Valley on NTB need; training in seed potato production and seed marketing, government permits to import Granola into NTB, and assistance in obtaining credit to support the venture.

PCN should also be tackled by other means:

- Potato regions should be surveyed to determine areas which are free. These areas will need improved protection to prevent infestation.
- Areas found to be infested will require resistant varieties. The identification of the Ro2 pathotype of PCN in the project provinces now allows resistant varieties to be identified and to be bred.
- The efficacy of trap crops should be investigated.

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11 Appendixes

11.1 Appendix 1: Baseline agronomic survey of potatoes

11.2 Appendix 2: Baseline economic survey of potatoes

11.3 Appendix 3: Baseline agronomic survey of cabbage

11.4 Appendix 4: Baseline economic survey of cabbage

11.5 Appendix 5: Potato seed system development – PCN

11.6 Appendix 6: Potato seed system development - WA seed supply chain analysis

11.7 Appendix 7: Potato seed system development - alternative seed supply system

11.8 Appendix 8: FIL – potatoes Java

11.9 Appendix 9: FIL – potatoes South Sulawesi

11.10 Appendix 10: FIL – potatoes NTB

11.11 Appendix 11: FIL – cabbage

11.12 Appendix 12: Post harvest

11.13 Appendix 13: Impact assessment - farmer conference

11.14 Appendix 14: Impact assessment - social impact study

11.15 Appendix 15: Abbreviations

Abbreviation acronym	Full name	Alternative language abbreviation/ acronym
ACIAR	Australian Centre for International Agricultural Research	
AFBI	Agri-Food & Biosciences Institute	
Al	aluminium	
a.i.	active ingredient	
ANOVA	analysis of variance	
AUD	Australian dollar	
AIAT	Assessment Institute for Agricultural Technology	BPTP
B	boron	
Balitsa	Balai Penelitian Tanaman Sayuran	IVEGRI
BCA	benefit to cost analysis (income/costs)	
BPSB	Balai Pengwasan dan Sertifikasi Benih (Agency for Seed Control and Certification)	
BPTP	Balai Penelitian Teknologi	AIAT
Ca	calcium	
$Ca(OH)_2$	hydrated lime (kapur mati)	
CJ	Central Java	
Cl	chloride	
CIP	International Potato Center	
CTT	Cabbage Technical Toolkit	
Cu	copper	
DBM	diamondback moth	
DPRD 1	Dewan Perwakilan Rakyat (Indonesian House of Representatives, provincial level)	
DW	dry weight	
FAO	Food and Agriculture Organisation of the United Nations	
Fe	iron	
FFS	farmer field school	SL
FIL	Farmer Initiated learning	Jarniport/PPP
G	generation of potato seed grown out from tissue culture	
G	gravitational force	
GAP	good agricultural practice	
ha	hectare	
Horsela	Hortikultura Sembalun Lawang	
ICM	integrated crop management	PTT
IPM	integrated pest management	PHT
IS	instrumental sphere	
IVEGRI	Indonesian Vegetable Research Institute	Balitsa
Jarnipor	pembela**jar**an peta**ni** pelo**por**	
K	potassium	
LBD	learning-by-doing (plot)	
LMF	leafminer fly	
LPTP	Lembaga Pengembangan Teknologi Perdesaan (Foundation for Rural Technology Development)	
LSD	least significant difference	

Abbreviation acronym	Full name	Alternative language abbreviation/ acronym
MAP	modified atmosphere packaging	
Mg	magnesium	
Mn	manganese	
N	nitrogen	
Na	sodium	
NH_4-N	ammonium nitrogen	
NO_3-N	nitrate nitrogen	
NPV	Net present value	
NTB	Nusa Tenggara Barat	
P	phosphorus	
P	probability	
PCN	potato cyst nematode	NSK
PCR	polymerase chain reaction	
PGPR	plant growth promoting rhizobacteria	
pH (H_2O)	soil pH tested in a solution of water	
pH (H_2O)	soil pH tested in a solution of potassium chloride	
PHT	pengendalian hama terpadu	IPM
PLB	potato late blight	
PLRV	potato leafroll virus	
PPP	pembelajaran petani pelopor	FIL/jarnipor
PTT	pengelolaan Tanaman Terpadu	ICM
PTT	Potato Technical Toolkit	
PV	present value	
PVPB	present value of project benefits	
PVX	potato virus X	
PVY	potato virus Y	
R^2	regression co-efficient	
Ro2	Race 2 of *Globodera rostochiensis*	
Rp	Indonesian rupiah	
S	sulphur	
s	second	
SADI	Smallholders Agribusiness Development Initiative	
SL	sekolah lapangan	FFS
SOP	standard operational procedure	
SS	South Sulawesi	
t/ha	tonnes per hectare	
TOT	training of the trainer	
UGM	Gadjah Mada University	
UPOV	International Union for the Protection of New Varieties of Plants	
US$	United States dollar	
WJ	West Java	
Zn	zinc	

Australian Government
Australian Centre for International Agricultural Research

Final report appendix 1

title	AGB/2005/167 Baseline agronomic survey of potatoes
prepared by	Ian McPharlin and Andrew Taylor
co-authors/ contributors/ collaborators	Peter Dawson, Ms Fiona Goss, Dr Eri Sofiari, Dr Mieke Ameriana (dec.), Rofik Sinung Basuki, Dr Nikardi Gunadi, Ms. Mimien Pakih, Mr Hidayat Sayono, Mr Himawan, Mr Suhari, Mr Mufrodin, Mr Akhmad Arifudin, Mr Frans Silva, Mr Mohammed Assad, Ms Helda Tahir, Mr Kunto Kumoro, Ms Sri Wahyuning Ning, Mr Zamzaini, Mr Achmad Sudjudi, Ms Baiq Nurul Hidayah, Ms Rini Murtiningsih, Nasrullah, Baso Aliem Lolugau, Nurjanami, Warda Mustafa.

1 Executive summary

Major limits to potato yield were identified in a survey of growing conditions and practices in four provinces of Indonesia from 2006 to 2009. A 'Stratified Cluster Sampling' design was used where the provinces were not randomly selected (i.e. stratified), but chosen because they are important potato growing or development regions. The districts/sub-districts (strata) and farms (sites) were randomly chosen within each province. A total of 88 farmer sites were chosen from the four provinces; 24 in Central Java (CJ), 25 in West Java (WJ), 19 in Nusa Tenggara Barat (NTB) and 20 in South Sulawesi (SS). The target variety was Granola in CJ, SS and WJ and Atlantic in NTB.

Some factors were directly measured such as type, incidence and severity of pests, diseases and weeds in the growing crop from monitoring by staff of Dinas Pertanian and soil (texture, macro and micro nutrient concentration and pH prior to planting) and plant fertility (macro and micro nutrient concentration of the petioles at different crop stages) from laboratory analysis. Other factors such as time of planting and harvest, planting density and depth, seed size, source, quality and cost, types and number of rotation crops, source, method and frequency of irrigation, seeding rate, types and rates of pesticides, fertilisers and amendments, relative importance of pests, diseases, weeds etc were answers from grower respondents to a survey questionnaire.

In most cases survey data was related to tuber yield measured from a standard sampling area (50 m^2) at each site (each site = 1 grower 'respondent') using either regression analysis for continuous data (e.g. planting density, soil and plant nutrient concentration) or analysis of variance (ANOVA) for discrete data (e.g. type of pest, weed or disease, method of irrigation) and the significance recorded for $P < 0.10$. Where it was not possible to relate data to yield frequency tables (% of respondents) were used.

Potato late blight (PLB, *Phytophthora infestans*) was identified as the most important disease limiting yield from both grower response and crop monitoring in all 4 provinces. There is also evidence that fungicides being used are ineffective for its control. For example the use of metalaxyl was most likely ineffective and costly because of resistant strains. Due to its widespread incidence and difficulty in obtaining accurate assessments of severity at each site it was difficult to obtain statistical relationships with yield. Assessments of severity were difficult due to rapid spread of the disease in the field, differences between the criteria used for severity in each district and missing data.

Higher sanitary quality of seed and size was in some cases associated with higher yield but not always. Whilst higher yield was associated with higher seed cost it was not associated with lower generation number, usually a guide to higher quality seed. However low generation number doesn't in itself guarantee higher quality as it depends on the effectiveness of the seed certification scheme. High incidence of potato leafroll virus (PLRV) lowered yield in WJ indicating management of this virus is important in seed schemes. Results suggested growers were skilled at selecting higher quality seed from their own crops and/or purchasing higher quality seed from off farm sources. It was suggested that higher yield maybe achieved with physiologically younger seed in some instances and may need to be considered by suppliers. Results of seed storage showed higher yield was associated with storage in diffuse light or darkened, and presumably cooler conditions, compared to light.

Nematodes appeared to be overlooked by grower respondents as a major problem in CJ and WJ even though most reported use of nematicides as a control measure. It is possible growers assume nematodes were controlled and not a problem although observations aside from the survey found potato cyst nematode (PCN, *Globodera sp*) widespread and uncontrolled in CJ. It is more likely it was not identified by both grower respondents and monitoring personnel. NTB was shown to be free of PCN through a targeted soil survey.

LMF (Leafminer fly; *Liriomyza huidobrensis*) and potato tuber moth (*Phthorimaea operculella*) were the most prevalent pests on the crops. Poor storage conditions of seed tubers combined with ideal weather conditions has lead to large incidences of tuber moth in all growing areas. Attempts to control pests appears to be through the use of broad spectrum chemicals but excessive use appears to have eliminated natural predators and chemical resistance is likely to have occurred for several of the pest species. Biological control agents are not used extensively by farmers to control pests in the potato crops.

Lower yields were significantly related with high concentrations of extractable soil and petiole Al in CJ and WJ as shown by linear regression. Related to this was the finding that higher yields were correlated with higher concentrations of Ca in the soil and petioles, the concentration of which increases in the soil with pH as distinct from extractable Al which increases in the soil as pH declines. These results suggest management of soil acidity is an important agronomic issue in these provinces.

Lower tuber yield was associated with low applications of fertiliser in NTB (N and K) and SS (N, P and K), but not CJ and WJ, and confirmed by low soil and plant fertility levels of these elements. By contrast over-use of P fertilisers may have contributed to reduced tuber yields in NTB.

The most significant results from the survey formed the main focus of learning-by-doing plots (LBD) in Farmer Initiated Learning (FIL) activities in subsequent phases of the project. In this respect LBD plots focussed on PLB control, integrated management of major pests such as LMF, seed quality and soil acidity/fertiliser management.

2 Background

Potato production in Indonesia increased six-fold from 150,000 t/yr in the mid-seventies to 900,000 t/yr in the mid-nineties. Whilst most of this increase was due to an increase in area of production it was also due to a doubling of average yield from 8 to 16 t/ha (Fuglie 2002). By increasing production the goal was to upgrade farm income, improve the nutritional status of consumers, and for the potato industry to act as a base for rural development (Adiyoda *et al.* 2001). The adoption of new varieties, increased use of high quality seed, increased use of production inputs and improved management practices by Indonesian farmers contributed to this yield increase.

The increase in area of production has meant potatoes are now grown in many locations amongst the Indonesian islands and therefore it is likely that different management techniques are practiced that will positively or negatively influence yield. Broad ranging qualitative and quantitative surveys help to identify the positive and negative management techniques and help in understanding the Indonesian potato farming system. For improved outcomes of families it is essential that farming systems are understood in enough depth for any intervention to be successful (Winter and Doyle 2008).

It is recognized there are significant limits to increased yield and quality in tropical environments such as Indonesia. Despite recent large gains, potato yield in Indonesia is still a lot lower than in countries with temperate climates. For example average yield of potatoes in one of Indonesia's neighbouring countries, Australia, is 40 t/ha. Varietal tolerance to key pests and diseases and their IPM management, seed management, followed by soil erosion, fertility and post harvest handling were ranked as the main potato research priorities in Indonesia in a review in 2002 (Dimyati 2002). It was noted that some pests such as LMF, once ranked as a secondary pest, had now become primary ones (Setiawati and Uhan 1997). The chemical measures taken to control key pests and diseases have in the past shown to be expensive and inefficient with the use of broad spectrum pesticides compounding management options (van de Fliert *et al*. 1999).

Potato experts ranked as the most important production limits to potato yield and quality in SE Asia, including Indonesia, the following; sanitary quality of seed, PLB, bacterial wilt, viruses (potato virus Y (PVY), PLRV) and their vectors, high cost and availability of good quality seed and lack of appropriate processing varieties (Maldonado *et al*. 1998, Fuglie *et al*. 2005, Fuglie 2007). Agronomic factors such as soil fertility, weed control, low soil pH, water management, soil structure, although not unimportant, were seldom ranked highly by themselves. However some of these agronomic factors maybe more important than first thought. For example potatoes, although reputedly tolerant of acid soils, were shown to respond to lime applications on very acids soils (pH 4.1) in West Java (Subhan and Sumarna 1998). Even though not ranked highly by themselves it was recognised that improved agronomic practices were an essential part of improved disease and pest control, in realising the potential of new varieties and in maximising both the quality and quantity of seed production systems. In this respect their ranking is higher than a simple "either/or" survey style approach, that ignores these vital interactions, would assign.

This survey aimed to identify limits to yield in Indonesia at the provincial level. The method used here was not only descriptive as for example rankings of limits by potato experts in the area of interest but a more quantitative approach. Using this approach important limits to yield were identified by correlating a range of production factors with yield in 4 potato producing provinces (CJ, NTB, SS and WJ) in Indonesia using either ANOVA or regression statistics. Where it was not possible or logical to relate data to yield frequency tables were used.

3 Objectives

A primary objective of the project was to conduct a baseline survey of potato crops in the in the wet and dry seasons of first year of the project (2006 to 2007) in CJ WJ. Surveys of additional crops were carried out in NTB and SS from 2007 to 2009.

The aim of these surveys was to identify the main limits to potato yield and quality in the 4 provinces. This was achieved primarily through a statistical analysis of the relationship between the growing conditions or practices with yield. These conditions and practices were recorded through answers from the grower 'respondents' to a written questionnaire and crop monitoring and direct measurements carried out by the 'enumerators'. In some cases survey data was presented as frequency tables (% of respondents reporting the issue) where statistical relationships to yield were not relevant.

Participants in the survey assisted in the preparation of the questionnaire and were trained in interview techniques, sampling and monitoring procedures and data collection and analysis.

The management of the most important limits to yield, identified from the baseline survey, would be tested by FIL groups in LBD plots in the subsequent phases of the project.

4 Methodology

4.1 Survey Design

Agronomic conditions and practices were surveyed over 4 different plantings (or provinces where 1 province = 1 planting) by farmers and Dinas Pertanian staff in CJ and WJ, SS and NTB. A 'Stratified Cluster Sampling' design was used where the provinces and districts/sub-districts (strata) were not randomly selected, i. e stratified, but chosen because they are important potato growing regions. The farms (sites) were randomly chosen within each province. In addition a participatory rural appraisal was done in SS (Annex 3).

A total of 88 farmer ('respondent') sites (1 site equals 1 farm) were chosen from the three islands; 49 in Java, 20 in SS and 19 in NTB. In CJ a total of 24 growers from 3 sub-districts in Banjarnegara (Pejawaran, Wanasaya and Batur) and 2 sub-districts in Wonosobo (Kejajar and Garung) were included in the survey with planting from January to May and harvest from April to August 2007 (Table 4.1), a 'dry season' crop. In WJ there were a total of 25 growers with 5 each from 2 subdistricts in Bandung (Pangalengan and Kertasari) and 3 sub-districts in Garut (Cikajang, Pasir Wangi and Cisurupan) with sowing from November 2007 to March 2008 and harvest from February to June 2008,' a wet season crop'. In SS there were a total of 20 growers from 3 sub-districts of Gowa district (Malino, Tompobulu and Tinggimoncong) with planting from October to November 2008 and harvest from December 2008 to April 2009, also a 'wet season' crop. In NTB there were a total of 19 growers from 2 villages (Sembalun Bumbung, 4 and Sembalun Lawang,15) in the same district with planting from July to August 2008 and harvest from October to December 2008, a 'dry season crop'. The variety Granola was grown in CJ, SS and WJ and Atlantic in NTB.

Table 4.1. Location and number of grower sites, variety, planting and harvest dates for the survey.

Province	No of sites*	Variety	Planting dates	Harvesting dates
C J	24	Granola	21/01/07 - 02/05/07	29/04/07 - 07/08/07
NTB	19	Atlantic	14/07/08 - 06/08/08	12/10/08 - 02/11/08
SS	20	Granola	24/09/08 -19/11/08	27/12/08 - 14/04/09
WJ	25	Granola	01/11/06 - 03/03/07	11/02/07 - 10/06/07

*each grower 'respondent' = one 50 m^2 site on one farm

The farmer respondents were interviewed by enumerators and answered a comprehensive set of questions on their potato growing practices and conditions (see questionnaire: Attachment 1) over 6 visits including harvest. In addition, the enumerators acted as assessors and carried out various sampling (i.e. soil, plant, insect etc) and monitoring activities of the state of the crop (i.e. crop growth and soil moisture status, incidence and severity of pests and diseases) at each visit. All these crop measurements were made from a consistent 50 m^2 sized plots so variability between growers based on farm size was not an issue in the survey. The enumerators (Dinas Pertanian and other staff) were trained in the monitoring of crops prior to the survey beginning.

4.2 Assessment of Agronomic practices and conditions

4.2.1 Practices

Agronomic practices such as sowing (rate, depth, date, method), rotation, tillage (method, frequency, depth), irrigation, fertiliser, weed, pest and disease management, selection and treatment of seed, date and method of harvest etc were recorded mainly from grower responses to the questionnaire.

4.2.2 Conditions

Agronomic conditions such as elevation, slope, weather and soil moisture were recorded mainly from grower responses to the questionnaire but some such as soil and plant nutrient status were determined by direct measurement.

4.2.3 Soil and Plants

Sampling and analysis of soil for nutrients and particle size.

One to two days before planting 25 individual soil samples were taken in a zigzag pattern across the sampling area from each 50 m^2 plot to a depth of 15 cm using a soil corer.

All soil samples were bulked into a single composite sample in a plastic bag and forwarded to the Indonesian Vegetable Research institute (IVEGRI) laboratory in Lembang for samples from CJ and WJ and the BPTP laboratories in Mataram Maros for samples from NTB and SS respectively. Samples were analysed for pH (H_2O and KCl), total N% (Kjeldahl) and %C (Walkley and Black 1934), extractable NO_3-N, NH_4-N (both in 10% KCl), P (Bray and Kurtz 1945 and Olsen *et al.* 1954), S, Al (CJ and WJ only), Fe, Mn Cu, Zn (all in $NH_4CH_3CO_2$ at pH 4.8), exchangeable K, Ca , Mg and Na (all in $NH_4CH_3CO_2$ at pH 7.0) and particle size (% sand, silt and clay). The bases K, Ca, Mg and Na were reported as cmol(+)/kg (= 1 milliequivalent/100g).

If there was a delay for more than 2 days in despatch, the soil was air dried in an area protected from the rain or in an oven at 35 °C for 48 hours at a Dinas Pertanian or BPTP office nearest to the sampling site.

Sampling and analysis of plants for nutrients

Thirty petioles were collected from the youngest fully expanded leaf (usually from the 5th leaf down from the growing point) in a grid pattern across the sampling area from each site. The first petiole sample was collected when the length of the largest tuber was 10 mm and thereafter at 2 week intervals to a total of 4 samples.

All 30 petiole samples were bulked into a single composite sample in a paper bag, for each site, and forwarded to the IVEGRI laboratory in Lembang for samples from CJ and WJ and to the BPTP laboratories in Mataram and Maros for samples from NTB and SS respectively. Petioles were analysed for total N, P, K, Ca, Mg, S, Na, Cl (all in % DW) and total Al (CJ and WJ only), B, Fe, Mn , Cu and Zn (all in mg/kg DW).

4.2.4 Identification of pest and disease type and assessment of incidence

Farmers recorded incidence of pests and diseases in the stored seed prior to planting and during the growth of the crop. Independent regular monitoring by trained Dinas Pertanian staff also recorded incidence (% of sites affected) and severity of pests (pest number/plant) and diseases (light, medium or heavy, % of plants affected per site) in the crop during five visits of the growing season. Control measures, such as chemical application and cultural methods prior and during the crop was recorded by the farmer.

For assessment of % incidence of viruses a random leaf sample (complete young leaf including all leaflets still attached to its petiole) was taken at each site from every fifth plant within each sampling area to a total of 50 plants per site in CJ and WJ. All leaf samples were placed in plastic bags immediately with 10 leaves into each of 5 plastic bags/site and sealed to remain fresh. Prior to submission for testing samples were stored in cooler boxes to retain freshness. Samples were then submitted to the IVEGRI virus laboratory for testing for presence of potato virus X (PVX), PVY and PLRV and the % incidence (% of sites) reported.

4.2.5 Yield

The total, marketable and reject yield of the crop at each site for the 50 m^2 was determined at harvest from the weight of tubers in 3 size grades (< 30, 30 - 50 and > 50 mm) and calculated in tonnes per hectare for statistical analysis.

4.3 Data analysis

With most of the data either regression analysis or ANOVA of the factor with yield was performed using Genstat v 13.0. In some cases it was not possible or relevant to relate the factor statistically with yield so frequency tables were used where % of total to respondent answers (where 1 grower response = 1 site or farm) were presented. For example some factors such as potato late blight (PLB) were so widespread as to occur on nearly all sites and be close to > 90% incidence (i.e. > 90% of grower respondents reporting PLB as a major factor limiting yield). In this case statistical relationships between yield and % incidence were not appropriate. Attempts to relate severity of PLB, a more relevant measure than incidence, with yield were also of limited value because the data set was incomplete.

Simple linear regression were used to analyse the relationship between the continuous measures of agronomic conditions (i.e. soil and plant nutrient concentrations), practices (i.e. plant spacing, density, rates of applied fertilizer and amendments) versus tuber yield across all the sites in each of the 4 provinces. A probability of < 0.10 was used as the minimum level of significance. Concentrations of nutrients considered deficient, adequate or excessive (toxic) according to Huett *et al.* (1999) at the 10 mm tuber stage were shown as vertical lines on each regression.

ANOVA was used to determine the relationship for discrete measures of presence or absence (i.e. pest and disease), education (i.e. sources), irrigation (i.e. type) and weeds versus total yield across all sites in each of the 4 provinces. A probability (P) of < 0.10 was used as the minimum level of significance rather than <0.05. The lower level of significance is considered more appropriate for surveys, compared with experiments, as in most cases there is much less control over the factors being tested. The least significant difference (LSD) was used to separate means where significant differences were found. It is noted that in such analyses there is a 10% probability of detecting erroneous significant relationships i.e. incorrectly concluding that a factor either, positively or negatively, influences yield or has no effect on yield.

Combined % relative yield was used when all the data from all 4 provinces was to be combined together and analysed as a single data set. To produce the combined relative yield each site was presented as a percentage of the highest total yield for that province (i.e. the highest total yield was equivalent to 100%). This was repeated for all 4 provinces and combined into one data set. The data was the analysed as above by simple linear regression and ANOVA versus total yield to determine significance with a minimum significance level of < 0.10.

5 Achievements against activities and outputs/milestones

Objective 1: To Adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas/Alliums suited to Java, NTB and Sulsel conditions.

no.	***activity***	***outputs/ milestones***	***completion date***	***comments***
1.2	Training in survey design, crop monitoring, sampling, data collection and analysis	Questionnaire finalised & training completed at workshops	CJ & WJ in 2006 & NTB & SS in 2008	Training at workshops was complimented by practical demonstrations during field visits to WJ in 2006, CJ in 2007 and NTB and SS in 2008.
1.3	Conduct baseline survey for potatoes in CJ, NTB, SS & WJ	Summary reports of baseline surveys completed and results presented at workshops	CJ & WJ in 2007 & NTB & SS in 2009	Summary reports all baseline surveys from each province included in annual reports. Results of surveys presented to workshops in WJ and CJ in 2007 and in NTB and SS in 2009.

PC = partner country, A = Australia

6 Key results and discussion

6.1 Results

Tuber yields by province were highest for NTB (36.2 t/ha) and lowest for CJ (17.7 t/ha, Table 6.1).

Table 6.1. Mean tuber yields (t/ha) for each province in the survey.

Province	Mean yield +/- se(t/ha)	Range(t/ha)
Central Java	17.7 +/- 4.0	6.0 to 44.3
Nusa Tenggarra Barat	36.2 +/- 5.0	23.2 to 49.6
South Sulawesi	21.5 +/- 8.8	8.0 to 45.0
West Java	23.2 +/- 3.5	7.8 to 40.6

In CJ yield was highest in Batur (25.8 t/ha) and lowest in Pejawaran (10 t/ha) sub districts in Banjarnegara (Fig 6.1) and highest in Pesurenan (44.3 t/ha) and lowest in Kasimpar village (6 t/ha).

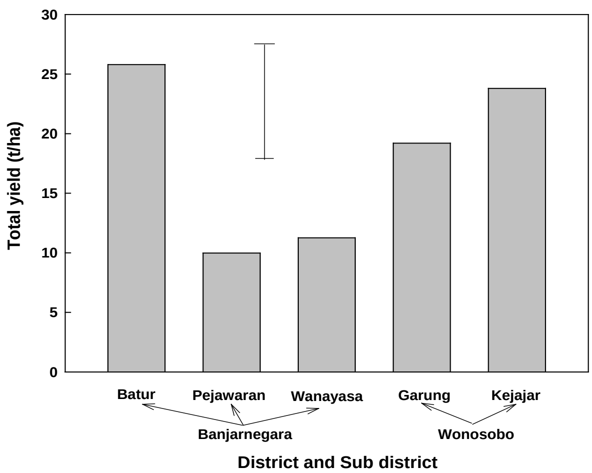

Figure 6.1. Mean tuber yield in subdistricts of Banjarnegara and Wonosobo. Differences between subdistricts and villages were ns in other provinces. Bar is LSD for differences (P < 0.10) in yield between districts/sub districts from the ANOVA.

6.1.1 Site

Higher yield was significantly associated with higher elevation in WJ, CJ and NTB but not in SS (Fig 6.2).

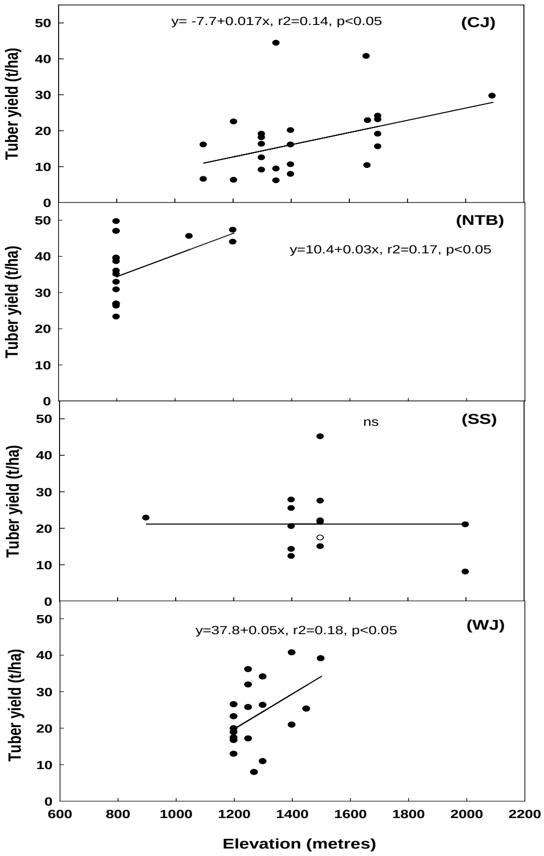

Figure 6.2. Linear regression between tuber yield and elevation (m) in Central Java (CJ), West Java (WJ), Lombok (NTB) and South Sulawesi (SS).

6.1.2 Learning

General

Yield was positively associated with years of potato growing in WJ (y = 12.7 + 0.83 x, $R^2 = 0.50$, $P < 0.01$, plot not shown) but not other provinces. Higher yield was associated with farmer's use of information from other farmers in CJ (Fig 6.3) but not other provinces. There were no significant correlations between the number of sources used for education on potato production and relative yield for all 4 provinces combined.

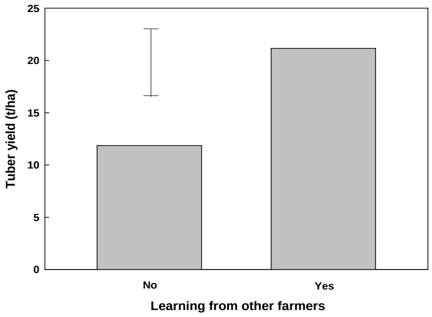

Figure 6.3. Tuber yield versus general learning options in CJ. Bar is LSD for differences (P < 0.10) in yield between learning options from the ANOVA.

Sources of information on pest and diseases

Higher yield was associated with accessing pest and disease (P & D) information from pesticide shops in CJ (Fig 6.4) but not other sources (extension officers or other farmers) and with number of sources of P & D information (y = 8.6 + 3.7 x, $R^2 = 0.16$, P < 0.05, plot not shown) in SS but not other provinces.

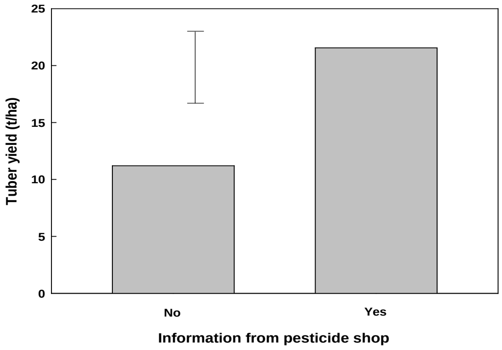

Figure 6.4. Tuber yield versus pest and disease information from pesticide shop in Central Java. Bar is LSD for differences (P < 0.10) in yield between information options from the ANOVA.

Lower yields were associated with use of information on pest and diseases from other farmers in SS (Fig 6.5).

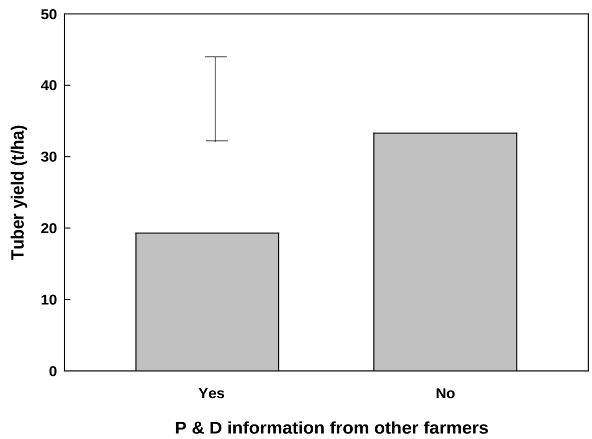

Figure 6.5. Tuber yield versus pest and disease (P&D) information options in SS. Bar is *LSD for differences (P < 0.10) in yield between information options from the ANOVA.*

All growers surveyed in SS accessed P & D information from their own family whilst in CJ learning on P & D from your family resulted in higher yields (Fig 6.6) than from other sources, but this was not the case in NTB and WJ. The number of sources of information on P and D did not affect the combined relative potato yield of the 4 provinces

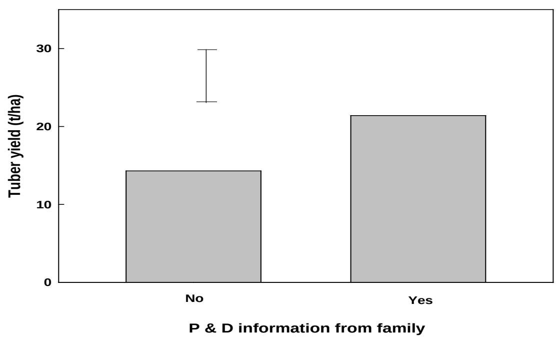

Figure 6.6. Tuber yield versus pest and disease (P&D) information options in CJ. Bar is LSD for differences (P < 0.10) in yield between information options from the ANOVA.

6.1.3 Seed and storage

Higher yield (47 t/ha) was associated with larger diameter seed (45 mm) compared with lower yield (27 t/ha) using smaller diameter (25 mm) seed in NTB (Fig 6.7) but not other provinces.

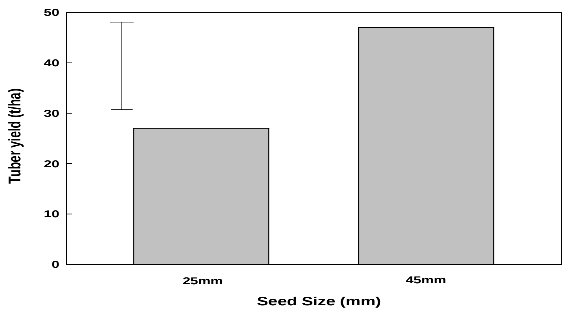

Figure 6.7. Tuber yield with seed diameter in NTB. Bar is LSD for differences (P < 0.05) in yield between seed diameters from the ANOVA.

By contrast higher yield (47 t/ha) was associated with seeds of about 65 g compared with yields (27 t/ha) from larger seeds of about 85g in NTB (Fig 6.8).

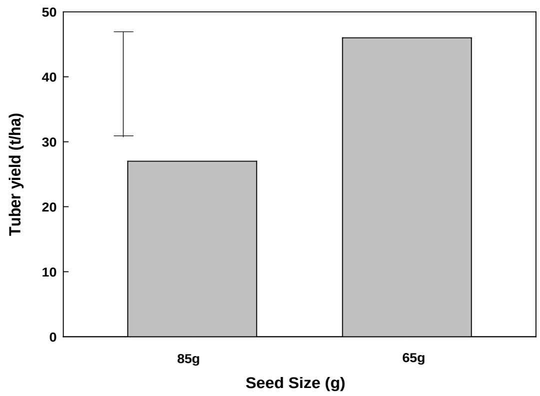

Figure 6.8. Tuber yield with seed weight in NTB. Bar is LSD for differences (P < 0.10) in yield between seed weights from the ANOVA.

Higher seed weight was not associated with higher yield in WJ, CJ or SS however it was associated with higher % relative yield for all provinces combined (y = 39.62 + 0.30 x, R^2 = 0.05, P < 0.10, plot not shown).

The relationship between sprout number and yield was ns in any province. In WJ higher yield was associated with shorter sprouts over the range 0.5 to 7.5 cm (Fig 6.9). Similarly in NTB higher yield was associated with shorter sprouts. A more detailed ANOVA (*P* < 0.10) showed yields of 40 t/ha from seed with sprouts of about 3.0 cm to 27 t/ha with 7.5 cm sprouts in NTB. The relationship between sprout length and yield was not significant in CJ nor between relative maximum yield (%) and sprout length in the 4 provinces combined.

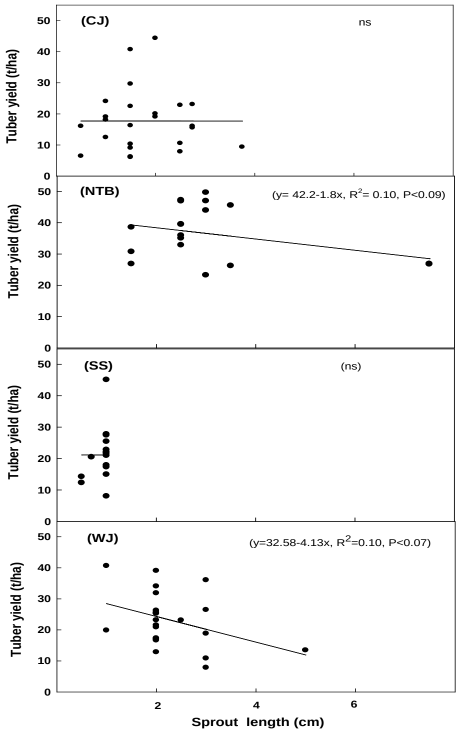

Figure 6.9. Linear regression of tuber yield with sprout length in 4 provinces.

Generation number of seed was not significantly related to yield except in CJ where higher yield was associated with higher generation number (y = 2.84 + 3.32 x, R^2 = 0.16, *P* < 0.05, plot not shown). Higher yield was not significantly associated with higher seed price in individual provinces but was with the combined % relative maximum tuber yield of the 4 provinces (Fig 6.10).

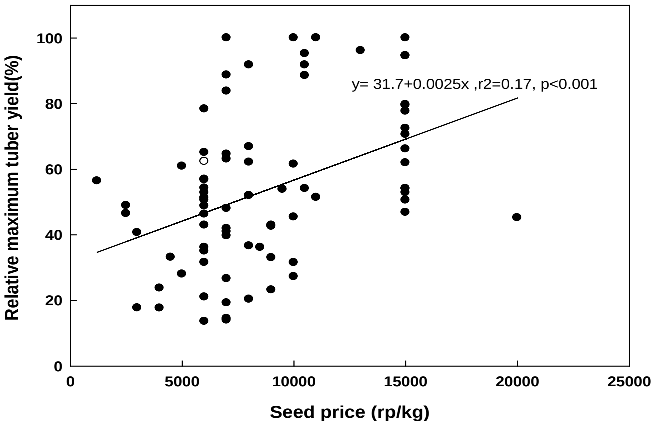

Figure 6.10. Linear regression of tuber yield (relative maximum %) with price (Rp/kg). Relative maximum yield (%) is highest tuber yield in each province/actual yield at each site x 100.

Higher yield was associated with seed selected on size and appearance compared with seed with no selection criteria in SS but not other provinces (Fig 6.11). Seed selected on either size or appearance only was not significantly associated with higher yield in any province

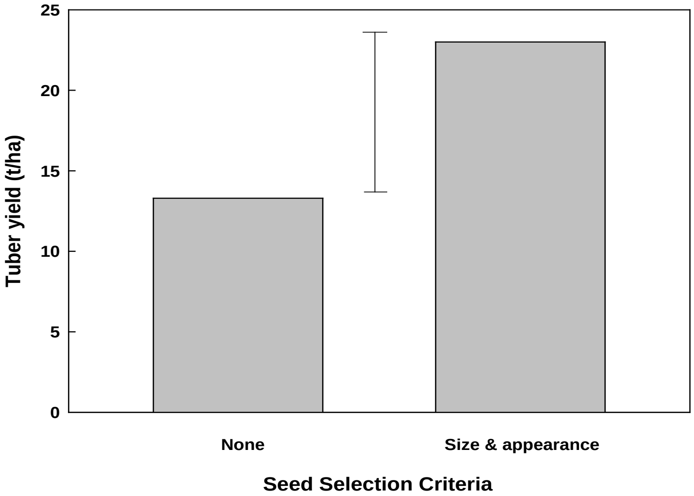

Figure 6.11. Tuber yield and seed selection criteria in South Sulawesi. Bar is LSD for differences (P < 0.10) in yield between selection criteria from the ANOVA.

Higher % relative maximum yield was associated with purchased compared with own seed for the combined data of 4 provinces (Fig 6.12). Yield differences between own versus purchased seed was not significant for individual provinces.

Figure 6.12. Yield (% relative maximum yield) versus origin of seed. LSD (P < 0.10) is for differences in % relative yield between seed origins.

There was no significant relationship between months of seed storage and yield in individual provinces but higher relative yield % was significantly related with longer storage period using the combined data of the 4 provinces (y = 33.4 + 0.6x, R^2 = 0.04, P < 0.05, plot not shown). Higher yield was associated with diffuse light storage (DLS) in WJ compared with storage in diffuse light + light (DL + L) or light only (L) (Fig 6.13) but not other provinces.

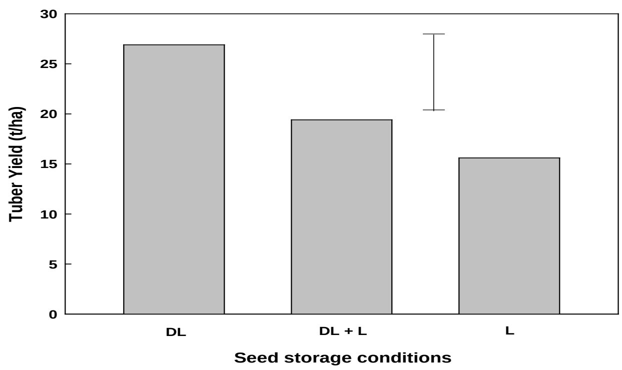

Figure 6.13. Seed storage conditions and yield in WJ. Bar is LSD for differences (P < 0.10) in yield between selection criteria from the ANOVA. For storage conditions D = dark, L = light and DL = diffuse light.

Higher %relative maximum yield was associated with storage in dark (D) or diffuse light (DLS) conditions compared with D + DLS+L or light (L) conditions for all 4 provinces combined (Fig 6.14).

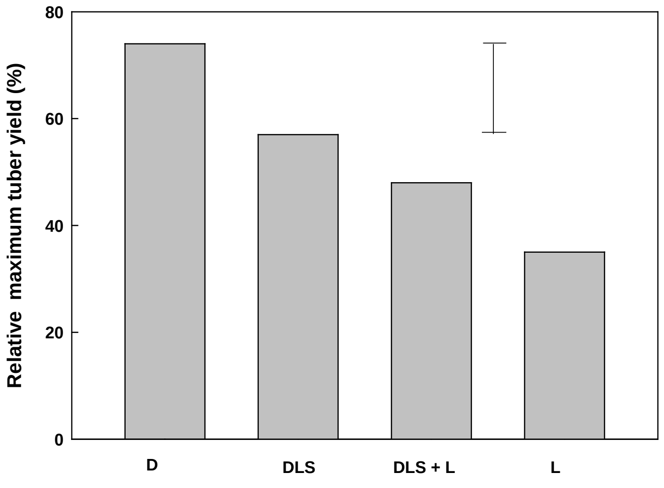

Figure 6.14. Seed storage conditions and %relative maximum yield for 4 provinces. Bar is LSD for differences ($P < 0.10$) in yield between selection criteria from the ANOVA. For storage conditions D = dark, L = light and DLS = diffuse light.

6.1.4 Fertiliser and nutrition

Fertiliser

Mean total rates of N ranged from 125 to 160, P from 17 to 117, K from 30 to 125 kg/ha and organic fertiliser from 2.1 to 14.9t/ha (Table 6.2). There was a wider range of rates of N, P, K application in CJ and WJ than NTB and SS. There was no significant relationship (regression) between yield and rate of applied N, P, K in CJ or WJ or with rate of applied organic fertiliser in any province.

Table 6.2. Total rates of application of N, P, K and organic fertiliser (mean and range) to potato crops in 4 provinces of Indonesia. 'Significance' refers to the relationship between tuber yield and rate by ANOVA (a) or regression analysis (b).

Province	Nutrient(kg/ha)	Mean (+/-SE)	Range	Significance#
CJ	N	146+/21	0-386	ns(b)
NTB	N	160+/-2	145-180	**(a)
SS	N	125+/-17	39-245	**(b)
WJ	N	153+/-14	0-247	ns(b)
CJ	P	59+/-9	0-134	ns(b)
NTB	P	117+/-8	45-136	*(a)
SS	P	17+/-3	7-56	**(b)
WJ	P	87+/-12	0-284	ns(b)
CJ	K	30+/-8	0-128	ns(b)
NTB	K	90+/-41	83-129	**(a)
SS	K	32+/-7	13-106	**(b)
WJ	K	125+/-20	0-320	ns (b)
CJ	Organic(t/ha)	7+/-2	0-30	ns(b)
NTB	Organic (t/ha)	2.1+/-0.34	0-3.5	ns(a)
SS	Organic (t/ha)	6.0+/-1.3	12-20	ns
WJ	Organic (t/ha)	14.9+/-1.3	0-25	ns(b)

ns=not significant or '*'= P < 0.1, '**'= P < 0.05,'***'=P < 0.01

In NTB higher yield was recorded at 159 and 180 (P < 0.10) than at 145 kg N /ha (Fig 6.15) and at 89 and 136(*P* < *0*.10) compared with 45kg P/ha (Fig 6.16).

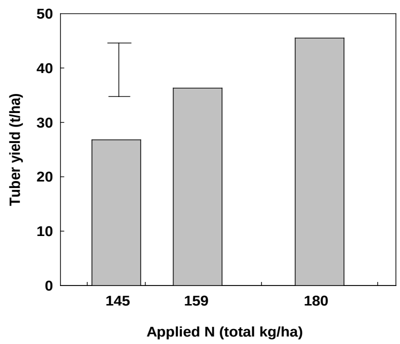

Figure 6.15. Tuber yield with rate of applied N in NTB. Bar is LSD for differences (P < 0.10) in yield between Kg N/ha from the ANOVA.

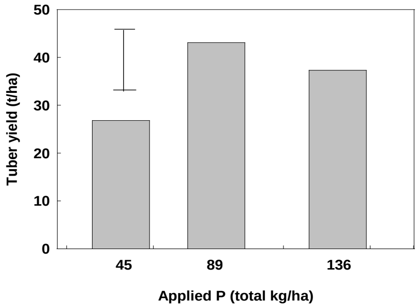

Figure 6.16. Tuber yield with rate of applied P in NTB. Bar is LSD for differences ($P < 0.05$) in yield between Kg P/ha from the ANOVA.

Yield was higher ($P < 0.001$) with 83 compared with 129 kg K/ha (Fig 6.17).

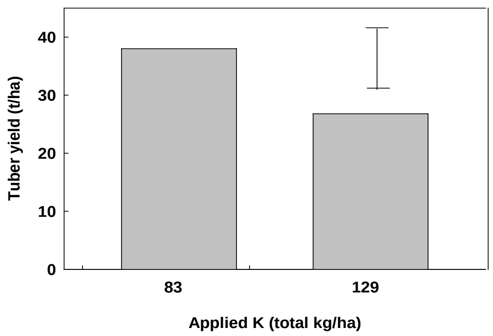

Figure 6.17. Tuber yield with rate of applied K in NTB. Bar is LSD for differences ($P < 0.05$) in yield between Kg K/ha ANOVA although showed differences were significant at $P = 0.001$.

In SS higher yield was linearly related ($P < 0.10$) to higher rates of applied N, P and K (Figs 6.18, 6.19, 6.20).

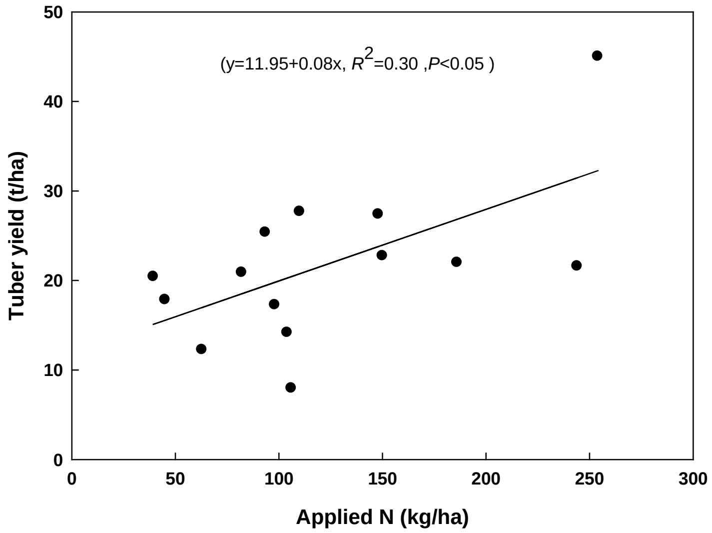

Figure 6.18. Linear regression between tuber yield and rate of applied N in SS.

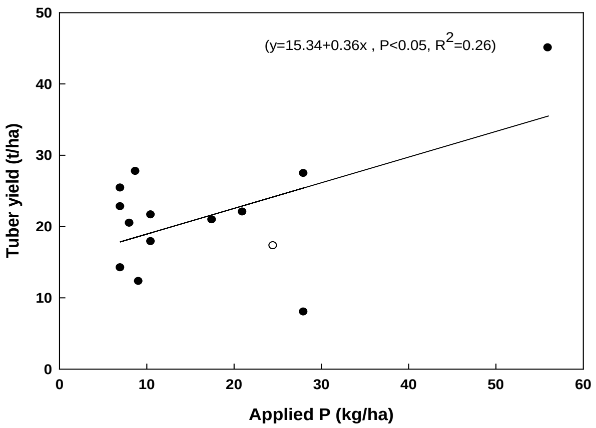

Figure 6.19. Linear regression between tuber yield and rate of applied P in SS.

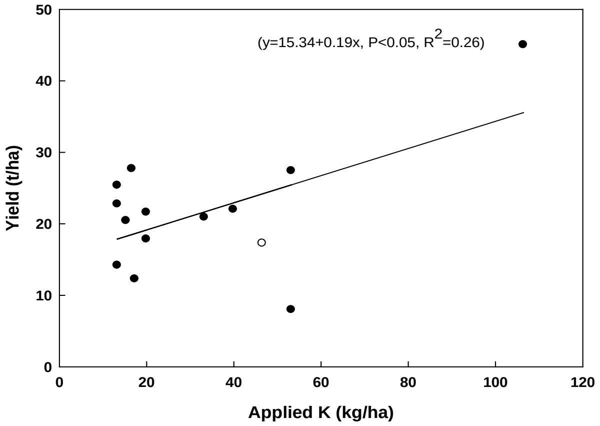

Figure 6.20. Linear regression between tuber yield and rate of applied K in SS.

N was applied in single fertilisers as urea or ammonium sulphate (ZA), K as muriate of potash and P as superphosphate (SP36) and all 3 in compound N, P, K fertilisers such as ‘Ponska’

Soil nutrients and pH

Micro-nutrients

There was a significant linear increase in concentration of Al as soil pH decreased in both CJ ($P < 0.001$) and WJ ($P < 0.05$) (Fig 6.21). Al concentration in the soil was not measured in NTB and SS.

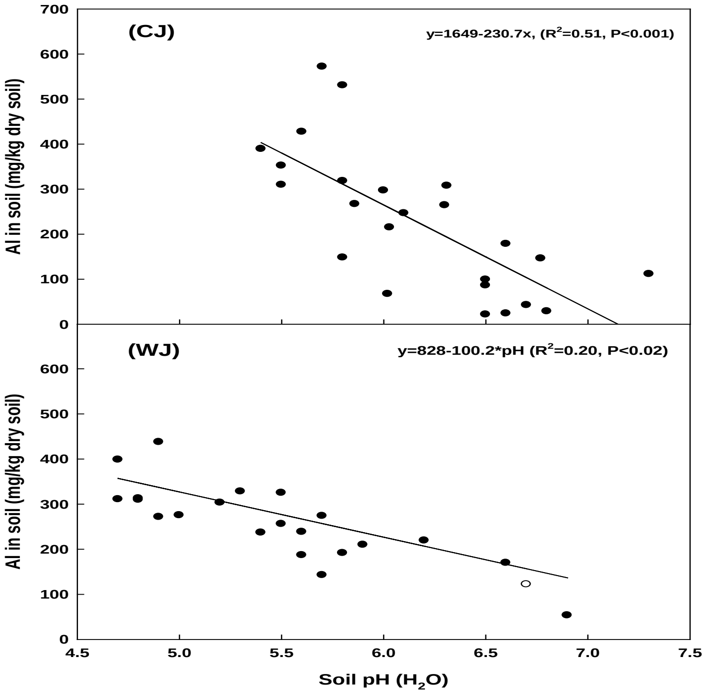

Figure 6.21. Linear regression between Al concentration versus pH in topsoil in CJ and WJ.

There was a significant linear increase in concentration of extractable Fe as soil pH decreased in both CJ ($P < 0.01$) and WJ ($P < 0.001$) (Fig 6.22) but not in NTB and SS.

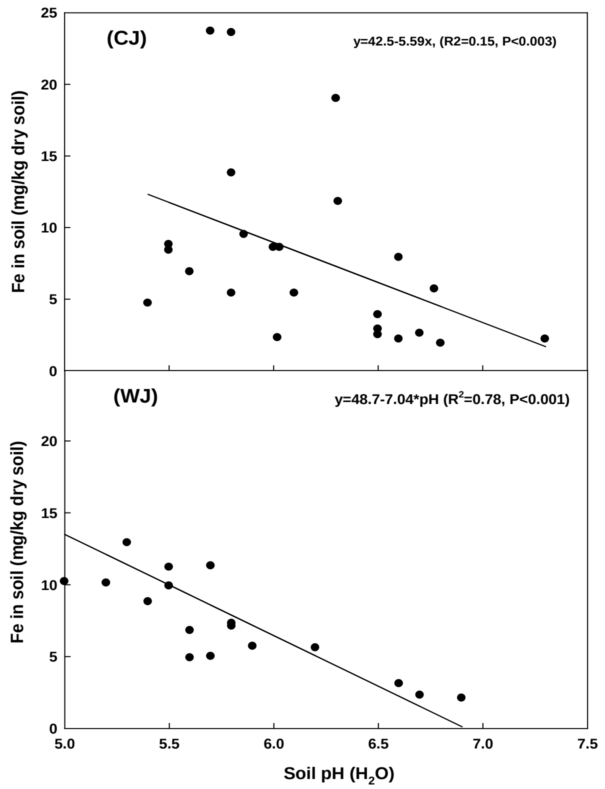

Figure 6.22. Linear regression between Fe concentration versus pH in topsoil in CJ and WJ.

Extractable Cu in the soil decreased linearly (-) with soil pH in WJ but was unaffected by pH in other provinces. Soil pH did not significantly change extractable Mn concentration in the soil in any province. Extractable Zn in the soil decreased with soil pH in NTB, increased with pH in SS and was unaffected by pH in other provinces (Table 6.3a)

Table 6.3a. Soil micro nutrient concentration and linear regression (- or +) with soil pH.

Province	Nutrient (mg/kg)	Mean (+/-SE)	Range	Significance# of regression
CJ	Al	227 +/- 32	21 - 572	****(-)
NTB	Al	-	-	-
SS	Al	-	-	-
WJ	Al	274 +/- 26	53 - 730	**(-)
CJ	Cu	0.80 +/- 0.05	0.5 - 1.3	ns
NTB	Cu	0.98 +/- 0.16	0.2 - 3.2	ns
SS	Cu	0.29 +/- 0.02	0.18 - 0.41	ns
WJ	Cu	2.3 +/- 0.3	0.7 - 8.0	0.09(-)
CJ	Fe	8.0 +/- 1.3	1.9 - 23.7	**(-)
NTB	Fe	53.2 +/- 5.8	15 - 96	ns
SS	Fe	12.95 +/- 1.6	7.3 - 30	ns
WJ	Fe	9.6 +/- 1.0	2.1 - 18.8	**(-)
CJ	Mn	3.7 +/- 0.5	0.8 - 9.9	ns
NTB	Mn	31 +/- 2.0	19 - 55	ns
SS	Mn	0.95 +/- 0.14	0.32 - 1.96	ns
WJ	Mn	8.0 +/- 0.96	2.5 - 20.3	ns
CJ	Zn	4.9 +/- 1.3	0.3 - 32.4	ns
NTB	Zn	9 +/- 1.2	2.2 - 21	***(-)
SS	Zn	0.29 +/- 0.07	0.02 - 0.94	0.009(+)
WJ	Zn	6.4 +/- 0.5	1.3 - 10.2	ns
CJ	pH	6.2 +/- 0.10	5.4 - 7.3	na
NTB	pH	6.2 +/- 0.07	5.3 - 6.6	na
SS	pH	5.2 +/- 0.04	4.8 - 5.6	na
WJ	pH	5.5 +/ -0.13	4.7 - 6.9	na

# *P < 0.10, **P < 0.05, ***P < 0.01, ****P < 0.001 and ns not significant and (–) and (+) refers to negative and positive linear regressions respectively.

Macro-nutrients

There was a significant linear increase in pre-planting concentrations of exchangeable Ca (Fig 6.23) and Mg (Fig 6.24) in the soil with pH in CJ, SS and WJ but not NTB.

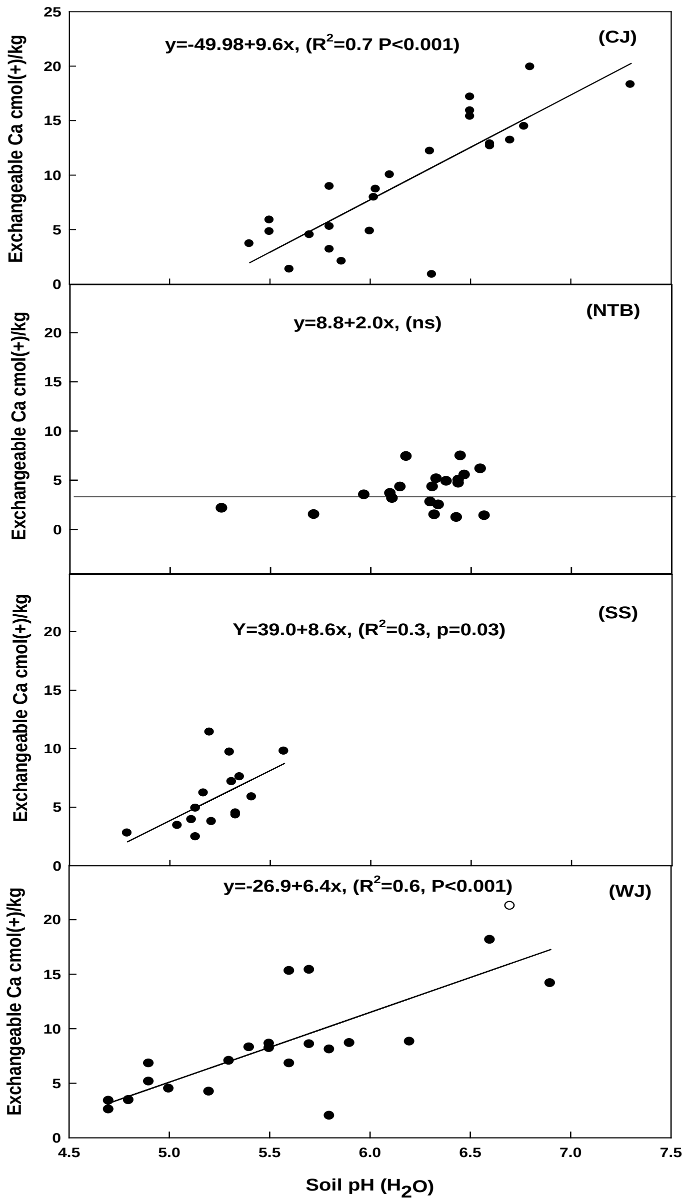

Figure 6.23. Linear regression between Ca concentration versus pH in 4 provinces.

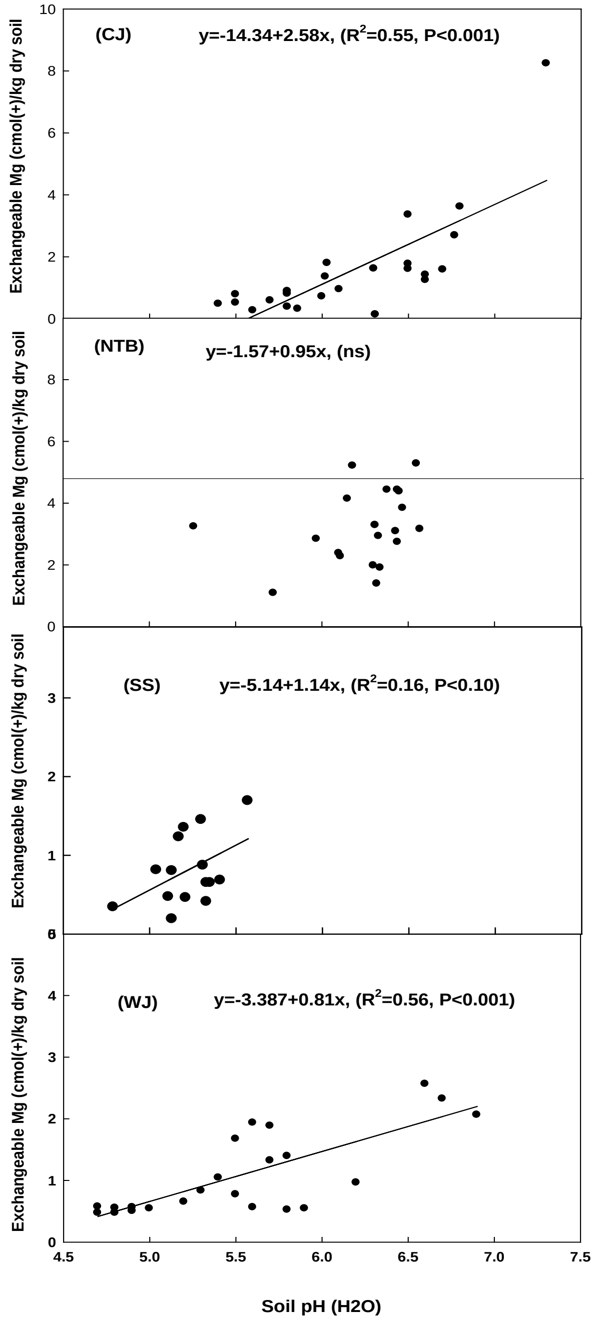

Figure 6.24. Linear regression between Mg concentration versus pH in topsoil in 4 provinces.

Exchangeable soil K increased linearly with soil pH in CJ and WJ but was unaffected by pH in other provinces and exchangeable soil Na was unaffected by soil pH in any province. Extractable NH_4-N in the soil increased significantly with pH in CJ only whilst extractable NO_3-N decreased in CJ and NTB but not other provinces. Total soil N (%) decreased with soil pH in CJ and SS but not other provinces. Extractable P (Olsen) increased with pH in CJ but in NTB and WJ (not measured in SS) whilst extractable P(Bray) was unaffected by pH in any province. Extractable S concentration in the soil decreased linearly with pH in CJ and WJ (not measured in NTB and SS) (Table 6.3b).

Soil carbon

Carbon in the topsoil (% organic carbon or %OC) was on average 2.35+/0.17% (range from 0.95 to 4.02%) in NTB and 2.03+/- 0.22 (range from 0.49 to 4.72%) in SS. Linear regressions between soil pH and %OC in topsoil were not significant in either province (plots not shown) and it was not measured in CJ and WJ.

Table 6.3b. Soil macro-nutrient concentration (% dry soil) and linear regression (- or +) with soil pH.

Province	Nutrient	Mean (+/-SE)	Range	Significance#	Nutrient	Mean (+/-SE)	Range	Significance#
CJ	Ca	9.3+/-1.2	0.85-19.9	****(+)	N(NH4-N)	1.8+/-0.30	0.57-5.36	**(+)
NTB	Ca	3.9+/-0.43	1.16-7.42	ns	N(NH4-N)	39+/-2	22-66	ns
SS	Ca	5.8+/-0.7	2.4-11.4	**(+)	N(NH4-N)	3+/-0.2	2-6	ns
WJ	Ca	8.4+/-1.0	2.0-21.0	***(+)	N(NH4-N)	1.0+/-0.21	0-4	ns
CJ	K	0.72+/-0.13	0.05-2.10	**(+)	N(NO3-N)	50+/-2	34-71	*(-)
NTB	K	0.38+/-0.06	0.11-0.95	ns	N(NO3-N)	51+/-7	5.8-124.2	**(-)
SS	K	0.61+/-0.05	0.3-0.86	ns	N(NO3-N)	48+/-9	3.5-98	ns
WJ	K	1.0+/-0.20	0.13-4.9	**(+)	N(NO3-N)	84+/-10	29-216	ns
CJ	Mg	1.54+/-0.35	0.13-8.23	****(+)	%N(total)	0.47+/-0.03	0.2-0.7	*(-)
NTB	Mg	3.19+/-0.27	1.08-5.27	ns	%N(total)	0.11+/-0.01	0.08-0.18	ns
SS	Mg	0.81+/-0.11	0.19-1.69	*(+)	%N(total)	0.57+/-0.04	0.3-0.8	*(-)
WJ	Mg	1.0+/-0.13	0.47-2.6	****(+)	%N(total)	0.49+/-0.03	0.2-0.8	ns
CJ	Na	0.21+/-0.02	0.09-0.53	ns	P(Bray)	26+/-5	1.00-92	ns
NTB	Na	0.21+/-0.02	0.1-0.41	ns	P(Bray)	71+/-16	2-258	ns
SS	Na	0.11+/-0.05	0.0-0.86	ns	P(Bray)	-	-	-
WJ	Na	1.9+/-0.02	0.02-0.45	ns	P(Bray)	40+/-7	45-165	ns

# *P < 0.10, **P < 0.05, ***P < 0.01, ****P < 0.001 and ns not significant and (–) and (+) refers to negative and positive linear regressions respectively.

Soil nutrients and yield

In CJ concentration of extractable Al, Cu and Fe in the soil was significantly associated with a linear decrease in yield but not other provinces and with extractable Zn in NTB only (Table 4a).

Table 6.4a. Linear regression between soil micro nutrient concentration and tuber yield.

Province	Nutrient	Regression	R^2	P
CJ	Al	y = 24.10-0.03x	0.16	**
NTB	Al	-	-	-
SS	Al	-	-	-
WJ	Al	y = 21.54+0.006x	-	ns
CJ	Cu	y = 35.5-21.2x	0.20	**
NTB	Cu	y = 23.6-0.17x	-	ns
SS	Cu	y = 22.8-5.6x	-	ns
WJ	Cu	y = 23.6-0.17x	-	ns
CJ	Fe	y = 22.21-0.6x	0.10	*
NTB	Fe	y = 34.08+0.04x	-	ns
SS	Fe	y = 22.49-0.102x	-	ns
WJ	Fe	y = 21.08+0.22x	-	ns
CJ	Mn	y = 16.61+0.30x	-	ns
NTB	Mn	y = 39.87-0.12x	-	ns
SS	Mn	y = 20.82+0.37x	-	ns
WJ	Mn	y = 21.61+0.19x	-	ns
CJ	Zn	y = 15.62+0.41x	-	ns
NTB	Zn	y = 41.85-0.61x	-	ns
SS	Zn	y = 22.0-2.86x	-	ns
WJ	Zn	y = 20.54-0.41x	-	ns

*<0.10, **<0.05, ***<0.01, ****<0.001 and ns not significant.

Table 6.4b. Linear regression between soil macro nutrient concentration and tuber yield. Regression for pH and yield is also shown.

Province	Nutrient	Regression	R^2	P	Nutrient	Regression	R^2	P	Province	Nutrient	Regression	R^2	P
CJ	Ca	y=14.37+0.36x	-	ns	N(NH4-N)	Y=13.06+2.6x	0.16	**	CJ	P(Olsen)	y=11.20+0.04x	0.19	**
NTB	Ca	y=38.39-0.54x	-	ns	N(NH4-N)	y=26.23+0.27x	-	ns	NTB	P(Olsen)	y=34.63+0.008x	-	ns
SS	Ca	y=20.5+0.12x	-	ns	N(NH4-N)	y=15.17+1.93x	-	ns	SS	P(Olsen)	-	-	-
WJ	Ca	y=23.7-0.06x	-	ns	N(NH4-N)	y=19.38+3.6x	0.14	**	WJ	P(Olsen)	Y=19.2+0.16x	-	ns
CJ	K	y=16.68+1.4x	-	ns	N(NO3-N)	y=.97-0.35x	0.12	**	CJ	pH(H_2O)	y=-3.6+3.5x	-	ns
NTB	K	y=36.05+0.5x	-	ns	N(NO3-N)	y=36.9-0.010x	-	ns	NTB	pH(H_2O)	y=-4.1+6.5x	-	ns
SS	K	y=31.11-16.3x	-	ns	N(NO3-N)	Y=18.8+0.05x	-	ns	SS	pH(H_2O)	y=-2.1+4.5x	-	ns
WJ	K	y=23.22-0.06x	-	ns	N(NO3-N)	y=26.81+0.04x	-	ns	WJ	pH(H_2O)	y=36.3-2.4x	-	ns
CJ	Mg	y=19.00-0.86x	-	ns	N(total)	y=15.4+4.8x	-	ns	CJ	S(total)	y=19.3-0.011x	-	ns
NTB	Mg	y=41.7-1.71x	-	ns	N(total)	y=31.5+41x	-	ns	NTB	S(total)	-	-	
SS	Mg	y=22.5-1.66x	-	ns	N(total)	y=22.9-3.0x	-	ns	SS	S(total)	-	-	
WJ	Mg	y=23.3-0.08x	-	ns	N(total)	y=16.9+13x	-	ns	WJ	S(total)	y=23. 9-0.015x	-	ns
CJ	Na	y=26.89-44x	0.11	*	P(Bray)	y=13.7+0.15x	0.12	**					
NTB	Na	y=36.89-3.2x	-	ns	P(Bray)	Y=35.9+.0004x	-	ns					
SS	Na	y=18.81+0.05x	-	ns	-	-	-	-					
WJ	Na	y=21.73+7.6x	-	ns	P(Bray)	y=26.85-0.09x	0.08	*					

*<0.10, **<0.05, ***<0.01, ****<0.001 and ns not significant

Petiole nutrients and yield

Micro-nutrients

There was a significant linear decline in yield associated with increasing concentrations of Al (average of 3 samples) in the petioles in CJ and WJ (Fig 24) and with Fe in CJ only (Table 5a , plot not shown for Fe). Al was not measured in the petioles in NTB and SS**.** Petiole Mn was associated with a linear decrease in yield in SS and an increase in yield in WJ. There was little evidence of micronutrient deficiency in potato crops in any province based on standards for deficient, adequate or excess concentration of micro-nutrient in the petioles at the 10 mm tuber stage for maximum yield (Attachment 2). For example B, Cl, Cu, Fe, Mn and Zn concentrations were in almost all cases either adequate or excessive (Fig 2, 3, 4, 5, 6 and 7 Attachment 2). Al concentrations were excessive in all crops and toxic (lowered yield) in CJ and WJ as already shown (Fig 1 Attachment 2).

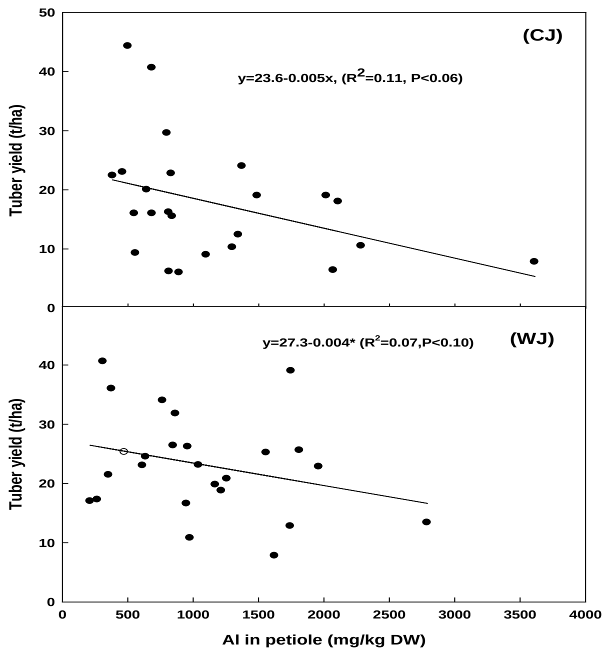

Figure 6.24. Tuber yield with Al concentration in petioles in CJ and WJ. Petiole concentration was average of 3 samples at 10mm tuber stage and 2 and 4 weeks later.

Table 6.5a. Petiole micro-nutrients (ave) and yield. Petiole concentration was average of 3 samples at 10mm tuber stage and 2 and 4 weeks after.

Province	Nutrient (mg/kg)	Mean (+/-SE)	Range	Regression	R^2	P
CJ	Al	1173+/-157	383-3610	y=23.6-0.005x	0.11	*
NTB	Al	-	-	-	-	-
SS	Al	-	-	-	-	-
WJ	Al	1062+/-128	213-2790	y=27.3-0.004x	0.07	*
CJ	B	30+/-1	22-43	y=26.3-0.29x	-	ns
NTB	B	-	-	-	-	-
SS	B	-	-	-	-	-
WJ	B	32+/-1	24-44	y=25.3-0.07x	-	ns
CJ	Cu	21+/-4	11-104	y=17.8-0.006x	-	ns
NTB	Cu	443+/-32	237-671	y=42.5-0.015x	-	ns
SS	Cu	19+/-8	5-102	y=20.4+0.041x	-	ns
WJ	Cu	18+/-1	12-26	y=20.6+0.14x	-	ns
CJ	Fe	572+/-82	200-1817	y=23.01-0.009x	0.10	*
NTB	Fe	1022+/-50	690-1590	y=44.6-0.008x	-	ns
SS	Fe	335+/-37	99-633	y=13.9+0.022x	-	ns
WJ	Fe	528+/-68	121-1324	y=26.81-0.007x	-	ns
CJ	Mn	503+/-42	124-1128	y=19.14-0.003	-	ns
NTB	Mn	790+/-44	493-1200	y=42.8-0.008x	-	ns
SS	Mn	477+/-30	316-670	y=37.44-0.03x	0.15	*
WJ	Mn	490+/-35	188-1131	y=14.2+0.02x	0.10	
CJ	Zn	97+/-9	37-201	Y=16.4-0.13x	-	ns
NTB	Zn	291+/-9	232-354	y=31.5+0.12x	-	ns
SS	Zn	110+/-17	39-264	Y=26.06-0.04	-	ns
WJ	Zn	73+/-4	36-110	y=16+0.098x	-	ns

*<0.10, **<0.05, ***<0.01 and ns not significant

Macro-nutrients

There was a significant linear increase in yield with concentrations of Ca (average of 3 samples) in the petioles in CJ and WJ but not in NTB and SS (Fig 6.25).

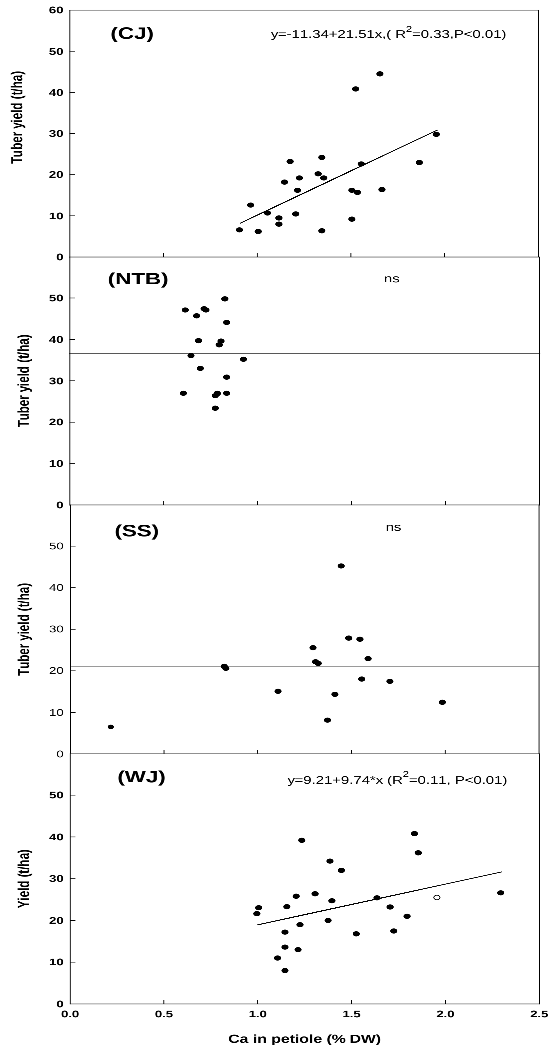

Figure 6.25. Linear regression between tuber yield and Ca concentration in petioles in 4 provinces. Petiole concentration was average of 3 samples at 10mm tuber stage and 2 and 4 weeks after.

Petiole Mg was associated with a linear decrease in yield in CJ and NTB but not other provinces (Fig 6.26). Based on standards for deficient, adequate or excess concentration of macro-nutrient in the petioles at the 10mm tuber stage for maximum yield there was evidence of both deficiency and excess in potato crops and some differences between the provinces (Attachment 2). For example all sites appeared deficient in petiole K in NTB whereas in the other provinces K concentrations ranged from low to high with most adequate (Fig 9,Attachment 2). Petiole Mg was mostly excessive in NTB (lower yield at high concentrations), possibly deficient in WJ and ranged from adequate to low in CJ and SS (Fig 10 Attachment 2). Petiole Ca was adequate to high for most sites in all provinces and tuber yield increased significantly with petiole Ca in CJ (Fig, Attachment 2). Most sites in all provinces were adequate in petiole N and S (Fig 11 and 14 Attachment 2) and petiole P may be deficient in some sites in NTB and ranged from adequate to low in WJ (Fig 13, Attachment 2). Petiole Na was not excessive on any site (Fig 12, Attachment 2).

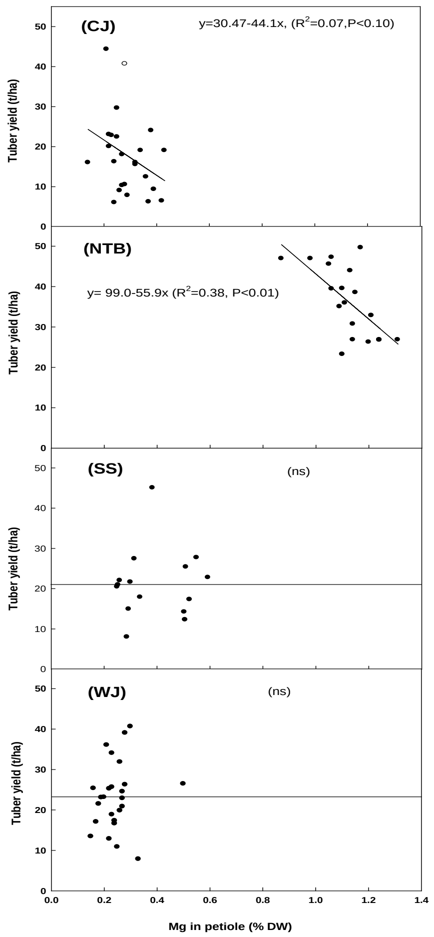

Figure 6.26. Linear regression between tuber yield and Mg concentration in petioles in 4 provinces. Petiole concentration was average of 3 samples at 10mm tuber stage and 2 and 4 weeks later.

Table 6.5b. Petiole macro-nutrients (ave) and yield. Petiole concentration was average of 3 samples at 10mm tuber stage and 2 and 4 weeks later.

Province	Nutrient (%)	Mean (+/-SE)	Range	Regression	R	P
CJ	Ca	1.35+/-0.06	0.91-1.96	y=-11.3+21.51x	0.33	***
NTB	Ca	0.8+/-0.02	0.60-0.90	y=48.8-16.5x	-	ns
SS	Ca	1.4+/-0.08	0.83-1.99	y=23.3-1.51x	-	ns
WJ	Ca	1.44+/-0.06	1.0-2.30	y=9.2+9.7x	0.11	*
CJ	K	9.6+/-0.12	8.6-10.9	y=14.6+0.33x	-	ns
NTB	K	5.4+/-0.07	4.9-6.0	y=16.13+3.8x	-	ns
SS	K	11.3+/-0.3	8.7-13	y=9.0+1.08x	-	ns
WJ	K	9.6+/-0.09	8.6-10.5	y=38.5-1.60x	-	ns
CJ	Mg	0.29+/-0.02	0.14-0.43	y=30.5-44.1x	0.07	*
NTB	Mg	1.1+/-0.02	0.9-1.3	y=99.0-55.9x	0.38	***
SS	Mg	0.4+/-0.03	0.25-0.59	y=19.3+4.7x	-	ns
WJ	Mg	0.24+/-0.01	0.15-0.49	y=18.4+19.8x	-	ns
CJ	Na	0.04+/-0.002	0.02-0.07	y=16.8+24x	-	ns
NTB	Na	0.1+/-0.01	0.04-0.13	y=53.2-17x	0.13	0*
SS	Na	0.06+/-0.01	0.04-0.09	y=25.00-65x	-	ns
WJ	Na	0.05+/-0.01	0.013-0.11	y=25.5-48.8x	-	ns
CJ	N	3.14+/-0.095	2.3-3.9	y=27.01-3.01x	-	ns
NTB	N	2.4+/-0.07	1.8-2.9	y=50.5-6.08x	-	ns
SS	N	4.0+/-0.08	3.5-4.5	y=19.9+0.32x	-	ns
WJ	N	3.06+/-0.11	2.1-2.4	y=38.9-5.2x	0.08	*
CJ	P	0.33+/-0.02	0.18-0.54	y=24.7-21.3x	-	ns
NTB	P	0.5+/-0.06	0.3-1.4	y=35.17+2.10x	-	ns
SS	P	0.4+/-0.02	0.3-0.50	y=11.5+24.3x	-	ns
WJ	P	0.31+/-0.22	0.16-0.44	y=36.92-44.5x	0.14	**
CJ	S	0.32+/-0.01	0.25-0.45	y=32.9-47.8x	-	ns
NTB	S	1.2+/-0.04	0.26-11.4	y=36.6-1.30x	-	ns
SS	S	0.4+/-0.02	0.26-0.46	y=26.6-13.8x	-	ns
WJ	S	0.29+/-0.01	0.19-0.48	y=26.53-11.5x	-	ns

* < 0.10, ** < 0.05, *** < 0.01 and ns not significant

6.1.5 Cropping sequence/Rotation

Yield of potato crops following beans (44.3 t/ha) was significantly higher ($P < 0.10$) than crops following celery, potato, tomato or no crops in Central Java (Fig 6.27).

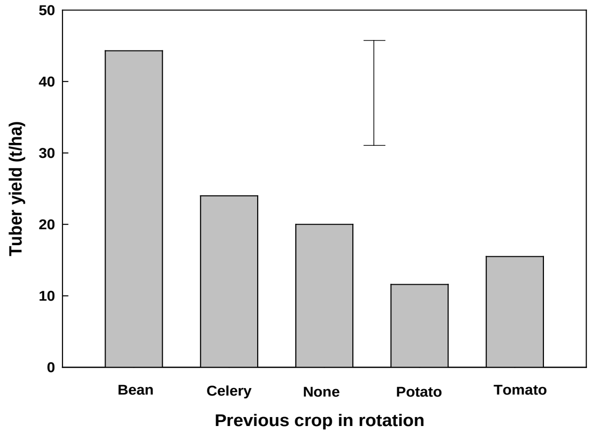

Figure 6.27. Yield of potato following different crops in rotation in CJ. Bar is LSD for differences ($P < 0.10$) in yield between rotation crop from the ANOVA.

Cropping sequence was not significantly associated with yield in other provinces. In CJ only higher yield was associated with a higher number of potato crops per year ($y = 8.06 + 5.96x$, $R^2 = 0.14$, $P < 0.05$, plot not shown). Distance to neighbours' potato crops or number of rotations was not significantly related to yield in any province.

6.1.6 Tillage/seed bed

Higher yield was associated with lower number of tillage times in CJ (Fig 6.28) but with higher number of tillage times in SS (Fig 6.29). Number of tillage times was not significantly related to yield in other provinces.

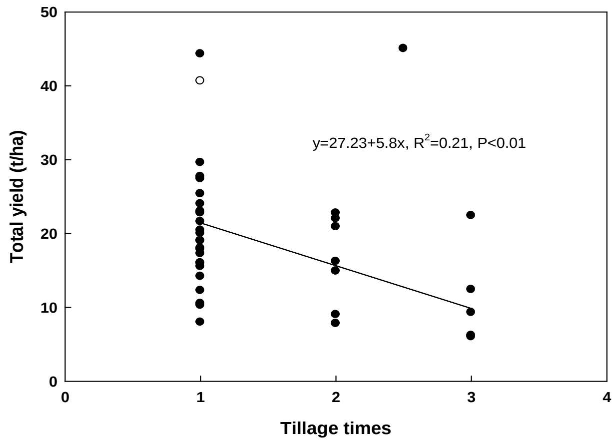

Figure 6.28. Linear regression between tuber yield and tillage times in CJ.

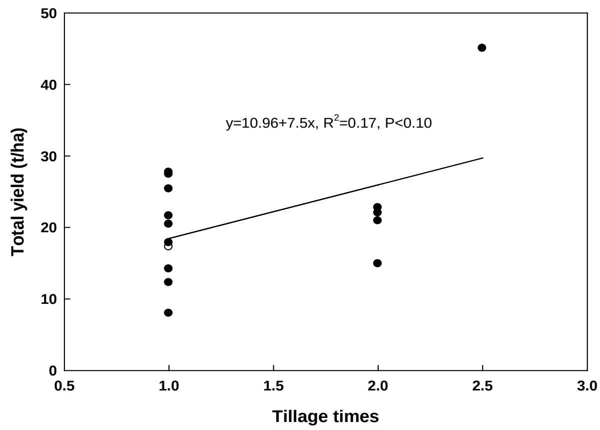

Figure 6.29. Linear regression between tuber yield tillage times in SS.

There was no opportunity to compare tillage methods in CJ and WJ as all growers manually tilled and there was no information on tillage methods from NTB and SS

Higher yield was associated with lower number of times of hilling in CJ (y = 30.42-7.2x, R^2 = 0.18, P < 0.05, plot not shown) but not in WJ. In NTB and SS all respondents hilled twice. Higher yield was associated with lower seed bed height in CJ (y = 31.11 - 0.43x, R^2 = 0.31, P < 0.01) not in other provinces.

Lower relative maximum yield (44%) was associated with the use of stakes (P < 0.01) compared with no stakes (61%) for all 4 provinces combined (Fig 6.30) but not for individual provinces.

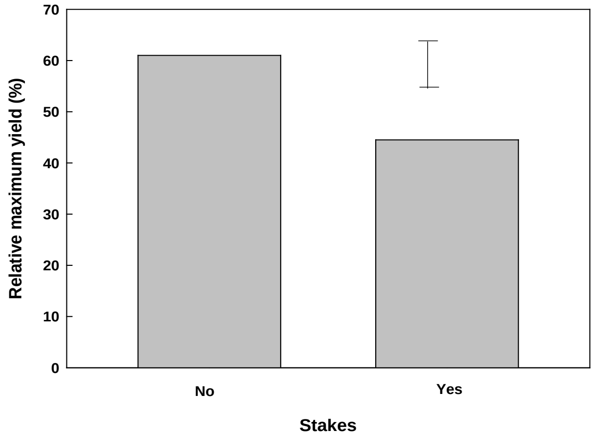

Figure 6.30. Relative tuber yield (%) of potato with use of stakes in 4 provinces combined. Bar is LSD for differences (P < 0.10) in yield between stake use from the ANOVA.

6.1.7 Time of planting and harvest and days of crop growth.

Higher yield was associated with higher number of days of crop growth (days between planting and harvest date) in WJ (Fig 6.31) and SS (Fig 6.32) but not other provinces. Yield was not significantly related to time of planting or harvest (expressed as day of the year = doy) in either province individually but higher relative maximum yield (%) was associated with a later date of planting (y = 43.9+0.07x, R^2=0.08, P < 0.01) and an earlier date of harvest (y = 61.5 - 0.05x, R^2 = 0.10, P < 0.10) for all provinces combined.

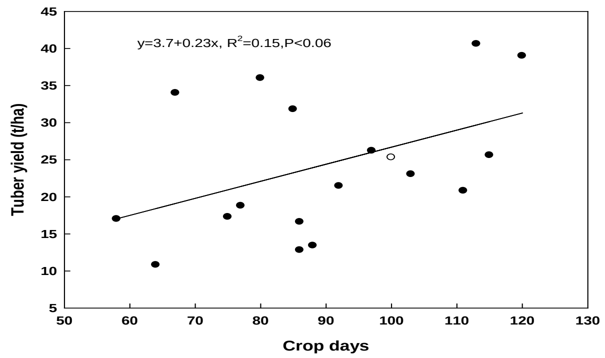

Figure 6.31. Linear regression between tuber yield and days of crop growth in WJ. Crop days = number of days between planting and harvest dates.

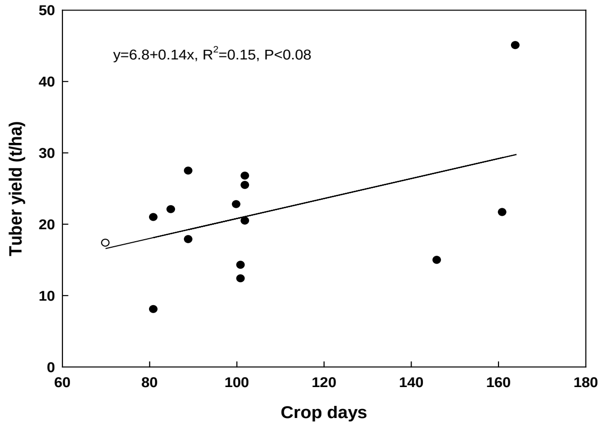

Figure 6.32. Linear regression between tuber yield and days of crop growth in SS. Crop days = number of days between planting and harvest.

6.1.8 Sowing depth, plant spacing and density.

Plant spacing was not significantly associated with yield in CJ, SS and WJ but wider row spacing and lower planting density was associated with higher yield in NTB only (Fig 6.33).

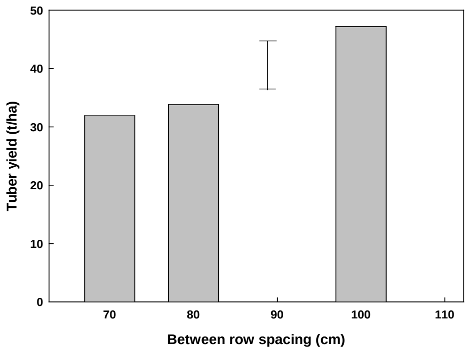

Figure 6.33. Tuber yield of potato and between row spacing in NTB. Bar is LSD for differences ($P < 0.10$) in yield between row spacing from the ANOVA.

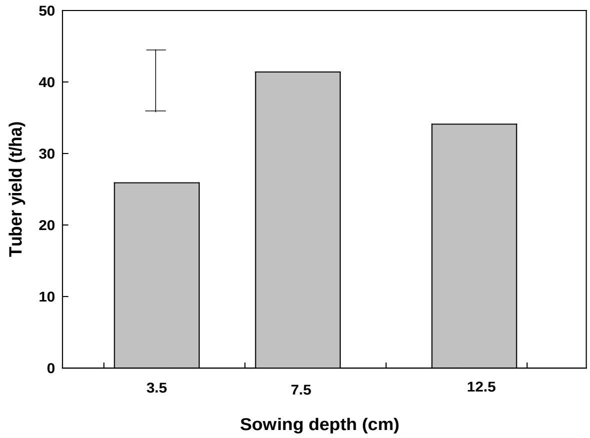

Figure 6.34. Tuber yield of potato and sowing depth in NTB. Bar is LSD for differences ($P < 0.10$) in yield between sowing depths from the ANOVA.

Higher yield was associated with sowing at 7.5 cm (41.4 t/ha) compared with other depths (2 to 4 cm or 12.5 cm) in NTB only.

6.1.9 Weeds/mulch

Higher yield (26.5 versus 14.3 t/ha) was associated ($P < 0.10$) with use of black plastic mulch in central Java (Fig 6.35) but not in WJ. Black plastic mulch was not used in NTB and SS.

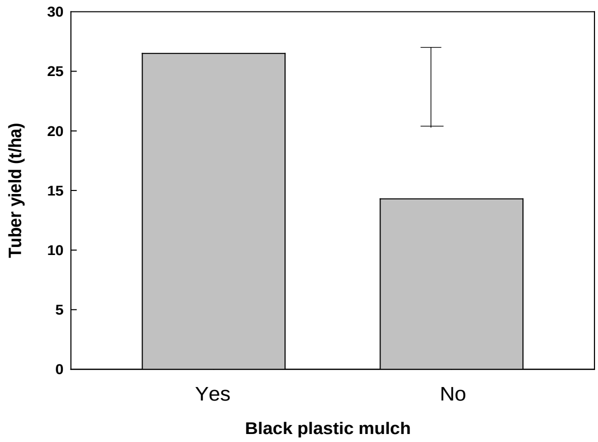

Figure 6.35. Tuber yield with use of black plastic mulch in CJ. Bar is LSD for differences ($P < 0.05$) in yield between mulch use from the ANOVA.

There was no significant relationship between weed type (species) and yield in WJ, CJ and SS and respondents only reported grass weeds in NTB. Increasing yield was associated with higher weed number in WJ (y = 15.03 + 5.0x, R^2 = 0.10, P < 0.10, plot not shown) but not in other provinces.

6.1.10 Irrigation

Increasing yield was associated (P < 0.05) with increasing frequency of irrigation in NTB but not other provinces (Fig 6.36). By contrast higher relative maximum yield (%) was associated with lower frequency of irrigation for the 4 provinces combined (y = 59.5 - 1.1x, R^2 = 0.03, P < 0.05, plot not shown).

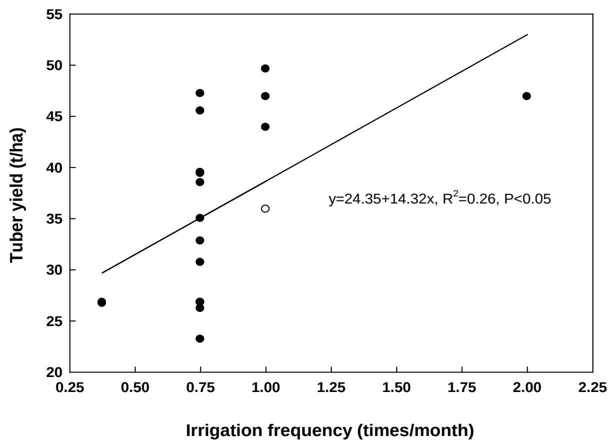

Figure 6.36. Linear regression between tuber yield and irrigation frequency in NTB.

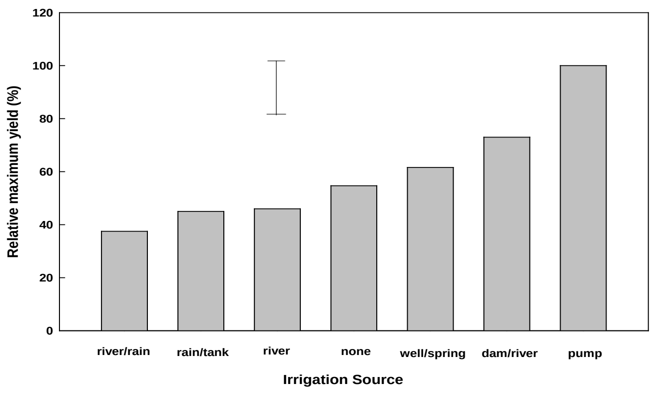

Figure 6.37. Relative maximum tuber yield % and source of irrigation water for 4 provinces combined. Bar is LSD for differences (P < 0.05) in yield between irrigation source from the ANOVA.

6.1.11 Crop monitoring

Higher yield was associated with the achievement of canopy cover in WJ (Fig 6.38) but not other provinces. Canopy cover was when the canopy of each row touched or overlapped with the canopy of adjacent rows.

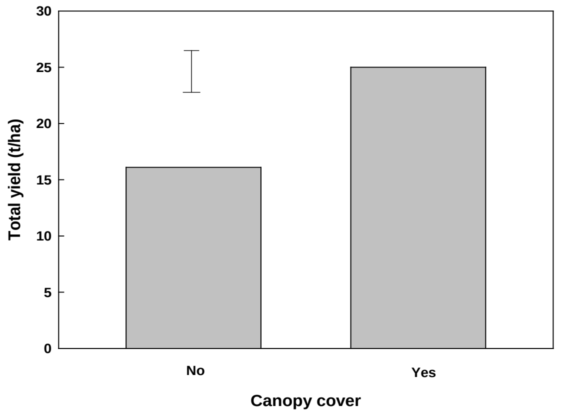

Figure 6.38. Tuber yield with canopy cover occurrence in WJ. Bar is LSD for differences ($P < 0.10$) in yield between canopy cover occurrence from the ANOVA.

An increase in tuber yield was associated with an increase in average plant height (Fig 6.39) but a decrease in average tuber size in linear regressions ($y = 44.5-0.12x$, $R^2 = 0.55$, $P < 0.001$, plot not shown) in SS.

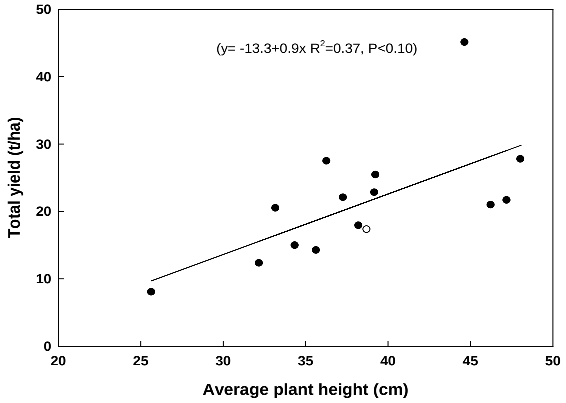

Figure 6.39. Linear regression between tuber yield and plant height (cm) in SS. Plant height was average of 5 measurements throughout crop starting at 10mm tuber stage.

6.1.12 Pest and Diseases in storage

Growers who PTM in their seed prior to planting had significantly higher yields than those who did not in WJ (Fig 6.40) but not in other provinces. Combining relative potato yield for all provinces was also significant (Fig 6.41). Other pests and diseases in storage did not have a significant effect on yield across all provinces and when combined.

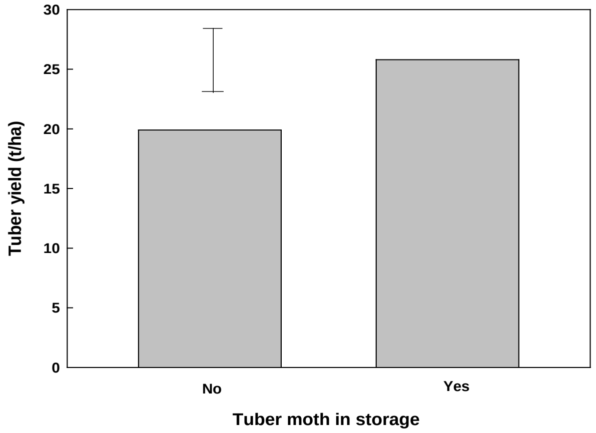

Figure 6.40. Yield with presence or absence of potato tuber moth reported in storage in West Java. Bar is LSD for differences (P < 0.10) in yield between PTM occurrence from the ANOVA.

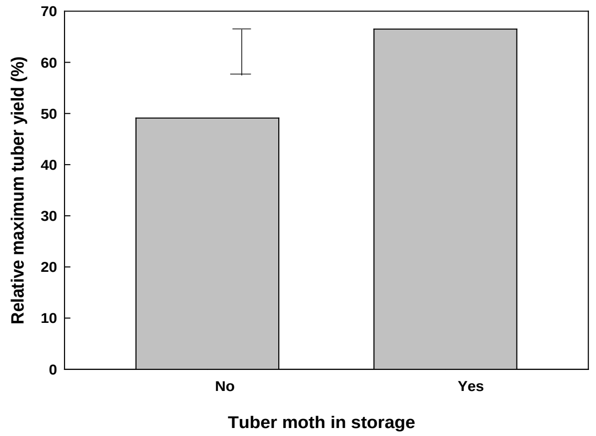

Figure 6.41. Relative maximum tuber yield% in presence or absence of potato tuber moth for all provinces. Bar is LSD for differences (P < 0.10) in relative yield% between PTM occurrence from the ANOVA.

6.1.13 Diseases in the field

Incidence (from respondents)

On average in all four provinces the disease with the greatest incidence as reported by grower respondents was PLB, >90% of sites) followed by bacterial wilt (>30% of sites) (Table 6.6).

Table 6.6. Incidence of disease (% of sites) in the field reported by farmer respondents in CJ, NTB, SS and WJ.

Disease	CJ	NTB	SS	WJ	Average
PLB	89	95	n/a	92	92
Bacterial Wilt	0	47	n/a	46	31
Blackleg	0	68	n/a	0	23
Early Blight	11	0	n/a	8	10
Scab	0	0	n/a	32	11
Virus	26	0	n/a	48	25

Incidence (from monitoring by enumerators)

Disease monitoring of crops by survey enumerators from Dinas Pertanian showed that all growers in WJ and NTB had PLB present. Monitoring also showed that all grower sites in NTB had blackleg and/or soft rot (*Erwinia*). Nematodes were detected by monitoring in CJ but not on any sites in NTB, SS or WJ Table 6.7).

Table 6.7. Incidence of disease (% of sites) in the field reported by survey enumerators* in CJ, NTB, SS and WJ.

Disease	CJ	NTB	SS	WJ	Average
PLB	54	100	93	100	87
Bacterial Wilt	29	11	0	68	27
Blackleg	0	100	7	0	27
Early Blight	0	21	0	0	5
Nematode	8	0	0	0	2
Virus	4	0	7	8	5

***** trained crop monitors from Dinas Pertanian.

Relationship of disease to yield

Higher yields were associated with farmers from CJ who had *Fusarium* wilt rather than growers who had no *Fusarium* wilt (Fig 6.42). There was no significant effect of *Fusarium* wilt on yield in other provinces.

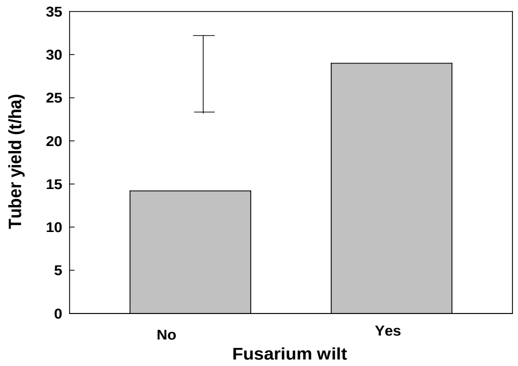

Figure 6.42. Tuber yield with the presence and absence of Fusarium wilt in CJ. Bar is LSD for differences (P < 0.10) in yield between Fusarium wilt occurrence from the ANOVA.

Growers in CJ who did not have any viruses in their crop had significantly higher yields (Fig 6.43) than those growers with virus. Viruses had no significant relationship to yield in other provinces.

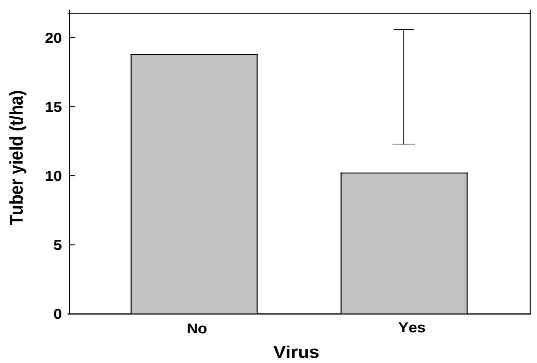

Figure 6.43. Tuber yield with virus presence and absence in CJ. Bar is LSD for differences (P < 0.10) in yield between virus occurrence from the ANOVA.

In WJ those growers who did not find virus in their crop reported higher yields than those who did (Fig 6.44).

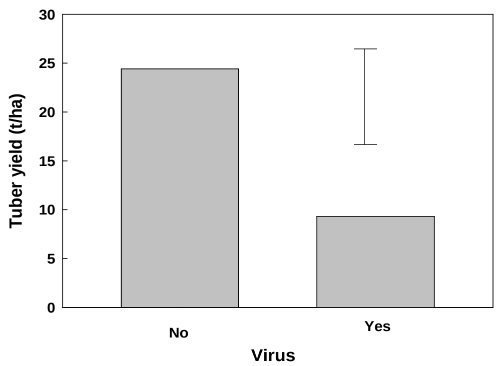

Figure 6.44. Tuber yields and viruses in WJ via disease monitoring. Bar is LSD for differences (P < 0.10) in yield with virus occurrence from the ANOVA.

In WJ lower tuber yield was associated with higher incidence of potato leafroll infection (PLRV) but not potato virus X, Y or S (Fig 6.45). Results are not reported for other provinces.

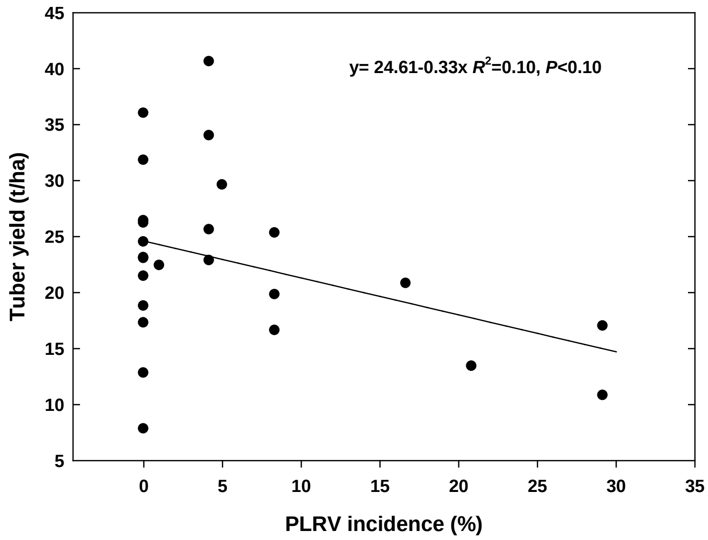

Figure 6.45. Linear regression between incidence of potato leafroll virus (PLRV, %) and tuber yields in WJ.

The presence of nematodes had a significant relationship to yield in CJ (Fig 6.46). Growers who reported nematodes had higher yields than those who did not, whilst the one grower who did not know whether nematodes were present recorded a yield of 40.6 t/ha. In contrast, growers in NTB who reported no nematodes had significantly higher yields (Fig 6.47) than growers who did not know whether or not nematodes were present. All growers in SS reported having no nematodes in their fields whilst WJ was not significant.

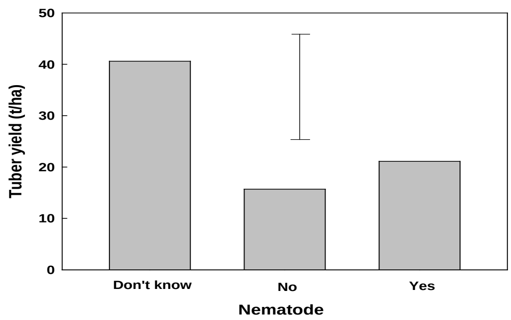

Figure 6.46. Tuber yield and nematode in CJ. Bar is LSD for differences ($P < 0.10$) in yield with nematode occurrence from the ANOVA.

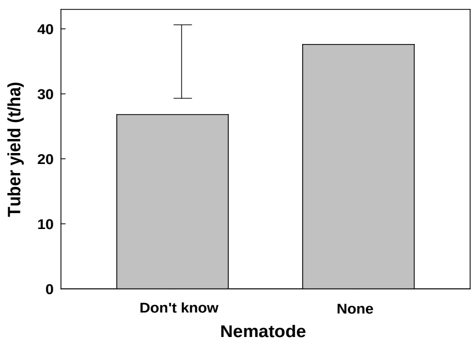

Figure 6.47. Tuber yield and nematode in NTB. Bar is LSD for differences ($P < 0.10$) in yield between with nematode occurrence from the ANOVA.

Higher yields were associated with growers who used nematicides in CJ (Fig 6.48) over those that did not. Similarly, by combining data for all provinces the growers that reported using nematicides had higher yields (Fig 6.49) than those growers that did not.

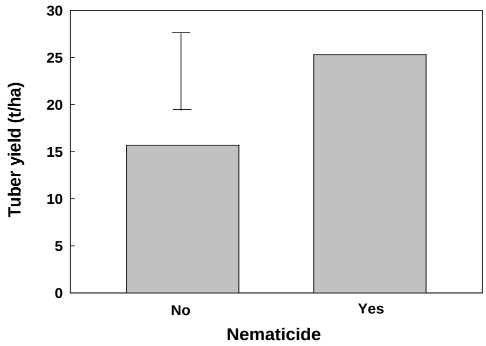

Figure 6.48. Tuber yield and the use of nematicides in CJ. Bar is LSD for differences (P < 0.10) in yield with use of nematicides from the ANOVA.

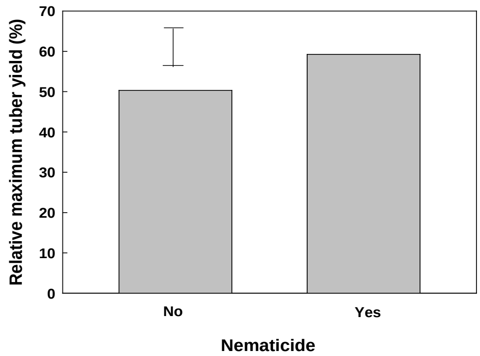

Figure 6.49. Relative maximum tuber yield% and the use of nematicides for all provinces. Bar is LSD for differences (P < 0.10) in yield with use of nematicides from the ANOVA.

In CJ the presence of PLB was associated with significantly lower yields (Fig 6.50).

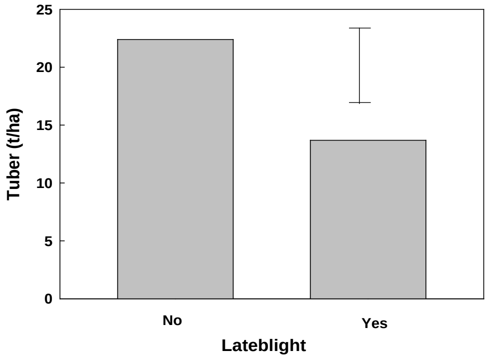

Figure 6.50. Tuber yields with presence of late blight, from disease monitoring, in central Java (CJ). Bar is LSD for differences (P < 0.10) in yield with PLB occurrence from the ANOVA.

Monitoring of crops in NTB found that those who reported bacterial wilt had significantly lower yields than those crops that did not (Fig 6.51). Bacterial wilt (*Ralstonia solancearum*) presence in other provinces was not significant.

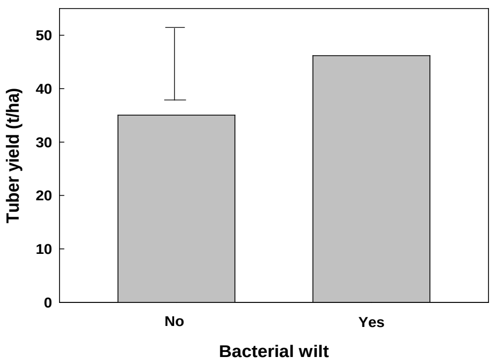

Figure 6.51. Tuber yields and bacterial wilt in NTB via disease monitoring. Bar is LSD for differences (P < 0.10) in yield with bacterial wilt occurrence from the ANOVA.

6.1.14 Pests in the field

Incidence (from respondents)

On average in all four provinces the most important pests as reported by grower respondents were cutworm (*Agrotis ipsilon*), LMF PTM and aphids (*Myzus sp*) (Table 6.8).

Table 6.8. Incidence of pests (% of sites*) in the field in CJ, NTB, SS and WJ.

Pest	CJ	NTB	SS	WJ	Average
Aphids	53	11	n/a	44	36
Cutworm	21	74	n/a	56	50
Leafminer fly	68	16	n/a	32	39
Potato tuber moth	35	n/a	n/a	68	34

*from respondents

Incidence (from monitoring)

PTM and LMF were the most important pests being identified on 70 and 56% of sites respectively (Table 6.9).

Table 6.9. Incidence of pests (% of sites*) in the field in CJ, NTB, SS and WJ.

Pest	CJ	NTB	SS	WJ	Average
Aphids	50	74	7	24	39
Cutworm	0	0	0	4	1
Leafminer fly	17	100	93	12	56
Thrips	21	47	0	32	25
Potato Tuber moth	17	100	100	64	70
Whitefly	0	0	0	12	3

*from monitoring

Relationship to yield

The absence of LMF was associated with higher yields in NTB crops (Fig 6. 52), but not in other provinces. In contrast, the presence of aphids was associated with higher yields in NTB crops (Fig 6.53) but not in other provinces. Fields in WJ that had cutworm present recorded yields that were significantly lower than those that did not have cutworm present (Fig 6.54).

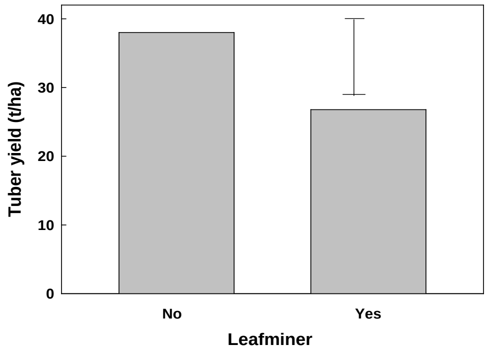

Figure 6.52. Tuber yield and leafminer fly presence in NTB via farmer reports. Bar is LSD for differences (P < 0.10) in yield with leaf miner occurrence from the ANOVA.

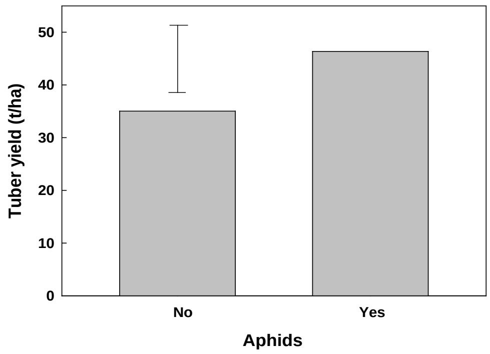

Figure 6.53. Tuber yields and presence of aphids in NTB via farmer reports. Bar is LSD for differences (P < 0.10) in yield with aphid occurrence from the ANOVA.

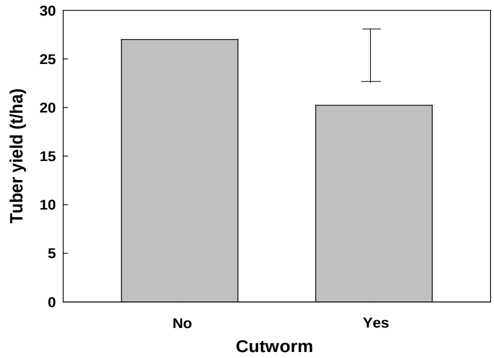

Figure 6.54. Tuber yields and cutworm in WJ via farmer reports. Bar is LSD for differences (P < 0.10) in yield with cutworm occurrence from the ANOVA.

The absence of aphids during monitoring was also associated with higher yields in NTB (Fig 6.55).

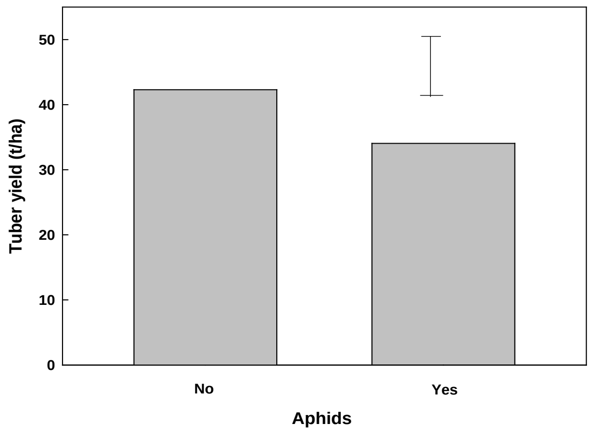

Figure 6.55. Tuber yield and the presence and absence of aphids in NTB via pest monitoring. Bar is LSD for differences (P < 0.10) in yield with aphid occurrence from the ANOVA.

In CJ all growers reported not finding white fly (*Bemisia tabaci*) and cutworm whilst monitoring whereas in all other provinces these pests were not significant.

6.1.15 Information on use of chemicals and cultural control of pest and diseases.

The cultural practice of roguing the crop was significant in CJ with those that did not rogue their crop achieving higher yields than those that did (Fig 6.56). Similarly, when all the provinces were combined those growers that did not rogue their crop reported higher yields than those that did (Fig 6.57). All growers from SS rogued their crop.

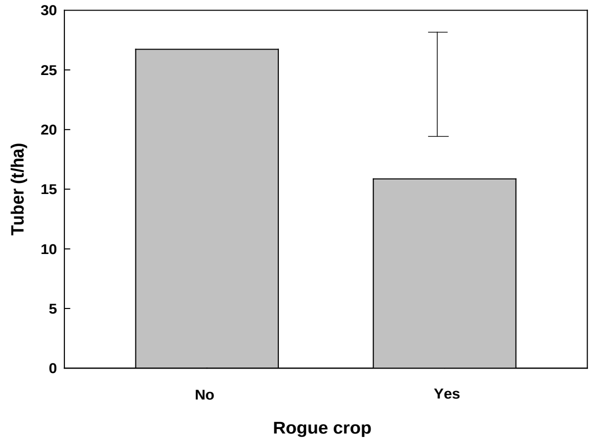

Figure 6.56. Tuber yields and roguing infected plants from crops in CJ. Bar is LSD for differences ($P < 0.10$) in yield with roguing options from the ANOVA.

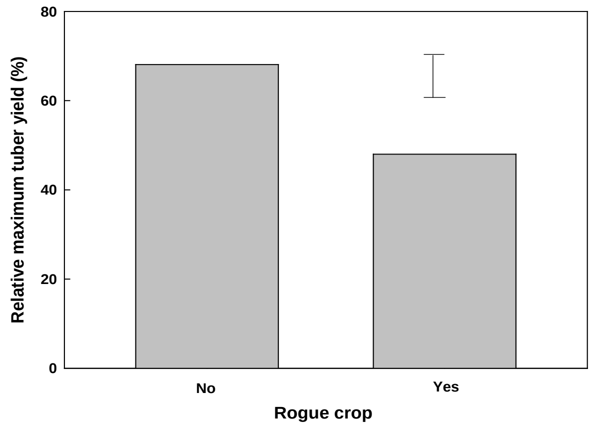

Figure 6.57. Relative maximum tuber yield% and the roguing of diseased plants for all provinces. Bar is LSD for differences ($P < 0.10$) in relative yield% with roguing options from the ANOVA.

No growers in SS used sticky traps to monitor insects and higher yields were associated with not using them in NTB (P < 0.10 from ANOVA, plot not shown). In WJ and CJ the use of sticky traps was not significant on yield.

In WJ the use of a wetting agent whilst spraying was associated with lower yields (Fig 6.58) whereas in NTB the use of a wetting agent was associated with higher yields (Fig 6.59). All growers in SS used a wetting agent with their spraying whilst in CJ and with all provinces combined the use of wetting agents were not significantly related to yield.

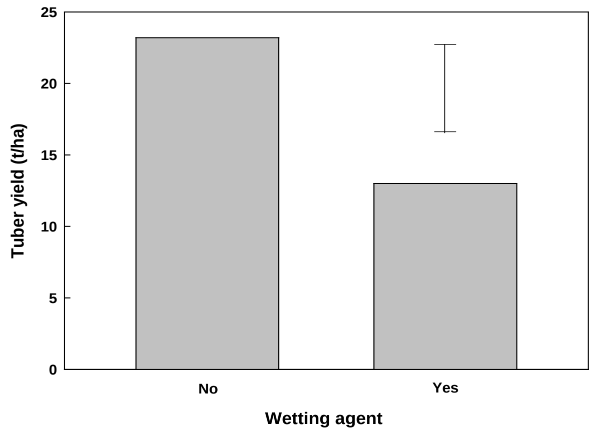

Figure 6.58. Tuber yields and the use of wetting agents in WJ. Bar is LSD for differences (P < 0.10) in yield with wetting agent options from the ANOVA.

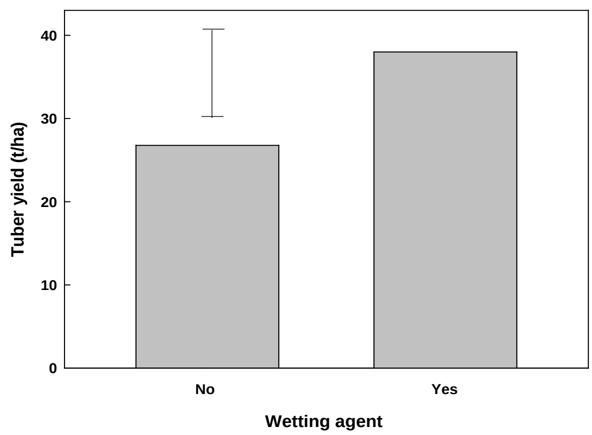

Figure 6.59. Tuber yields and the use of wetting agents in NTB. Bar is LSD for differences (P < 0.10) in relative yield % with wetting agent options from the ANOVA.

The type of sprayer used and the information regarding protective clothing was non significant for all provinces.

6.2 DISCUSSION

The aim of the survey was to identify the most important constraints to potato production for which improved management techniques could offer a solution. These improved management techniques would be tested in LBD plots run by the FIL groups.

The first section of results reporting yields from districts and provinces, as well as the sources of learning and information. This is provided as background information and is not discussed in detail.

6.2.1 Seed quality

Larger seed size and higher quality was in some cases associated with higher yield but not always and in some cases contradictory. Whilst higher yield was associated with higher seed cost, use of purchased versus own seed, selection on size and appearance and weight or diameter it was lower with lower field generation (G) number. This suggests growers are skilled at selecting higher (sanitary) quality seed from their own crops or in purchasing higher quality seed from off-farm sources.

Lower G number doesn't in itself guarantee higher seed quality as it depends on the effectiveness and standards of the relevant seed certification scheme. Higher G number seed could be of at least the same sanitary quality as lower G seed, provided seed scheme rules were adhered to, but this is more likely in temperate environments than in tropical Indonesia. Under the high pressure of diseases experienced in the tropics it is unlikely the seed of greater than G2 would have higher sanitary quality than seed of lower G number. The significant relationship between the higher incidence of PLRV and lower yield in WJ shows the important role of seed schemes in ensuring seed of low virus infection is produced. No significant relationship was shown between yield and % incidence of PVX and PVY in WJ. This information was unfortunately unavailable for the other provinces.

The association of higher yield with shorter sprout length in some cases suggests physiological, as distinct from sanitary, quality maybe an issue as well. Shorter sprout length and lower number suggests younger physiological age and lower tuber number per plant in the subsequent crop (Struik and Weirsema 1999). It may be better in tropical environments to use physiologically younger seed so that crops produce a fewer tubers per plant resulting in a high proportion of large marketable tubers at harvest. Using 'older' seed may lead to a high proportion of small unmarketable tubers that will not 'fill out' if for example the crop growth cycle is shortened by disease.

The many seed factors associated with yield indicate that seed is an important factor in potato production and should be a focus for FIL learning-by-doing plots in the next phase of the project.

6.2.2 Fertiliser management

Higher tuber yield was associated with higher rates of applied N in SS (Fig 6.18) and NTB (Figure 6.15) but not CJ and WJ. Rates of applied N in NTB ranged from 145 to 180 kg N/ha and from 39 to 245 kg N/ha in SS. Rates of applied N recommended for high yields of potatoes in Indonesia ranged from 170 to 237 kg /ha (Duriat *et al.* 2006). This suggests that potato crops in SS and NTB which receive the lower rates of applied N may be short of N and have reduce yield. High yield was not predicted by high concentrations of total N nor extractable nitrate or ammonium N in the soil before planting or % N in the petioles in

NTB and SS. For example there was no evidence of N deficiency based on petiole N at the 10 mm tuber stage in any province and especially NTB and SS (Fig 11, Attachment 2).

Higher tuber yield was associated with higher rates of applied P in SS (Fig 6.19) but not CJ and WJ. In NTB higher yields were associated with medium and high rates of P compared to low rates (Fig 6.16). Rates of applied P in NTB ranged from 45 to 136 kg P/ha and from 7 to 56 kg P/ha in SS. Rates of applied P recommended for high yields of potatoes in Indonesia ranged from 44 to 70 kg P /ha (Duriat *et al.* 2006) suggesting the lowest rates of P applied in NTB and especially in SS could be restricting yield. In NTB petiole P at the 10 mm tuber stage appeared to be deficient across all sites according to both Australian and International Standards (Maier and Shepherd 1998, Huett *et al*. 1997). The significantly higher yield with higher petiole P at the 10 mm tuber stage in NTB supports the proposal the P fertilisation may have been inadequate (Fig 13, Attachment 2). By contrast high yield was not predicted by high concentrations of extractable P in the soil before planting in NTB (not measured in SS).

Higher tuber yield was associated with higher rates of applied K in SS (Fig 6.20) but not CJ and WJ. In NTB higher yields were associated with lower rather than higher rates of applied K (Figure 6.17). Rates of applied K in NTB ranged from 83 to 129 kg K/ha and from 13 to 106 kg K/ha in SS. Rates of applied K recommended for high yields of potatoes in Indonesia ranged from 113 to 163 kg K /ha (Duriat *et al.* 2006) suggesting even the highest rates of applied K used in SS could be limiting yield. It is not clear why lower yields were associated with 129 versus 89 kg K/ha in NTB as this rate is unlikely to cause K toxicity. The concentrations of extractable/exchangeable K in the soil prior to planting appeared to be deficient across all NTB sites (Maier 1986). Despite the higher rates of K applied in NTB to other provinces petiole data that indicated K concentrations were deficient for maximum yield on most sites. The apparent contradictory results between applied K and K in the soil and petioles was considered an ideal opportunity to develop a potassium FIL activity to resolve whether K fertiliser management is an issue in NTB.

6.2.3 Soil acidity

Potatoes are considered more tolerant of acid soils than most other vegetables (Maynard and Hockmuth 2007). Al, Fe and Mn concentrations in soil normally increase as pH declines as was found here with Al and Fe but not Mn (Table 6.3a). It is assumed therefore that potatoes may possess some tolerance to high concentrations of these elements but we found otherwise. For example lower tuber yield of Granola was associated with high Al in soil (pre-planting) (Table 6.4a) and petioles (Table 6.5a) in CJ and WJ. The increased yield of Granola in response to applied lime on an acid soil in Ciwidey WJ was assumed to be due to reduced Al toxicity as the soil pH increased (Subhan and Sumarna 1998). There was no information for NTB and SS as Al was not measured in the soil or petioles in those provinces. Concentrations of exchangeable Al > 0.90 cmol (+)/kg (or 81 mg/kg dry soil, pre-planting) were associated with lower tuber yields of the potato variety Kennebec grown on eight coarse textured soils typical of potato production areas in Canada (van Lierop *et al*. 1982). Results showed 79% of the sites in CJ and 96% of the sites in WJ had exchangeable soil Al levels above 81 mg/kg dry soil, pre-planting (Fig 6.21) and so reduced tuber yield could be expected. This Al value in the soil corresponds to a pH (H_20) in CJ of 6.7 and in WJ of >7.0, considerably higher than the pH below which potato yield is normally expected to be reduced (i.e. 5.0, van Lierop *et al.* 1982). Therefore high soil Al may lower tuber yields in Indonesia more than in Canada and so high soil Al is more important than pH by itself. This is borne out by the survey results where low soil pH was not significantly associated with lower yield in Java (Table 6.4b) even though soil Al was in CJ (Table 6.4a) and soil Al increased at lower pH (Fig 6.21).

There are no published critical concentrations for petiole Al above which excess or toxicity (reduced yield) is expected for potatoes (Huett *el al*. 1997). However it is reasonable to use the critical concentrations for Mn, an essential micro-nutrient, of 200 mg/kg dry weight as guide (Gupta *et al.* 1995) at the 10 mm tuber stage, for Al, a non-essential micro-nutrient. Using this value all crops from had petiole Al concentrations that may contribute to reduced yield.

Lower yield was also associated with high soil and petiole Fe in CJ only (Tables 6.4a and 6.5a).

There was no significant relationship between soil Mn and yield in any province (Table 6.4a) and with petiole Mn in CJ and NTB (Table 6.5a). Other results for Mn in the petiole were contradictory with high yield associated with high petiole Mn in WJ but low yield in SS (Table 6.5a).

In contrast to Al, Fe and Mn, concentrations of exchangeable Ca, Mg and K (the bases) in the soil, pre-planting, usually increases as soil pH increases and this was shown here in all provinces except NTB for Ca and Mg and for K in Java but not NTB and SS (Table 6.3b). In contrast to Al and Fe, higher yield was associated with higher concentrations of Ca in both the petiole and soil (exchangeable) in CJ and WJ but not NTB and SS (Table 6.4b and Fig 6.25). It is interesting to note that higher yield was associated with petiole Ca concentrations above that considered adequate for maximum yield at the 10 mm tuber stage (i.e. 0.5% dry weight, Huett *et al.* 1997). It is possible that higher plant Ca is needed to counteract the negative effects of high plant Al.

By contrast exchangeable Mg in the soil was not related to yield in any province (Table 6.4b) and low yield was associated with high concentrations of Mg in the petiole in CJ and NTB (Fig 6.26).

The identification of soil acidity and associated crop nutrition issues of high soil and plant Al and low Ca is important for sustainable potato production. These issues may be easily solved through soil testing and liming of acid sites. Soil pH should be a focus of FIL learning-by-doing plots in the next phase of the project.

6.2.4 General agronomy

In respect of general crop agronomy (rotation, tillage, weed control, time of planting, depth of sowing, plant spacing etc) a number of factors were sometimes significantly associated with lower or higher yield but this was not consistent across all provinces and was sometimes contradictory. For example higher yield was associated with a higher number of tillage times in CJ but a lower number in WJ and frequency of irrigation was associated with higher yield in NTB but not other provinces and with a lower frequency of irrigation for the relative yield of the 4 provinces combined. Rotation was significant in CJ where highest yield was associated when beans and lowest when tomatoes were the previous crop but not in other provinces. It is generally assumed crops botanically unrelated to potatoes are best used in rotation to minimise the negative effects of pests and diseases that they are poor hosts for. For example none of six species (*Beta vulgaris, Brassica campestris, Hordeum vulgare, Pisum sativum, Triticum aestivum, Zea mays*), commonly used in rotation with potatoes in Canada, were infected by potato isolates of *R. solani (*Bains *et al.* 2002).

In some cases it was not possible to test the factor as all growers carried out the same practice or the information was missing as for example all growers using the same tillage methods in CJ and WJ or no information on tillage methods in NTB and SS. Similarly the higher yield associated with the use of black plastic mulch in CJ may infer improved weed control, or soil moisture retention, in that province but the relationship was not significant in WJ. There was no use of plastic mulch in NTB and SS. Weed control is sometimes underestimated as a factor limiting yield in potato crops in small holdings because of the availability of manual labour and the size of the plantings. However poor weed control is often apparent in crops in Indonesia and the use of plastic mulch may have benefits directly on weed control and indirectly on improving soil moisture or reducing alternate hosts of pests and diseases. The association of higher yield with higher weed number in WJ may reflect better observation of the crop there than an actual reduction in yield. This result was not repeated in other provinces or with the combined data of all 4.

That a factor is not significantly related to yield across all provinces doesn't automatically mean that it is not important in individual provinces and should be addressed. For example wider row spacing and lower planting density was associated with higher yield in NTB but not other provinces. This still maybe worth investigating as Atlantic was grown in NTB compared with Granola in the other provinces and the variety plus growing conditions there may suit lower plant densities. Similarly yield of Atlantic grown from cut seed produced higher yields from lower planting densities due it appears from higher tuber numbers per plant at a high yielding site in West Java (Dawson *et al.* 2004). By contrast higher yield was associated with lower planting density, but higher tuber number per m^2, when whole seed was used. Higher yield was associated with higher sowing density for a number of varieties in Vietnam (McPharlin *et al*. 2003). These contrasting results with density illustrate the need to determine the optimum density for the variety, seed treatment, growing conditions and other requirements specific to the area of interest. In Vietnam for example the low density was related to the need to have wide distances between rows to aid drainage in flood irrigated sites. There was however some capacity to decrease row spacing or use double rows to increase density without jeopardising drainage.

Crop monitoring showed higher yields associated with a longer period of crop growth, between date of sowing and harvest, in WJ and SS but not other provinces. Yield would be expected to be related to period of crop growth with disease like PLB shortening it substantially when out breaks are severe. Similarly higher yield of Atlantic was associated with a longer period of crop growth over 4 sites in WJ in (Dawson *et al.* 2004). The shorter period of crop growth was assumed to be correlated with more severe infections of PLB. There was no consistent relationships between time of planting or harvest and yield in either province but higher yield was associated with later planting when the yield from all 4 was considered. However yield of Granola maybe sensitive to time of planting. For example yield of Granola was reduced by a delay in planting after the 1st of February in Nuwara Eliya and after the 15th of June in Badulla, Sri Lanka (McPharlin *et al*. 2005). Yield of Arka and Desiree also declined when planted after November in Kalitiya in NW Sri Lanka (Kuruppuarachchi 1987).

6.2.5 Potato late blight

Despite there being no significant relationship between yield and incidence of PLB (*Phytophthora infestans)* it was the disease with the greatest recorded incidence in the survey (Tables 6.6 & 6.7). The lack of significance indicates that PLB presence is a constant threat for potato farmers in Indonesia regardless of grower ability and therefore efficient and sustainable management techniques are required. A limitation of the survey technique is that if the incidence of a factor such as PLB is widespread across all or most sites and of some consequence (severe) on all the sites then the chance of deriving a relationship with yield is small. A better chance of deriving relationship with yield with PLB is if there is an accurate assessment of severity at each site and this severity varies with yield. This level of accuracy of assessing severity was not possible in this survey due to missing data, differences in describing severity between districts and the rapid spread of the disease.

It is not surprising PLB was ranked the major issue and it is considered the major biotic constraint to potato production worldwide (Fuglie 2007), with estimates of crop reductions of 15% (de Vries 2004) to 20% (Forbes 2009). With weather conditions highly suitable for the development of PLB epidemics (de Vries 2004); the favoured use of susceptible varieties Granola (de Vries 2004; Fuglie *et al*. 2005,) and Atlantic (de Vries 2004); short or no crop rotations (Jayasinghe 2005) and use of late generation seed, controlling the disease is a constant requirement for Indonesian potato farmers. It is for this reason that control of PLB was ranked the highest priority of needs for the improvement of potatoes in developing countries (Fuglie 2007).

Interestingly, there was a marked difference between the PLB incidence recorded by the farmers and that recorded by the Dinas Pertanian staff during the monitoring (Compare Table 6.6 with Table 6.7). The higher incidence recorded by the farmers indicates that growers may attribute damage caused by other diseases to PLB, whereas the trained Dinas Pertanian staff were correctly identifying the disease. This indicates that correct training in disease symptoms and signs is an important requirement for Indonesian farmers. The relatively low incidence of PLB recorded by Dinas Pertanian staff in CJ is likely the result of the survey taking place during the dry season and therefore the disease pressure for PLB being lower.

Controlling PLB in Indonesia revolves around the use of multiple applications of fungicides with the majority of farmers using either a simple backpack sprayer or motorised hand sprayer. Applications of up to 22 pesticides per potato crop have been recorded previously (van de Fliert *et al*. 1999), with an average of 18 being used specifically to control PLB (de Vries 2004). Chemical usage in NTB indicated growers were spraying between 4 and 20 times specifically for PLB during the crop (data not shown). This adds significant costs to the production of potatoes in Indonesia with conservative estimates of fungicide costs of US $224/ha and a total cost nationwide specifically for PLB at US $180 million (de Vries 2004). Excessive and inefficient use of fungicides to control PLB in Indonesia has been reported in the past (van de Fliert *et al*.1999).

Compounding the overuse of chemicals is the current lack of understanding of what strains of PLB are present in Indonesia. The A2 mating type has been found amongst Indonesian isolates (Nishimura *et al*. 1999) but there is uncertainty as to what strains currently dominate in Indonesia. Several of the farmers surveyed revealed that they are still applying products containing metalaxyl for the control of PLB. Metalaxyl resistant strains are present in several countries in Europe (Erwin and Ribeiro 1996), America and Canada (Fry and Goodwin 1997), and given the presence of the A2 mating type in Indonesia it would be likely that there are resistant strains present in Indonesia.

To combat the high use of fungicides for control of PLB the introduction of resistant cultivars has been encouraged. Several resistant cultivars have been released in Indonesia but uptake of the varieties has not occurred. This is a common occurrence in developing countries with the resistant varieties from the International Potato Center (CIP) accounting for only 6% of the potato producing area in those countries in 1997; a fall from 40% in the 1990's (Walker *et al*. 2001). Market forces, the slow multiplication rate of potatoes, breakdown of resistance and poor or informal seed schemes have lead farmers to favour the use of susceptible varieties (Forbes 2009).

The high incidence of PLB in the survey and the reported overuse of fungicides show that improved control of PLB is an ideal activity for a FIL LBD plot. Better management of this disease may benefit farmers through reduced input costs while maintaining or increasing yield.

6.2.6 Pests

Leafminer fly (Liriomyza huidobrensis)

LMF was consistently recorded despite there being some difference between the incidence recorded by the farmers and the incidence recorded via regular crop monitoring. This may indicate a lack of knowledge on the identification of the symptoms caused by LMF and or the fly itself which was first identified in Indonesia in 1994 (van de Fliert *et al*. 1999). This may explain the situation in NTB where the absence of LMF was associated with higher yields (Fig 6.52). NTB farmers have not been growing potatoes as long as growers in Java or SS. It has been noted that the importance of LMF varies a lot between years and location de Vries (2004). Growers mention that LMF is more of a problem in the dry season than the wet season in Indonesia. However this survey found LMF was a constant issue in both wet and dry growing seasons.

Control of LMF is similar to that of PLB in Indonesia with frequent use of insecticides. Only a small percentage of growers in Java and NTB used yellow sticky traps, an indication of familiarity with integrated pest management methods, and NTB users produced significantly lower yield. Similar low proportions of farmers using management techniques besides pesticides were recorded by van de Fliert *et al*. (1999). It is estimated that total pesticide application for potatoes costs US $378/ha (van de Fliert *et al*. 1999), a third of which is spent on insecticides (Fuglie *et al*. 2005), mainly for the control of LMF. Despite occurring in Indonesia, numbers of natural beneficial predators are low due to the overuse of broad spectrum insecticides (van de Fliert *et al*. 1999).

Potato tuber moth

PTM was another pest that was consistently recorded in all surveys. Temperatures between 20 – 25 °C are optimum for PTM and results in the completion of a generation in approximately three weeks (Hanafi 1999). With a lack of cool storage facilities it is not surprising that PTM is an ever present problem for potato farmers in Indonesia. The finding in WJ that higher yield was associated with growers who reported PTM in their seed before planting (Fig 6.40) may be explained as correct problem identification and subsequent amelioration through seed grading. Growers who didn't report PTM in stored seed may have not recognised infestation symptoms. Added to this most farmers in Indonesia do not practice good seed selection and there is a lack of availability of high quality seed (van de Fliert *et al*. 1999). Improved seed schemes with greater seed and site selection would therefore be an important means of reducing the impact of seed borne pests and diseases (Fuglie 2005).

Potato cyst nematode

Few growers in Indonesia believed that nematodes were present in their crops yet many still used nematicides. It is unlikely that the growers performed soil tests for nematodes prior to planting and were using nematicides as an insurance policy or felt that the nematicides were controlling the nematodes present. Of particular concern is that only one respondent from Java identified PCN as being present on their property. PCN was first identified in East Java in 2003 (Indarti *et al*. 2004) and is now endemic in potato growing areas of highland CJ causing significant yield reductions. Despite government regulations on growing potatoes on land known to have PCN these are poorly regulated and enforced whilst soil is spread easily through movement on and between farms and erosion. If left to continue unabated this will lead to significant problems for the potato industry of Indonesia in the future. In Australia where PCN is closely monitored and the severity much lower than in Indonesia, any spread of PCN is estimated to cost the industry approximately $18.7 million annually and a total cost of $370 million over 20 years (Hodda & Cook 2009). Therefore PCN represents a significant problem for both the Indonesian farmers and government now and in the future.

7 Impacts

7.1 Scientific impacts

The survey identified PLB, LMF, PTM, seed quality and soil acidification/crop nutrition as major limits to potato yield and quality in Indonesia. Identification of PLB as the major disease limiting yield supports findings in previous surveys in Indonesia. It shows that despite major concentrated research and development efforts in Indonesia, usually with international input, control of this disease is still the dominant issue in the management of potatoes. Knowledge of PLB epidemiology including current dominant mating types and specific strains are not known in Indonesia and this is evident from the variable management techniques employed by farmers from the different provinces. Results showed opportunities for more appropriate and efficient use of fungicides for its management. These results were incorporated into LBD plots of FIL groups to assess the agronomic and economic benefits of more appropriate use of fungicides compared to traditional farmer practice.

The survey highlighted that management of pests in Indonesia revolves around the excessive use of broad spectrum insecticides. Discovered in Indonesia in 1994, LMF is considered by growers to be a significant pest particularly in dry season crops. This is despite several large projects identifying suitable softer management practices than broad spectrum chemicals in Indonesia. With this knowledge, targeted extension and practical learning programs were incorporated to educate farmers on the use of biological controls and the practice of IPM to reduce impacts of pests. PTM is a problem pest for Indonesian farmers and is compounded by the poor storage of seed and handling of seed. The poor storage conditions leads to continual infection of PTM and continuation of the lifecycle while there are no crops in the field leading to poor seed quality. These findings led to the development of an Integrated Pest Management LBD plot activity for FIL groups. This was tested in NTB. Results yet to be received.

Seed quality, both sanitary and physiological, was shown to be an important factor in high yield and farmers appeared to be skilful in selecting seed of good sanitary quality in terms of price and source, as well as physiological age, for their needs. The absence of relationships between G number of certified seed, as defined by seed schemes, in most cases and yield is of no concern as seed of the same G number can be of similar quality. It doesn’t imply that certified seed schemes are of limited value in Indonesia but rather their capacity needs to be expanded. Farmers clearly identified availability of affordable high quality seed as a major factor limiting yield. It is difficult to produce large quantities of high quality seed in the tropics using what is essentially a seed scheme appropriate for temperate climates with 4 or more field generations. It is proposed that Indonesia considers augmenting its seed scheme with a hybrid scheme involving the use of Western Australian seed as a primary source of PCN free seed which can be bulked once in areas of Indonesia which are known to be free of PCN and which have low disease pressure. This idea is expanded in Appendix 5.

The identification of soil acidity and associated crop nutrition issues such as high soil and plant Al and low Ca is of interest considering the reputed tolerance of potatoes to low soil pH. These issues have been ranked lowly by experts in previous surveys. This finding does however highlight the continuing problem of soil acidity in high rainfall/leaching environments such as Indonesia. There was awareness of the issue both by scientific staff and farmers as shown by some regular use of limes to counteract the acidifying effect of fertilisers but these issues maybe not addressed in many situations. Soil pH management requires that the needs of other crops in the rotation are taken into account. For example brassicas require a higher soil pH to inhibit clubroot disease. The soil pH needs of the Brassica crop must be balanced against the possibility of over-liming potatoes which may promote diseases such as common scab. In respect of lime use there was an increased capacity of trainers and farmers to more accurately determine lime requirements and a greater appreciation of the aspects of lime quality needed to make the most efficient use of it. Prior to the project there was little awareness of the central role of soil carbon (% organic carbon or %OC) in determining soil pH, in addition to soil particle size, and in particular lime requirements (Atiken *et al.* 1990). For example soil particle size is shown as the main determinant of lime requirements in locally used handbooks (Tantowijoyo and van de Fliert 2006). The role of %OC in soil pH management is dealt with in more detail in the LBD plots and laboratories used by farmers are now informed of the value of measuring %OC.

The failure of the survey to identify some important constraints to yield such as PCN in Java is of concern. Either the selected sites were free of the nematode, assumption that it was controlled or there was inadequate knowledge of the nematode by the farmers and training of the enumerators in the identification of the disease. It is interesting to note that even though farmers often considered nematodes of low priority there appeared to be widespread use of nematicides. Aside from this, the finding in this project that PCN was not known to occur in NTB provides an opportunity for this area to be used as a seed production area for Indonesia free of one of the most damaging diseases of potatoes worldwide. The parallel finding that WA is now declared free of PCN removes an important sanitary barrier between the 2 regions enabling co-operative opportunities in seed production to be explored.

7.2 Capacity impacts

Conducting the survey increased the capacity of the project staff (enumerators or assessors) in survey design, procedures, identification of pests and diseases and other crop disorders, assessment of crop growth, collection and analysis of data. The survey differed from traditional surveys that depended on ranking of limits to yield by expert staff as answers to questionnaires. This survey aimed to be more ‘objective’ by statistically relating growing practices and conditions to yield. This approach required the use of direct measurements of some of the growing conditions such as soil and plant nutrient status as well as monitoring of crops for type and incidence of pests and diseases and crop growth and development. All measurements were taken from a 50 m^2 monitoring plot which was used at harvest to accurately measure yield (Figure 7.1). Staff understanding and skill in these areas was improved as the results of the surveys attest. Staff needed to take and submit soil and plant samples correctly (Figure 7.2) as well as monitor pests and diseases, with the aid of purposely designed identification booklets, and assess crop growth according to detailed protocols in the sampling area at each grower site. These tasks were very demanding as the enumerators had to not only collect a large amount of data on practices from interview by also follow strict protocols for collection of samples and identification of pests and diseases as described. Potato crops in the tropics are commonly infested with a number of pests and diseases especially near maturity. Identification of diseases by visual symptoms is difficult due to the damage caused by the interaction of other pests and diseases and sometime agronomic limits such as fertiliser deficiency. It takes skill in making accurate assessments at each site in these circumstances compared with for example experiments were factors are controlled. The enumerators performed exceptionally well, and the respondent farmers very generous and co-operative, in coping with very demanding survey in terms of the data collected. The analysis of soil and plant samples at the IVEGRI in WJ and BPTP laboratories in NTB and SS was of a high standard. There was increased understanding of the central role of soil carbon in determining lime requirements and in important aspects of lime quality in selecting the most appropriate lime in each situation.

Surveys like this which include monitoring and direct measurements are more costly than questionnaire-only surveys. This means it is necessary to use a smaller number of sample sites but the benefits are more detailed and reliable data from each site. However site numbers were adequate for appropriate statistical analysis especially in Java and when data from all 4 provinces were combined. The direct measurements and monitoring by staff was a useful cross check on answers in the questionnaire. For example it was possible to cross check rankings of types and incidence of pests and diseases from monitoring with answers from farmer respondents to the questionnaire. Similarly respondent answers to type and rates of applied fertiliser could be evaluated against measures of soil and crop nutrient status.

7.3 Community impacts

The main limits to yield identified by the baseline survey formed the main focus of the LBD plots in the FIL activities in the four provinces. These LBD plots aimed to test new management techniques which may improve the sustainability and profitability of potato production in the relevant areas. For example more effective use of pesticides (fungicides/insecticides) which are appropriate for the target pest maximise profit and minimise waste in the environment. The use of insecticides 'soft' on predators of insect pests but effective on the target pests benefit the environment and the community. Important health and safety information with the dealing of agricultural chemicals and their correct disposal was presented to farmers to minimise exposure of individuals, the community and the environment. This was the aim of all LBD activities arising from the survey related to disease and pest management.

Management of soil pH is a persistent sustainability issue which is common in wet tropical areas such as Indonesia and must be managed for all crops in the rotation. With greater knowledge and skill in assessing lime requirements and selecting the most appropriate lime, on specific quality parameters, farmers will be able to make more effective and profitable decisions in the use of lime.

7.4 Communication and dissemination activities

Table 7.4. Potato baseline survey communication and dissemination activities.

Date	Personnel	Organisation & Position	Location	Activities
Sep 06	Ian McPharlin Peter Dawson Julie Warren Peter Ridland Elske van de Fliert Bruce Tomkins	Potato Agronomist Potato Seed Specialist Economist Potato Entomologist Extension Specialist Post Harvest Specialist	Lembang	Preparation of final version of survey questionnaire. Presentations on GAP for potato production. Training in techniques for components of survey.
Oct 06	Peter Dawson Fiona Goss	Potato Seed Specialist Youth Ambassador	Lembang	Practical training in techniques for components of survey.
Jan 07	Ian McPharlin Roger Jones Fiona Goss	Potato Agronomist Potato Virologist Youth Ambassador	W and C Java	Practical training in survey techniques in West and Central Java potato crops including sampling for viruses. Presentation on virus management.
Aug 07	Ian McPharlin	Potato Agronomist	Pangalengan	Training in analysis of survey results, presentation of preliminary results in WJ at TOT Workshop.
Dec 07	Andrew Taylor	Potato Pathologist	Kledung (C Java)	Presentation of CJ potato crop survey findings
Feb 08	Ian McPharlin Peter Dawson Andrew Taylor	Potato Agronomist Potato Seed Specialist Potato Pathologist	Bandung	Presentation of CJ and WJ (combined) potato crop survey findings
Aug 08	Ian McPharlin Andrew Taylor Dolf De Boer Peter Ridland	Potato Agronomist Potato Pathologist Potato Pathologist Potato Entomologist	Kledung	Cabbage baseline and preparation of LBDs for potatoes and cabbage FFS
Feb 09	Andrew Taylor	Potato Pathologist	South Sulawesi, C Java.	Training for PLB trials in Sulsel for LBD plots. Design and implement correct LBD plots in C Java.
Oct 09	Andrew Taylor	Potato Pathologist	Bandung (W Java)	Review field sites for upcoming LBD plots. Training of facilitators of LBD in WJ including experimental design, PLB monitoring, seed, gross margin and insect control. Questionnaire on the effectiveness of the training program,

Figure 7.1. Enumerators setting up a survey monitoring plots and taking pre planting soil samples.

Figure 7.2. Training enumerators in plant sampling for petiole nutrient content analysis.

8 Conclusions and recommendations

8.1 Conclusions

The survey was successful in identifying growing conditions and practices associated with high yield. Whilst the survey identified numerous limits to yield it was thought prudent to focus on 4 major areas (PLB, IPM of pests, seed quality and soil acidity) as it was more likely that improvements could be made if effort was focussed on fewer areas than trying to address all possible limits. These 4 areas subsequently formed the basis of the LBD plots in the FIL groups.

In some instances the major limits confirmed findings of previous surveys and general farmer knowledge for example diseases and pests such as PLB, LMF and PTM. Factors with widespread incidence, such as PLB, are difficult to relate to yield as they are often recorded on all or most of the sites. Such relationships with yield can be derived if there is an accurate assessment of severity at each site. This was not possible here due to the variability in the skills of the assessors, the rapid spread of the disease within a crop, the visual symptoms of other factors limiting yield interacting with that of PLB or other pests and diseases and missing data. However our methodology allows for relationships to be further tested in the LBD plots of the FIL groups.

In other cases the limits identified were unexpected such as high soil and plant Al and low Ca, associated with low soil pH, contributing to low yield in Java. Previous surveys have ranked soil acidity low in priority but agronomic factors in conjunction with improved pest and disease control, and the varietal tolerance of, have been ranked higher. It is important to point out that Al toxicity associated with low pH was the specific issue rather than pH alone. Whilst potatoes in general tolerate low pH soils, and there is evidence that high pH increases the incidence of common scab, high extractable Al in acid soils can reduce growth. The concentrations of extractable Al in the potatoes soils of CJ and WJ were high compared to internationally published standards for Al excess in potato soils. Al in soil and plant was not measured in NTB and SS.

This survey educated Indonesian farmers and scientists in the process of undertaking scientific assessment and evaluation. Farmers were empowered to take their own samples, including soil, pH and petiole, whilst also educated in processes of the scientific method despite there being a vast difference in education levels between districts and amongst provinces. By highlighting the fact that many variables are involved in producing high yielding potatoes the capacity of those involved in the survey was improved.

8.2 Recommendations

It appears that the importance of nematodes such as PCN were underestimated or overlooked as a major limit to potato production in CJ and WJ. It is therefore recommended that there is more training of assessors in the identification of nematodes.

It was difficult to get an accurate assessing severity of diseases in this survey due to missing data, differences in describing severity between districts and the rapid spread of the disease. This information is important in deriving statistical relationships between yield and ‘severity’ which is an important measure, in addition to ‘incidence’, of the impact of a disease on crop yield and quality. More practical training of ‘assessors’ in the measurement of the severity of the main potato diseases is recommended

It is recommended that pesticide education for farmers continue through reputable sources to prevent growers from being influenced by salesman promoting quick fix solutions and inappropriate products. Farmers from all 4 provinces were consistently found to be using excessive amounts of both insecticides and fungicides or unproven biopesticides during the study. Continued education on issues such as the appropriate dosage, rotation of chemicals, types of chemicals is needed to help farmers make more informed decisions particularly as new products are developed and established.

Further education on the occupational safety and health issues associated with potato farming in Indonesia are required. The majority of farmers are self taught or have had their farming practices passed down through the family and therefore aspects of safety surrounding the storage and handling of chemicals, safe machinery operation and manual labour need to be presented.

Better storage facilities for seed potatoes are required in Indonesia to prevent physiological ageing of potatoes and seed infected with pests and diseases. Simple, cheap and effective storage designs are required to improve the seed performance and to increase yield and profitability.

Given the finding the excess soil Al, as a consequence of low soil pH, may have contributed to lowering potato yield in CJ and WJ it is important that laboratories in Mataram and Maros have the capacity to measure extractable Al in the soil and total Al in the petioles. All soil laboratories had the capacity to measure % organic carbon (%OC) in the soil so it was more that research and extension staff needed to be more aware of the role of OC in the determining soil pH and in lime requirements to change pH.

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10 Annexes

10.1 Annex 1. Agronomy baseline survey questionnaire

To identify potato cropping and post-harvest practices capable of providing maximum yield, quality and profit in Central and West Java.

Characteristics of selected farmers:

Large and small-scale farmers
Farmers cultivating potato and brassicca
Farmers who had yet to plant potato crops at the time of selection

Location code/identification (Province/District/Subdistrict/Village) and name of farmer determined by IVEGRI staff member for the purpose of analysis.

Province :.. (Filled in by staff member).

District :..

Subdistrict :......................................; Village
....

Farmer's Name :..

10.1.1 FIRST VISIT – Prior to planting potato crop

Name of staff member/interviewing officer:

Date of the first visit:

To be filled in by staff member:

1) Crops grown at an elevation of: ……………….metres above sea level

2) Soil sample taken:

Day: ………………..…../Date:…………………..…/Month: ………………..….

3) How steep is the gradient of the land?

(1) Flat (0 – 10 %)

(2) Gentle slope (11 – 30 %)

(3) Steep slope (> 30 %)

4) How deep is the soil layer?

(Measure soil depth: in 3 places to a depth 40 cm)

Soil analysis - (Collect 25 soil sub-samples, mix them into one composite sample and send to Balitsa for analysis)

To be filled in by Soil Laboratory officer at IVEGRI:

5) Analysis covering/ soil texture

1. Loam
2. Sandy-loam
3. Clay

6) Soil nutrient analysis:

pH		
N-total		
NO_3-extractable		
NH_4-extractable		
P		
K		
Mg		
Ca		
S		
Na		
Fe		
Mn		
Cu		
Zn		

AGRONOMIC PRACTICES

To be answered by farmer:

7) How many years have you been growing potatoes?

8) Where did you learn to grow potatoes?

From father or family member
Self taught
Formal training (please state details...)
PHT field school
Other (please state details...)

9) When are you planning to plant your next potato crop?

………..

10) State the origin of the seed potato you are planning to plant. Please explain % and generation

Source	%	Generation
1. Self-produced		
2. Purchased		

11) If you purchased them, where did they come from?

.... generation local certified seed
.... generation local non-certified seed

Imported seed

12) If you purchased imported seed, which country did they come from?

1. Australia
2. Germany
3. Scotland
4. Canada
5. Holland
6. Other: ……………
7. Don't know

13) If you purchase imported seed, what is your preferred country of origin?

1. Australia
2. Germany
3. Scotland
4. Canada
5. Holland
6. Other: ……………
7. Don't know

14) What are your reasons for choosing imported seed from that country? ……………

15) What generation is the seed you are planning to plant? ……………

16) If you use your own seed, how many seasons have you used it for? ……………

17) What variety of seed are you going to you plant? ……………

18) When you purchased the seed, how many varieties were available in the market? ....varieties

19) Please state the varieties available in the market:

....

20) What variety did you buy?

....

21) Was the reason for you choosing to buy that variety a result of:

When you chose that variety, to what extent was your choice affected by the factors below? Please state:

Reason	Not at all important	Not important	Slightly important	Important	Very important
1. Cheap price					
2. Agronomic character					
3. To suit contract with buyer					
4. Only that variety was available					
5. From experience the variety is good					
6. Suited market demand/high selling price					
7. Recommended by supplier					
8. Recommended by the government					
9. Recommended by other farmers					

22) Have you ever heard of the varieties below? If yes, have you tried growing them in your fields?

Variety	Familiar Yes/No	Have tried growing before Yes/No
1. Manohara		
2. Amudra		
3. Merbabu		
4. Revita		
5. Tango		
6.Balsa		
7. Friesta		
8. Crespo		
9. Erika		
10. Granola L		
11. Atlantic M		

23) In general what are your considerations when buying seed potato?

Criteria	Not at all important	Not important	Slightly important	Important	Very important
1. Cheap price					
2. Agronomic character/variety					
3. Generation					
4. Origin of imported seed					
5. Recommended by seed supplier					
6. Recommended by extensions officer/government					
7. Recommended by other farmers					

24) How much does seed cost? ………….. Rp/kg

1. Price when you purchased it - Rp.........

2. Current market price for seed - Rp..........

25) Do you select and grade seed quality before planting?

1. Large seeds are bisected

2. Small seeds are planted with a tight spacing

3. Damaged seeds are thrown away. What % is discarded?: …………….%

4. No seed grading.

26) What criteria/characteristics do you use to select seed?

Size
Appearance (diseased/damaged)
Size and appearance

27) How do you store seeds?

1. In bamboo baskets exposed to daylight.

2. In hessian sacks exposed to daylight.

3. In bamboo baskets in the dark

4. In hessian sacks in the dark

5. In a cool store

6. Other: …………………………………………………………

28) How long do you store seeds before planting? ………… months

29) Are seeds damaged by pests and diseases while in storage? If yes, list the pests/diseases that cause damage:

LOCAL NAME	SCIENTIFIC NAME

30) While seed is in storage do you apply fungicide, insecticide or rodenticide? If yes, please state the names of pesticides used:

Brand name	Active ingredients

31) Approximately how many shoots do seed tubers have when planted?
…………………………………………………………………………………………......................................

32) Approximately how long are the shoots when planted? …………. cm

33) Do you usually pull up unhealthy plants when planting in the field?

1. Yes

2. No

10.1.2 SECOND VISIT – (When shoots reach approximately 10mm in length)

Name of staff member/interviewing officer:

Date of visit

34) Date/month planted: ....

35) Were chemicals applied to the seed when planted? If yes please state

Active ingredient	Brand name
Carbendazim	
Thiram	
Captan	
Other (please state): …………..	
No chemical application	

36) Approximately how deep were the seeds planted? ………… cm

37) How big were the tubers planted?

Number of tubers per kg : ……………………………………….

38) What was the plant spacing?

1. Double rows in beds

Spacing in the rows? …………...…. cm

Spacing between rows? …………. cm

2. Single rows

Spacing in the rows? …………...…. cm

Spacing between rows? …………. cm

39) Are poles used to support the plant canopy?

1. No
2. Yes

40) Is mulch used?

No
Silver black plastic
Plant stubble/straw
Other: …………………………………………………..

CROP ROTATION

41) How many crop types are planted in the location per year? ....types

42) How many times are potatoes planted in the location per year? ....times

43) What crops are planted in the area other than potatoes?

44) What is the distance from the closest neighbouring potato field?

TILLAGE

45) How is the land tilled before planting?

Ploughed and turned by hand tractor
Ploughed by hand tractor and turned manually
Tilled entirely by hand

46) How many times is the land tilled?

47) Explain tilling methods

Using machinery
Using manual labour
Other: ……………………………………………….

48) Are raised seedbeds used?

1. yes
2. no

49) If raised seedbeds are used:

1. Seedbeds are piled up ....times
2. Height of the raised seedbeds.............cm

Further crop monitoring conducted by staff member/officer:

Monitoring growth and soil moistness

Criteria	Result
Date of the first visit:	
Rainfall since planting (mm)	
Number of plants	
Number of primary branches	
Canopy height (cm)	
Has canopy cover reached 100%? (Yes/no)	
Length of longest tuber (mm); 2 tubers /row	
Soil moistness (dry, wet, too wet)	

Pest monitoring and management

Pest monitoring and management	Tuber moth	Aphid	Thrips	Leafminer fly	Whitefly
Date					
Pest					
Number per plant					
Severity (5%, 5-25%, >25%)[1]					
Management used by farmer[2]:					

[1] For Aphids > 20 per plant = heavy, for leafminer flies use the published scale

[2] Specify chemicals used, number of applications and doses

Disease monitoring and management

Criteria	Result
Date	
Disease	
Number of plants affected	
Severity (light/medium/heavy)	
Management used by farmer[1]:	

[1] Specify chemicals used, number of applications and doses

10.1.3 THIRD VISIT – 2 WEEKS AFTER SECOND VISIT

Name of staff member/interviewing officer:

Date of visit

PEST AND DISEASE MANAGEMENT

50) Soil treatment for pest and disease control

Active ingredients	Brand name
Bleaching Powder	
Formaldehyde	
Azoxystrobulin	
Tolclofos-methyl	
Chlorpyrifos	
Neem	
Fipronil	
Phorate	
Others:	

51) What types of nematodes are affecting your potato crops?

(1) No nematodes
(2) Don't know
(3) Golden cyst nematodes
(4) Rootknot nematodes
(5) Other: ………………………………………..

52) Do you apply nematicide before planting? If yes, please specify

Active ingredients	Brand name
No application	
Carbofuran	

53). What insecticides do you use to control pests before planting?

Active ingredients	Brand name
Neem	
Fipronil	
Esfenvalerate	
Methamidophos	
Abamectin	
Permethrin	
Acephate	
Acetamiprid	
Carbaryl	
Dichlorvos	
Dimethoate	
Endosulfan	
Imidacloprid	
Cyhalothrin	
Cypermethrin	
Methidathion	
Methomyl	
Omethoate	
Pirimicarb	
Pymetrozine	
Sulphur	
Spinosad	
Thiodicarb	
Cyromazine	
Profenofos	
Cartap	
Dimehypo	
No control	

54) What pests affect your potato plants?

	Scientific names	Local names
Aphids		
Thrips		
Cutworm larvae		
Whiteflies		
Cotton aphids		
Mites		
Tuber moths		
Leafminer flies		
Slugs		
10. Locusts		
11. Mole crickets		
12. Other (specify)		

55) Do you use yellow/blue sticky traps to monitor leafminer flies (Liriomyza)?

No
Yes

56) Are any plants wilting?

No
Yes

57) If yes, what it the cause?

Scientific names	Local names
1. Bacterial wilt	
2. Fusarium wilt	
3. Soft rot	
4. Lack of water	
5. Other	

58) Specify any leaf rot diseases affecting your crops

Scientific Names	Local Names
1. None	
2. Late blight *(P. infestans)*	
3. Early blight *(A. solani)*	

59) Specify any other diseases affecting your crops

Scientific names	Local names
1. None	
2. Scab	
3. Potato leafroll virus	
4. Potato virus Y	
5. Stem canker (*Rhizoctonia solani*)	
6. Black rot (Black leg)	
7. White mold (*Sclerotinia*)	
8. Other (specify)	

Further data entry/growth monitoring to be conducted by interviewing officer:

Monitoring growth and soil moistness

Criteria	Result
Date of the first visit:	
Rainfall since planting (mm)	
Number of plants	
Number of primary branches	
Canopy height (cm)	
Has canopy cover reached 100%? (Yes/no)	
Length of longest tuber (mm); 2 tubers /row	
Soil moistness (dry, wet, too wet)	

Pest monitoring and management

Criteria	Result
Date	
Pest	
Number per plant	
Severity (light/medium/heavy)[1]	
Management used by farmer[2]:	

[1] For Aphids > 20 per plant = heavy, for leafminer flies use the published scale

[2] Specify chemicals used, number of applications and doses

Disease monitoring and management

Criteria	Result
Date	
Disease	
Number of plants affected	
Severity (light/medium/heavy)	
Disease control used by farmer[1]:	

[1] Specify chemicals used, number of applications and doses

10.1.4 FOURTH VISIT – 2 WEEKS AFTER THIRD VISIT

Name of staff member/interviewing officer:

Date of visit

Weeds

60) Are weeds a problem for your potato crop?

Scientific names	Local names
1. No	
2. Grasses	
3. Broad leafed weeds	
4. Don't know	

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61) How do you control weeds before planting?

By hand
Mechanical weeding…………………(specify)
Using chemicals: ………………… (specify)
Other: ………………………………

62) How do you control weeds after planting?

By hand
Mechanical weeding…………………(specify)
Using chemicals: ………………… (specify)
Other: ………………………………

IRRIGATION

63) What irrigation methods do you use?

No irrigation
Water channels
Watering
Water channels and watering
Sprinkler
Hose & nozzle
Other

64) How many times do you irrigate your plants in a week? ……………

65) Is there sufficient water for irrigation?

(1) yes

(2) no

66) Where does water for irrigation come from?

None
Dam
River
Water tank
Other: ……………………………..

Water quality data to be completed and filled in by interviewing officer:

(Analysis of water quality for pesticide dilution)

Criteria	Result
1. pH	
2. Salt concentration	
3. Bacteria	present or absent
4. Other	

(Irrigation water analysis)

Criteria	Result
1. pH	
2. Salt concentration	
3. Bacteria	present or absent
4. Other	

Data to be completed and filled in by interviewing officer:

Monitoring growth and soil moistness

Criteria	Result
Date of the first visit:	
Rainfall since planting (mm)	
Number of plants	
Number of primary branches	
Canopy height (cm)	
Has canopy cover reached 100%? (Yes/no)	
Length of longest tuber (mm); 2 tubers /row	
Soil moistness (dry, wet, too wet)	

Pest monitoring and management

Criteria	Result
Date	
Pest	
Number per plant	
Severity (light/medium/heavy)[1]	
Management used by farmer[2]:	

[1] For Aphids > 20 per plant = heavy, for leafminer flies use the published scale

[2] Specify chemicals used, number of applications and doses

Disease monitoring and management

Criteria	Result
Date	
Disease	
Number of plants affected	
Severity (light/medium/heavy)	
Disease control used by farmer[1]:	

[1] Specify chemicals used, number of applications and doses

10.1.5 FIFTH VISIT – 2 WEEKS AFTER FOURTH VISIT

Name of staff member/interviewing officer:

Date of visit

FERTILISER

67) Type of chemical fertiliser (e.g. Urea) and other material (e.g. compost, dolomite, organic fertiliser) applied before and after planting

Date	Name	Doses	Unit	Comments
Before				
After				

PESTICIDE SAFETY

68) What form of protection is used when spraying?

None
Masker
Plastic coat
Waterproof gloves
Other protection: ……………………………..

69) Where is information about pest and disease management obtained?

From other farmers
From extension officers
From pesticide shops
From pesticide company representatives
Other: …………………………………

70) How is spraying undertaken?

Using back pack sprayer
Motorised sprayer
Watering can
Other: …………………………………………..

71) What wetting agents do you use when applying pesticide?

None
Agral
Other: …………………………………..

Monitoring growth and soil moistness

Criteria	Result
Date of the first visit:	
Rainfall since planting (mm)	
Number of plants	
Number of primary branches	
Canopy height (cm)	
Has canopy cover reached 100%? (Yes/no)	
Length of longest tuber (mm); 2 tubers /row	
Soil moistness (dry, wet, too wet)	

Pest monitoring and management

Criteria	Result
Date	
Pest	
Number per plant	
Severity (light/medium/heavy)[1]	
Management used by farmer[2]:	

[1] For Aphids > 20 per plant = heavy, for leafminer flies use the published scale

[2] Specify chemicals used, number of applications and doses

Disease monitoring and management

Date	
Disease	
Number of plants affected	
Severity (light/medium/heavy)	
Disease control used by farmer[1]:	

[1] Specify chemicals used, number of applications and doses

10.1.6 SIXTH VISIT – HARVEST TIME

Harvest data

73) Date/month of harvest: …………………………………………………..

74) Why did you choose this date for harvesting?

1) High market price
2) Weather
3) Other reason: ……………………………………………………….

75) How many more weeks would the crop have lived, if you had not harvested it early? :………

76) What time of day did harvesting take place?

In the morning
In the afternoon
All day

77) Yield: weigh and record for a sample unit area of $50M^2$

Tuber class	Weight (g)	Number of tubers
< 30 mm		
30-50 mm		
>50 mm		
Rejected		
Main reason for rejection *		

* Select: disease, pest damage, mechanical damage, too large, other.

10.2 Annex 2. Tuber yield with petiole nutrient concentration tuber stage 1 (10mm)

10.2.1 Micro Nutrients

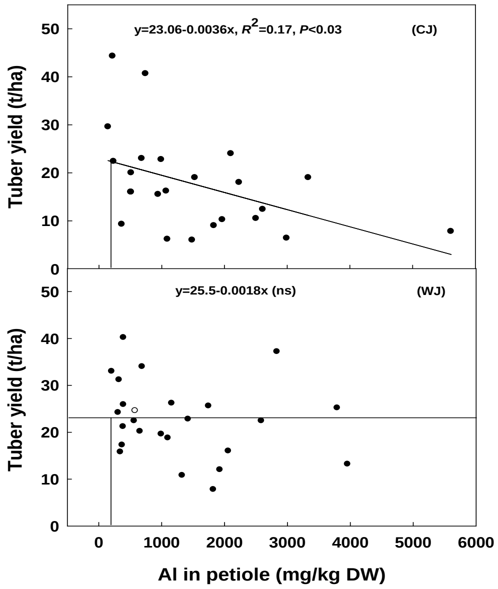

Figure 1. Linear regression between tuber yield (t/ha) and Al concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ) and West Java (WJ). Nutrient values higher than vertical line intercept will reduce yield.

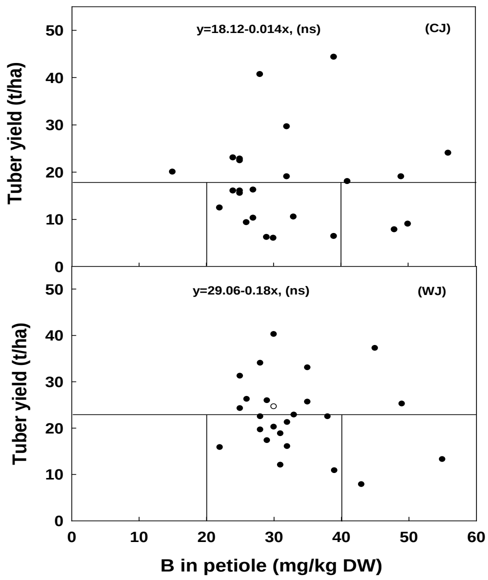

Figure 2. Linear regression between tuber yield (t/ha) and B concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ) and West Java (WJ) Nutrient values between vertical line intercepts adequate for maximum yield (after Huett *et al.* 1997).

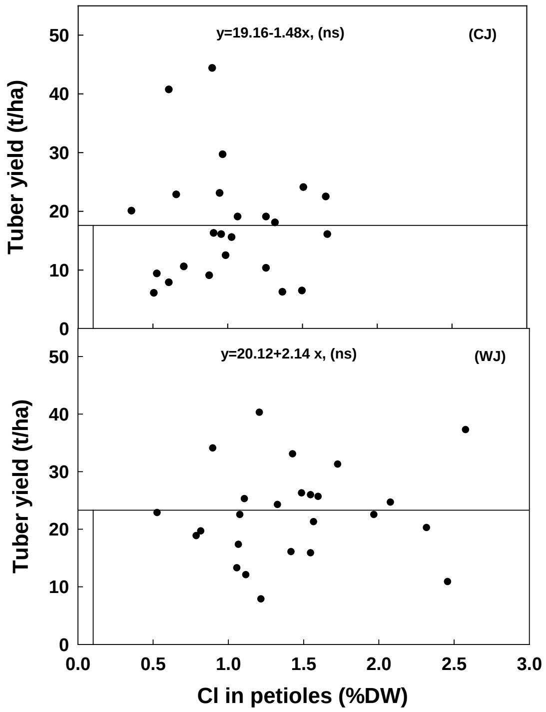

Figure 3. Linear regression between tuber yield (t/ha) and Cl concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ) and West Java (WJ). Nutrient values higher than vertical line intercept will reduce yield (after Huett *et al.* 1997).

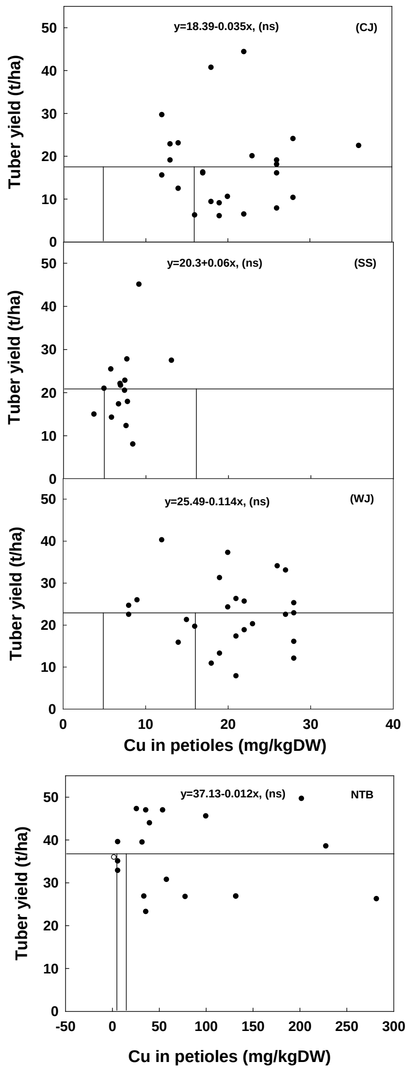

Figure 4. Linear regression between tuber yield (t/ha) and Cu concentration (mg/kg DW) in petioles at tuber stage 1 (10mm) for potatoes in Central Java (CJ), South Sulawesi (SS), West Java (WJ) and Nusa Tenggara Barat (NTB). Nutrient values between vertical line intercepts adequate for maximum yield (after Huett *et al*. 1997).

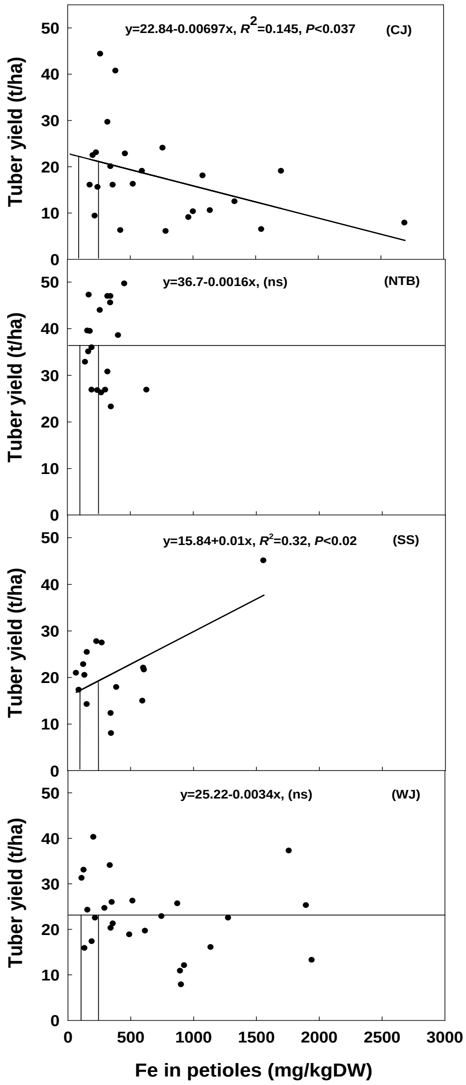

Figure 5. Linear regression between tuber yield (t/ha) and Fe concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ), Nusa Tenggara Barat (NTB), South Sulawesi (SS) and West Java (WJ). Nutrient values between vertical line intercepts adequate for maximum yield (after Huett *et al.* 1997)

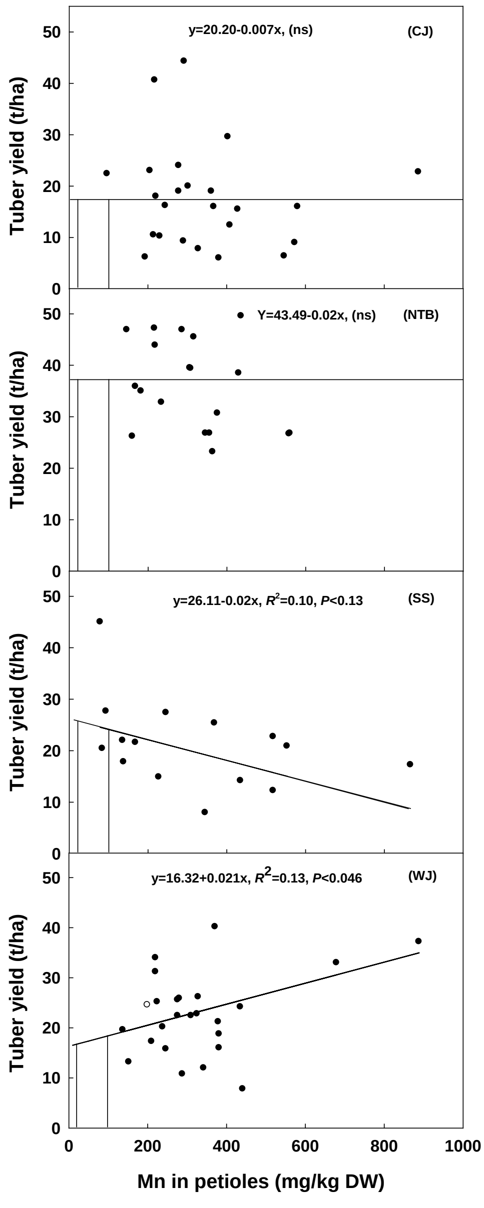

Figure 6. Linear regression between tuber yield (t/ha) and Mn concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ), Nusa Tenggara Barat (NTB), South Sulawesi (SS) and West Java (WJ). Nutrient values between vertical line intercepts adequate for maximum yield (after Huett *et al.* 1997).

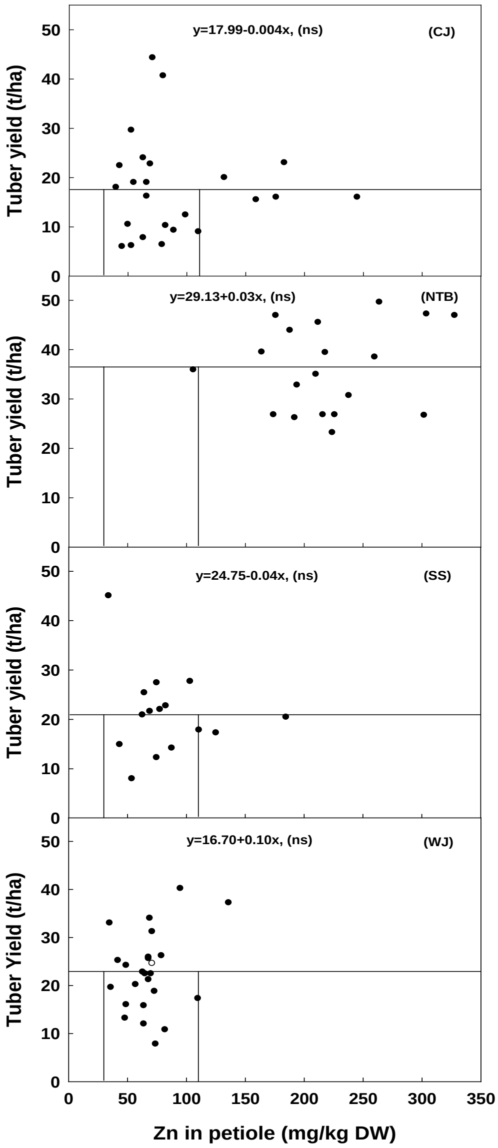

Figure 7. Linear regression between tuber yield (t/ha) and Zn concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ), Nusa Tenggara Barat (NTB), South Sulawesi (SS) and West Java (WJ). Nutrient values between vertical line intercepts adequate for maximum yield (after Huett *et al.* 1997).

10.2.2 Macro Nutrients

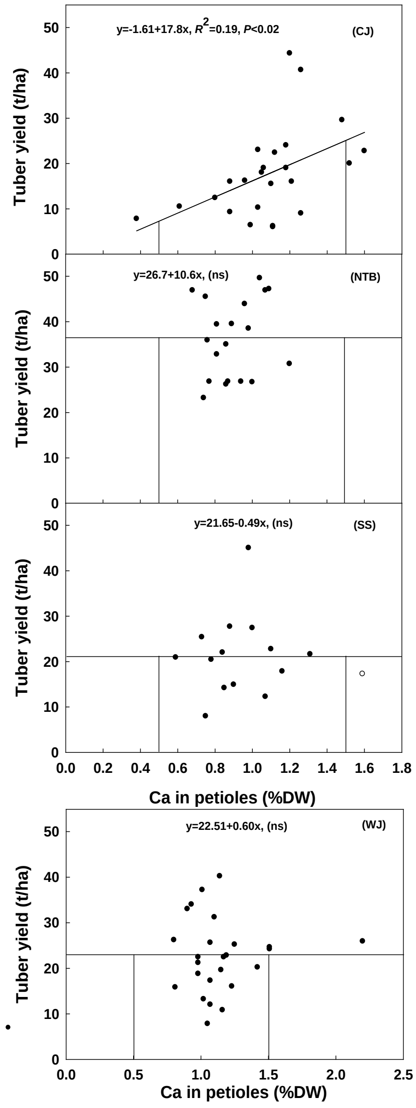

Figure 8. Linear regression between tuber yield (t/ha) and Ca concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ), Nusa Tenggara Barat (NTB), South Sulawesi (SS) and West Java (WJ). Nutrient values between vertical line intercepts adequate for maximum yield (after Huett et al. 1997).

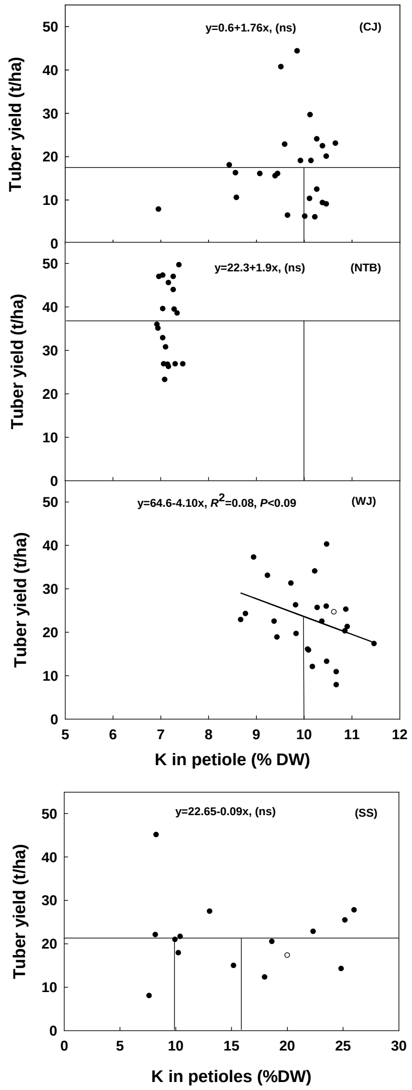

Figure 9. Linear regression between tuber yield (t/ha) and K concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ), Nusa Tenggara Barat (NTB), West Java (WJ) and South Sulawesi (SS). Nutrient values less than vertical line intercept deficient for maximum yield in CJ, NTB and WJ and between vertical line intercepts adequate for maximum yield in SS(after Huett *et al.* 1997).

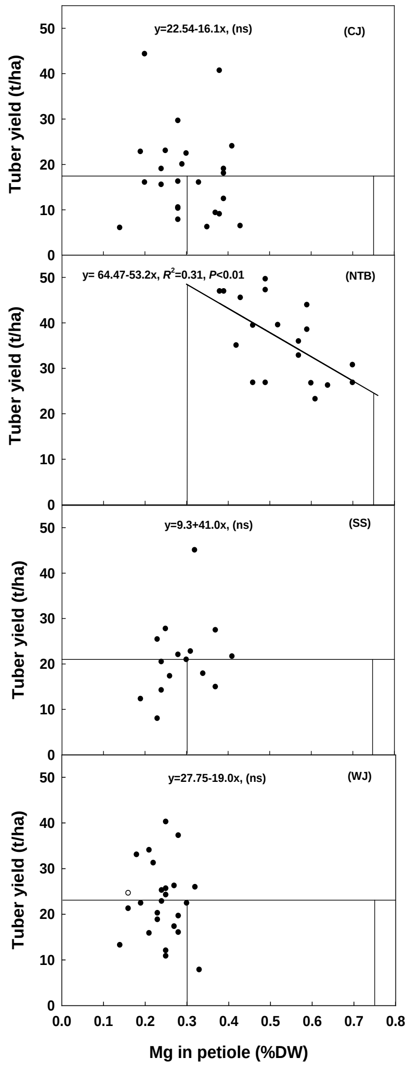

Figure 10. Linear regression between tuber yield (t/ha) and Mg concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ), Nusa Tenggara Barat (NTB), South Sulawesi (SS) and West Java (WJ). Nutrient values between vertical line intercepts adequate for maximum yield (after Huett *et al.* 1997).

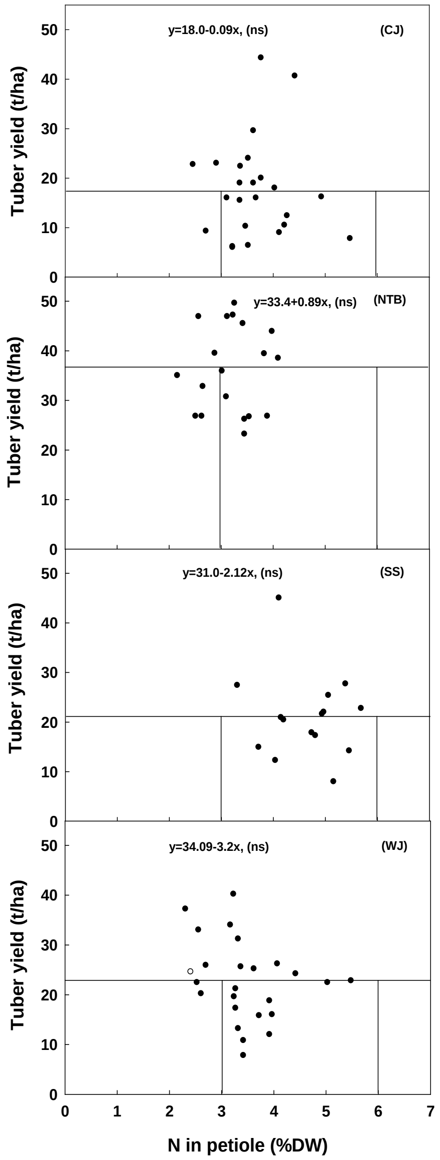

Figure 11. Linear regression between tuber yield (t/ha) and N concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ), Nusa Tenggara Barat (NTB), South Sulawesi (SS) and West Java (WJ). Nutrient values between vertical line intercepts adequate for maximum yield (after Huett *et al.* 1997).

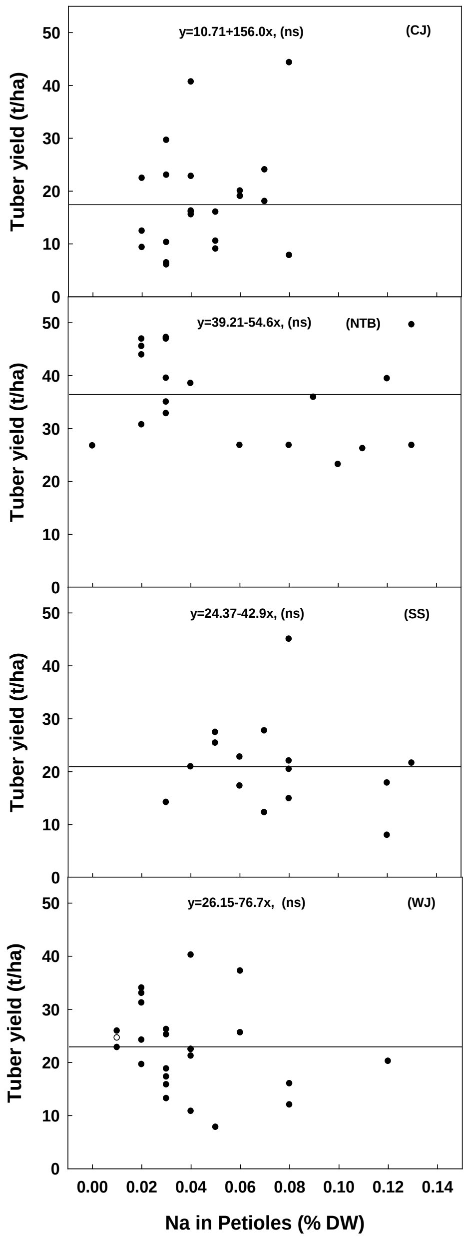

Figure 12. Linear regression between tuber yield (t/ha) and Na concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ), Nusa Tenggara Barat (NTB), South Sulawesi (SS) and West Java (WJ). All values less than concentration that reduces yield(after Huett *et al*. 1997).

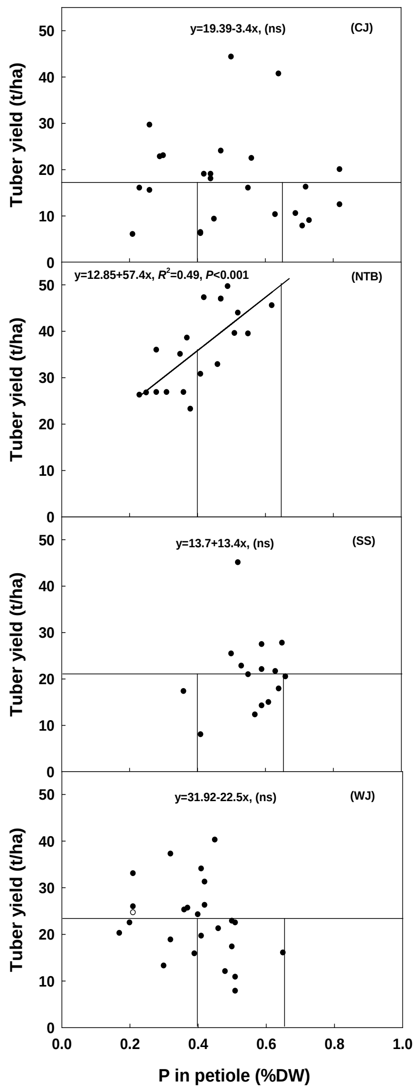

Figure 13. Linear regression between tuber yield (t/ha) and P concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ), Nusa Tenggara Barat (NTB), South Sulawesi (SS) and West Java (WJ). Nutrient values between vertical line intercepts adequate for maximum yield (after Huett *et al.* 1997).

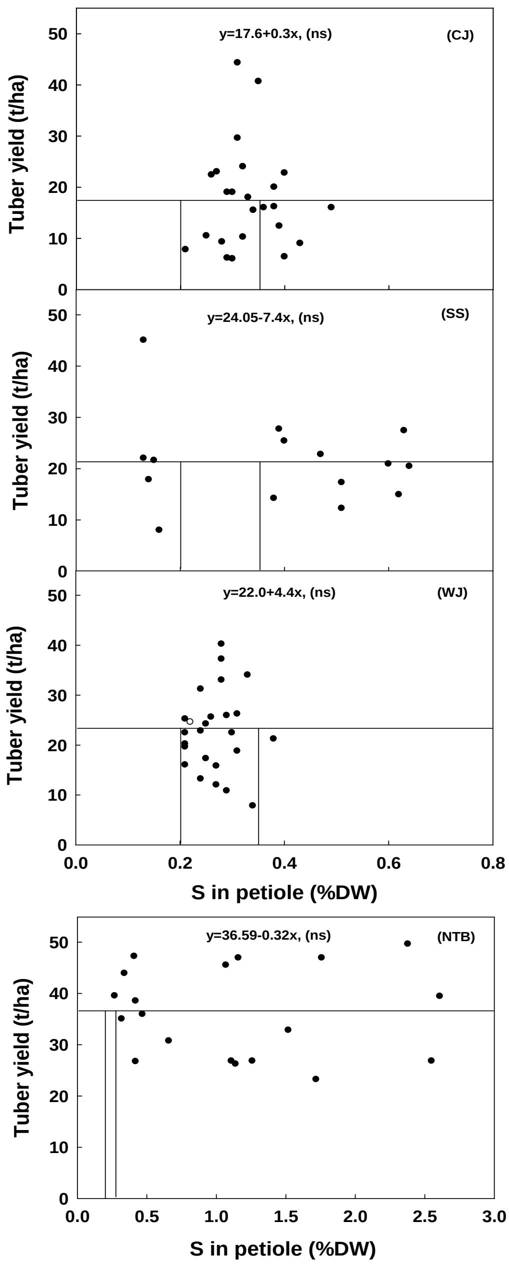

Figure 14. Linear regression between tuber yield (t/ha) and S concentration (mg/kg DW) in petioles at tuber stage 1(10mm) for potatoes in Central Java (CJ), South Sulawesi (SS), West Java (WJ) and Nusa Tenggara Barat (NTB). Nutrient values between vertical line intercepts adequate for maximum yield (after Huett *et al.* 1997).

10.3 Annex 3. Participatory rural appraisal. The agronomic and pest management practices of potato farmers in Gowa district, South Sulawesi

Muh. Asaad, Baso Aliem, Warda, Nasrullah and Hilda Tahir
South Sulawesi Assessment Institute for Agricultural Technology

10.3.1 Abstract

Potato is one of the most important horticulture commodities in South Sulawesi. Planted area of potato about 2,720 ha with the productivity of 7.02 t/ha. To identify agronomic and pest management practices of potato farmer and farming problems it was done survey with PRA approach at two subdistrict (Tinggimoncong and Tombolopao) in Gowa district. Result indicated that granola was the most popular variety planted by farmers. Most of farmers planted seed grade G4 with spacing of 25 cm x 80 cm. Most of farmers planted on February or March during the wet season. Cropping system was mostly potato – cabbage – carrot. Most of farmer used chicken manure and chemical fertilizer (Urea, ZA, SP-36, KCl and compound fertilizer) with the dosage ranging from 900 to 20,000 kg/ha for chicken manure and 100 – 800 kg/ha for chemical fertilizer. Majority of farmers from these areas could recognize pests and diseases. Leaf miner was considered to be the most destructive pest and late blight was the most destructive disease. All of the farmers from both areas did control of pests and diseases using chemicals every season and one farmer had used sticky-yellow trap for controlling leafminer. Insecticides of sipermetrin and permetrin were used to control leafminer with formulation dosage of 1,750 ml per 0.5 ha and fungicides of mankozeb, dimetomorf, simoksamil and maneb were used to control late blight disease with formulation dosage of 6 kg per 0.5 ha. For controlling pests, the majority of farmers sprayed once a week or once in three days, while for controlling late blight, farmers sprayed 6 – 10 times during planting season. In fact, some of farmers sprayed once in two days when high damage intensity of late blight during the wet season. Potato crop was harvested at 100 to 120 days after planting with yield ranging from 8.5 to 12 t/ha.

10.3.2 Introduction

Potato is one of the important horticulture commodities in South Sulawesi because of as alternative food source in food security program. South Sulawesi has high potency for development of potatoes because of supporting suitable agro-climate, available land and market and high supporting of national and regional government. The land potency for development potato in South Sulawesi was about 11,455 ha consisting of 2,720 ha of planted area and 8,734 ha of land for development. That land was distributed in seven of districts that had the different agro-climate and planting time.

The productivity level of potato in South Sulawesi during 1988-2002 was 7.02 t/ha. It was still low comparing with its potential yield that reached 30 t/ha. It was caused by some of the factors such as limited high yielding or new variety, poor quality seed, not-optimal agronomic management and pests and diseases.

Studies on agronomic and pest management practices of potato farmer have not much been conducted in South Sulawesi province especially in production area such as Malino, Enrekang and Tator. Information of those mostly was obtained from staff of local agriculture services and local government (district government), but sometimes it was not in detail. Therefore, studies on agronomic and pest management practices of potato farmer should be determined, although those were in small scale.

The objective of the study was to identify agronomic and pest management practices of potato farmer and identify problems and constraints potato farming in Malino, Gowa District, South Sulawesi.

10.3.3 Method

The survey was conducted at Tinggimoncong and Tombolopao subdistrict, Gowa District, South Sulawesi in June, 2008. It was done by using Participatory Rural Appraisal (PRA) Approach with choosing randomly ten potato farmers in both subdistrict and two nurserymen. Besides interview to farmers, nurserymen and staff of agriculture services, it was also done observation in the fields to recognize agronomic and pest management practices done by farmers. Besides interview and field observation, it was also done collection of secondary data from the related institutions.

10.3.4 Results and discussion

Demographic profile

The age of farmers interviewed in that area ranged from 31 to 43 year. Most of them graduated in elementary school, but there was one farmer graduated from university. Their experience in potato farming was relatively long. Some had experienced in vegetable Farming School. Almost of all farmers had farmer group. The landholdings ranged from 0.25 to 30 ha. The farmer who has large land was also as nurserymen.

Agronomic practices

Land preparation for potato was generally similar to the other vegetable planted in high land. Most of farmer in land preparation used mattock ("cangkul" in Indonesian) and usually prepared about one month before planting. After that, farmers made bed with the size of 80 cm in width, length depending on the land size, and 30 cm of space between the bed.

Granola was the most popular potato variety planted by farmers in the both areas. The other varieties was also planted by farmers such as Atlantic, but those were not larger than Granola. Healthy, clean and good quality seeds are important in potato farming. Most of farmers obtained and planted seed grade G4 and G3 from nurserymen, only few farmers planted seed grade F2 and F3(its mean G6 and G7). This meant that almost of all farmers had already known how the importance of seed quality in potato farming is. According to the farmer who planted seed grade F2 that the capital became a main problem to plant seed grade G4 continuously.

Planting time was mostly started from February or March during rainy season (December to June). Most of farmers planted in this season. Only few of farmers planted in dry season (July to October). Cropping system was mostly potato – cabbage – carrot. Potato was planted in February or March. While cabbage was in the beginning of July and carrot in October.

The fertilizing is important to supply nutrient and support the growth of potato crop. Most of farmer used the same kind of fertilizer such as chicken manure, chemical fertilizer (Urea, ZA, SP-36, KCl and compound fertilizer), but it generally was different in dosage depending on farmer capital and experience. For manure, all of farmers used chicken manure obtained from other district (Sidrap and Makassar). The dosage of chicken manure used by farmers were different with range from 900 to 20,000 kg/ha. Most of farmers applied manure once a year at planting time. That was applied in row between the plant and then covered by soil.

Plant spacing used by farmers was 25 cm x 80 cm depending on farmer experience. Farmers rarely replaced dead seedling with the new ones because percentage of seedling death was very low (≤ 1%). Chemical fertilizer (Urea, ZA, SP-36, KCl and Ponska) was different in farmer level. The dosage of those used by potato farmer were indicated at Table 1. Not all of chemical fertilizer was used each farmer. Most of farmers used four kind of fertilizer such as Urea, ZA, SP-36 and KCl, while the other only used compound fertilizer (Ponska) and ZA. A few of farmers used only Urea. Fertilizer was applied in row between the plant.

Most of farmers conducted weed control by hand weeding. Piling up of the bed was done by farmers once and two times per planting season. Hand weeding and pilling up of the beds were done at the same time.. Irrigation was also important to support plant growth. Most of farmers had used modified sprinkle irrigation. According to the farmers, irrigation only done if it was not rain that usually done once a week.

Table 1. The kind and dosage of chemical fertilizer used by potato farmer at both of survey areas in Gowa District, South Sulawesi.

No.	Kind of fertlizer	Dosage range (kg/ha)	Frequency and time ofapplication
1.	Urea (N)	100 – 500	Once to two times per planting season. If only once, usually applied at 25-30 days after planting (DAP), but if two times, first at 25 DAP and second at 40-50 DAP.
2.	ZA (N)	100 – 200	
3.	SP-36 (P)	100 – 200	
4.	KCl (K)	100 – 150	
5.	Ponska (N,P,K)	150 - 800	

Pest and Disease Management Practices

According to the farmers that there were three pests was dominant found in the field such as aphid (Myzus persicae), black cutworm (Agrotis sp.) and leafminer (Liriomyza huidobrensis) and two diseases was dominant in the field such as late blight (Phytophthora infestans) and wilt (Fusarium sp.). The other pests and diseases on potato had not well recognized by farmers. Majority of farmers from these areas could recognize pests and diseases, but most of them could not recognize life stadia of the pests except the imago. The farmers were also asked to rank pests and diseases according to their perception and experience of destructiveness to the potato crop. From the responses, it was apparent that leaf miner was considered to be the most destructive pest and late blight was the most destructive disease. According to farmers that leaf miner and late blight were always found each planting season.

For controlling of the pests and diseases, all of the farmers from both areas did control using chemicals every season. All of farmers used insecticides for controlling aphid, cutworm and leafminer and only one farmer used mechanical measure to control leafminer using sticky-yellow trap. Yellow trap was made from HVS paper and covered by plastic, then its upper surface was spread by motor oil. Farmer put a yellow trap per two meter of land. The kind and formulation dosage of pesticides used by farmer for controlling pests and disease were indicated at Table 2.

Table 2. The kind and formulation dosage of pesticides for controlling potato pests and diseases.

No.	Pests and Diseases	Pesticides	Formulation dosage
1.	Aphid (*M. persicae)*	Sipermetrin	-
2.	Black cutworm (*Agrotis* sp.)	Sipermetrin, Permetrin, alfametrin	1,000 ml for 0.5 ha
3.	Leafminer (*L. huidobrensis)*	Sipermetrin, permetrin	1,750 ml for 0.5 ha
4.	Late blight disease (*Phytophthora infestans*)	Mankozeb, dimetomorf, simoksamil, maneb	6 kg for 0.5 ha
5.	Wilt disease *(Fusarium* sp*.)*	-	-

The time and frequency of application of pesticides for controlling pests and diseases were different depending on the farmer capitals and experiences. According to farmers that in general, leafminer attacked at 7 – 60 DAP, cutworm attacked at 7 DAP and aphids attacked at 40 DAP. For controlling leafminer, cutworm and aphid, the majority of farmers conducted spraying once a week and once in three days when high infestation of the pests. While for controlling late blight disease, farmers conducted spraying 6 – 10 times during planting season depending on the rainfall. In fact, some of farmers sprayed once in two days when damage intensity of late blight disease was very high in the field particularly during the wet season. There was one farmer made formulation with the ratio of 3 kg fungicides + 0.5 l of adhesive + 230 l of water to control late blight. This indicated that farmers had not well known spraying volume of the fungicides.

Harvest, Yield and Marketing

Harvesting age of potato in both of survey areas was 100 to 120 days after planting for consumption and 75 to 80 days after planting for seed depending on variety and climate condition. Harvest was done by using mattock on plant bed, then lifting up the plant including seed/tubers. After that, conducted selection or sorting. Selected tubers then put in fertilizer sack to be picked up to farmer's house.

Productivity or yield of potato that obtained by farmers ranged from 8.5 to 12 t/ha. There were four grades of potato yield according to the farmers i.e. grade A (large), grade B (medium), grade C (for seed) and grade D (small). Most of grade A and B were sold to the collectors or trades to be sold to Makassar city, Sinjai district and Kalimantan island. Grade C was usually kept to seed preparation, while grade D was mostly sold to local market (Malino, Tombolo) or neighbor district (Manipi-Sinjai). According to the farmers, the average of percentage of grade A, B, C and D obtained every season was 20%, 30%, 30% and 20%, respectively. According to farmers, harvesting yield was directly sold to the trader when the price was appropriate, but if not they kept it until the price was high. Price in farmer level was varied from Rp 2,500 to 5,000 per kg and Rp 6,000 to 10,000 per kg in trader level depending on planting season and supply from the other production area such as East Java and North Sulawesi (Manado). According to farmers that the price would be low when harvesting time was on June or July because supply also came from Java and Manado. On the contrary, when harvesting time was on December, the price would be high.

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Final report appendix 2

title	AGB/2005/167 Economic baseline survey of potatoes
prepared by	Paul Mattingley
co-authors/ contributors/ collaborators	Julie Warren Mieke Ameriana Dr Eri Sofiari, Dinas Pertanian, West Java, Dinas Pertanian, Central Java, BPTP NTB, Putu Cakra Putra Adnyana, BPTP South Sulawesi.

1 Executive summary

One of the main activities at the commencement of the project was a broad baseline survey of potato and Brassica crops for the wet and dry seasons. The economics component of the survey aimed to identify relationships between key economic drivers for potato and Brassica production across the project provinces for different conditions and different varieties. The economics survey was conducted at the same time as a baseline agronomic survey.

The format for the economics survey was developed by DAFWA and IVEGRI Economists. In practice the surveys were not uniform across all the provinces as local data collection teams tailored the survey to enable information to be gathered in the most appropriate format.

The potato economics survey looked at Granola potato production for the ware market in Central Java (CJ), West Java (WJ) and South Sulawesi (SS). In Nusa Tenggara Barat (NTB) growers produce the Atlantic variety for use by the crisp processor Indofood Fritolay.

The survey sampled 25 growers in CJ, 24 in WJ, 28 in SS and 28 in NTB. The yield data from CJ and WJ was verified through cross referencing with the trial samples taken from the baseline agronomic survey.

The survey demonstrated that there are a wide range of yields, prices and input costs.

The baseline agronomic survey identified that the main constraints facing Indonesian potato growers are diseases – primarily late blight, seed quality, low soil pH affecting crop nutrition and pests – primarily leafminer.

The importance of these issues to growers is reflected in the production input costs expended to manage these problems. Seed expenditure including chemicals and planting was between 34% to 53% of total average costs across the four provinces. Only with NTB growers was there a positive correlation between the amount of seed used and gross margin. The other main costs are fertilisers and agro-chemicals. Fertilisers represent between 9% and 26% of cost for the province averages, fungicides 3% to 14% and insecticides 3% to 11%. Accordingly the financial performance of the crop is sensitive to the effectiveness of these inputs.

The analysis found a positive correlation between yields and gross margin returns for all four provinces. Growers achieving less than 10 – 12 tonnes per ha in CJ, WJ and NTB were unlikely to be profitable. For SS higher prices received for product enabled growers with lower yields to remain profitable.

Apart from NTB where growers sell their product to Indofood Fritolay, the three other provinces face variable producer prices and in SS and CJ there was a positive correlation at $P < 0.05$ between prices received and gross margin returns.

There was no correlation between fertiliser costs and yields, prices received or gross margin returns. Clearly there is a need to work on the issue of fertiliser management across the provinces.

SS was the only province to have a positive correlation between insecticide cost and gross margin whereas in CJ the correlation was negative.

Fungicides appear to be ineffective in increasing yields and the additional costs lead to a negative correlation for gross margin in CJ.

There needs to be further research work on improving the efficiency of the use of inputs particularly fertilisers, insecticides and fungicides.

Analysis of costs for each province found that SS had the highest average gross margin with its low yield of 12.5 tonnes offset by high prices and low input costs. The lowest average gross margin was seen in NTB where high returns of Rp 56.7 million were negated by very high input costs of over Rp 40 million per ha, more than Rp 11 million higher than the next highest WJ. Of all the provinces NTB has the opportunity to benefit most from optimising input use to reduce costs.

The results of the economics baseline survey provides the basis for measuring improvement in profitability and economic efficiency of potato production in the four provinces. It can be used to assess advances in crop management made through Farmer Initiated Learning groups. An economic assessment of the impact of the development of a PCN free potato seed supply in Sembalun providing PCN free seed to SS showed a project benefit of Rp 89 million or $AUD 10 million. The value of the projects *systemic-contact-systemic* recommendations for PLB control were assessed. The present value of project benefits for improved efficiency in PLB control was Rp 18.1 billion $AUD 2 million) for both provinces.

2 Background

The project aims to increase the returns to potato and Brassica growers in WJ and CJ, SS and NTB through adapting proven Australian, Indonesian and CIP practices. At present there are a wide spread of agricultural practices employed by growers throughout the four provinces and the management of crops is often not optimal or uniform. Accordingly an economic baseline survey was undertaken to document and analyse the practices employed by growers and link practices to profitability or losses. The economic analysis was then used to assess improved profitability resulting from new management techniques developed by the project. These new techniques were tested in simple experiments through a series of Farmer Initiated Learning (FIL) activities (referred to as Farmer Field Schools in the project proposal). The growers recorded their inputs and yields and these were then used to model the financial impact of revised practices. The improved returns would then act as an incentive for growers to implement the new practices so increasing adoption. In addition the growers and researchers will develop knowledge of how to measure financial performance and analyse change to their production system.

Indonesian potato growers normally do not have access to computers to record and analyse financial information. Supporting institutions such as IVEGRI and provincial Dinas Pertanian offices have professional economists and computers, however undertaking a baseline survey of 40 – 50 growers throughout a production season required significant manpower and transport. The funds provided by ACIAR enabled the Indonesian and Australian researchers to undertake a comprehensive study.

This report details the findings of the baseline survey for all four provinces.

3 Objectives

The primary objective was to conduct a baseline economic survey of potato crops in CJ, WJ, NTB and SS to identify relationships between key economic drivers for potato production such as the effectiveness of inputs (agro-chemicals and fertilisers), impact of prices, yield and commercial relationships.

The economics survey provided a snapshot of production practices and profitability across the four provinces at the beginning of the project. This would provide a future opportunity to compare changes to practices resulting from project recommendations and gauge their financial impact for growers.

A subsidiary aim was to use the survey as a training opportunity to develop the capacity of the counterparts in survey design, data collection, analysis and interpretation. The survey was conducted collaboratively by DAFWA and Indonesian counterpart economists.

4 Methodology

4.1 Baseline survey

4.1.1 Gross margin analysis

The team used a standardised model for gross margin analysis which measured revenue from sales minus costs (predominantly variable costs) of production. See Annex 1, – Potato Economics Survey for details of the questions in the survey.

4.1.2 Development of the questionnaire

The draft questionnaire covering production costs and sales income for potatoes was developed by Australian Agricultural Economists. The draft survey was translated and then sent to each of the provinces for comment. Where necessary changes were made and clarification sought on certain issues.

Survey enumerators were trained to interview growers and record their responses. The growers were visited regularly during the cropping period to ensure that data was recorded as activities were undertaken. A field booklet was later developed to enable growers and enumerators to easily record their inputs (DAFWA 2010a) as part of the FIL.

The baseline survey focused on variable costs because potato production is small scale with limited use of capital equipment. The farms surveyed were of differing sizes and the results were converted to a per hectare basis to enable comparison.

4.1.3 Analysis

The data was sent from Indonesia to Western Australia where it was analysed in Excel. A sensitivity analysis was conducted to gauge the impact of changes in input costs on the gross margin using the Sensit Add-in in Excel. This was used to determine regressions that should be investigated. A yield and price sensitivity for the gross margin was also performed. Regression analysis was used to investigate whether there was a relationship between practices and grower yields, prices and gross margin. Where no graph is presented there is no significant correlation found between the variables. Where necessary, counterparts and later the enumerators from the provinces were consulted to clarify any issues with the data. The regression analysis sought to find correlations between the following main variables shown in Table 4.1.

Table 4.1. Column headings show the main variables and the body of the columns shows the correlations that were investigated.

Gross Margin Correlations investigated:	Yield & correlations investigated:	Average price & correlations investigated:
Yield		
Average price of produce sold	Average price produce sold	
Scale	Scale	Scale
Fertiliser expenditure	Fertiliser expenditure	Fertiliser expenditure
Insecticide expenditure	Insecticide expenditure	Insecticide expenditure
Herbicide expenditure	Herbicide expenditure	Herbicide expenditure
Fungicide expenditure	Fungicide expenditure	Fungicide expenditure
Quantity of seed used	Quantity of seed used	Quantity of seed used
Value of seed used	Value of seed used	Value of seed used

4.1.4 Validity of data

This baseline economics survey was conducted at the same time as the baseline agronomic survey which looked at agronomic, pathological and entomological factors and their impact on yield and quality/price (ACIAR Project AGB/2005/167 Final Report Appendix 1 Baseline agronomic survey of potatoes). The agronomic survey included a 50 m^2 plot in the crop cultivated by the grower to provide accurate yield information. This data was used to cross reference the data provided as part of the economics survey by the same growers. Where there was a difference of +/- 25% between the yield reported in the economics survey and agronomic yield plot data the results for that grower were disregarded.

4.1.5 Impact evaluation

PCN freedom of South Sulawesi through use of PCN free seed from Lombok

The Present Value (PV) of project benefits of preventing potato cyst nematode (PCN) from establishing and spreading in SS were assessed. PCN freedom can be assured by exploiting the opportunity developed through the project of an alternative supply of PCN free seed from Lombok (ACIAR Project AGB/2005/167 Final Report Appendix 7 Alternative potato seed supply system for Indonesia). A gross margin was prepared for crops free or affected by PCN based on the SS gross margin presented in Table 6.1. The impact of PCN on potato production was reflected in the model by reducing yield by 55% which then reduces returns to break even (returns just cover costs). This yield reduction falls well within the estimated yield reductions due to PCN of 30 – 90% (Hadisoeganda 2006). Infestation rates for the “PCN infestation” and “PCN freedom” scenarios for 20 years in the future were estimated. The 2009 area of potato production (BPS 2010)1 in SS was multiplied by the rate of spread to give the area affected. This affected area was valued by multiplying it with the PCN gross margin and adding this to the unaffected area multiplied by the free from PCN gross margin. The “PCN infestation” scenario has the yield and gross margin remaining constant over the 20 years of the analysis. Each year’s value of the “PCN infestation” scenario was subtracted from that year’s “PCN freedom” scenario value to give the benefit for the year. PV of benefits was calculated in Excel using the NPV formula, year 1 is not discounted and years 2 – 20 are discounted at 7% per annum. The result is the Present Value of project benefits; this is not the net present value of project benefits as project costs have not been subtracted from project benefits. The analysis is based on real money terms which do not incorporate inflation.

Improved potato late blight management

The gross margins developed for the cabbage FIL LBD results of the Pemuda Tani Vetran farmer group (Table 7.17) were used to calculate the Present Value (PV) of the benefits of the work. The use of a local variety without lime is called the “without project” scenario while the use of the clubroot resistant variety Maxfield with lime is called the “with project” scenario. Adoption rates for the use of lime and Maxfield within each scenario” were estimated for 10 years in the future.

The value of the projects *systemic-contact-systemic* recommendations for PLB control were assessed for wet season production. This assumed that 50% of total production per province is grown during the wet season. Whilst the LBD trial in NTB generated increased yields of 8.3% this was for very high use of fungicides (> Rp 10 million per hectare). Accordingly the analysis focuses on the benefits of reduced costs to control PLB rather than increased yields. The anecdotal evidence provided by the WJ and CJ growers pointed to savings of 34% in pesticide costs and these savings are assumed to be manly due to fungicides for PLB control using project recommendations (Section 8.3.1 Input costs) A “with project” and without project scenario for WJ and CJ provinces was developed and annual benefits calculated from the savings multiplied by the area grown in the wet season and the appropriate adoption rate. WJ and CJ were only assessed as they will accrue the major benefits as individually their potato areas are an order of magnitude larger than NTB and SS combined. Adoption rates are shown in Appendix 2, Table 7.2). It is assumed that without the project the improved practices would be adopted at a much slower rate than with the project. The analysis is conservative assuming there is no increase in the area of potato grown across both despite increased profits resulting from reduced costs. Likelihood of success for new systems developed and demonstrated by the project is 80%. Attribution of benefits to the project is 80%. The discount rate = 7%.

5 Achievements against activities and outputs/milestones

Objective 1: To Adapt and apply robust integrated crop production, pest management and postharvest handling systems for potato and Brassicas/Alliums suited to Java, NTB and South Sulawesi conditions.

No.	Activity	outputs/ milestones	completion date	Comments
1.2	Training in survey design, crop monitoring, sampling, data collection and analysis	Questionnaire finalised & training completed at workshops	CJ &WJ in 2006 & NTB & SS in 2008	Training at workshops was complimented by practical demonstrations during field visits to WJ in 2006, CJ in 2007 and NTB and SS in 2008.
1.3	Conduct baseline survey for potatoes in CJ, NTB, SS & WJ	Summary reports of baseline surveys completed and results presented at workshops	CJ &WJ in 2007 & NTB & SS in 2009	Summary reports all baseline surveys from each province included in annual reports. Results of surveys presented to workshops in WJ and CJ in 2007 and in NTB and SS in

PC = partner country, A = Australia

6 Key results and discussion

The surveys in WJ and CJ were carried out in 2007 and in NTB and SS in 2009.

The WJ and CJ surveys surveyed the same groups of growers and so the agronomy and economics data could easily be cross referenced. Data from 13 growers from the CJ and 13 from the WJ were discarded because the yield results varied too widely from the agronomic survey.

The SS and NTB agronomy and economics surveys did not include the same growers and so there was no opportunity to verify yield data for the economics survey. Accordingly nearly all those surveyed are included in the analysis, those omitted from the NTB and SS surveys have not answered large parts of the questionnaire.

The majority of potato growers in Indonesia grow the table variety Granola as did the survey respondents in WJ, CJ and SS. The growers in NTB however grow the Atlantic processing variety of potato for Indofood Fritolay who process the potatoes into crisps at their factories. The economics of production differs between NTB and the other provinces.

6.1 Gross margins across the four provinces

Gross margins were produced for potato production in the four provinces and are shown in Table 6.1.

The average figures showed processing growers of the NTB achieve the highest income but also had the highest costs primarily due to the high cost of seed. The NTB growers also had the highest expenditure on insecticide and fungicide. A detailed analysis of the potato gross margin for NTB can be found in Annex 2 which is a translation of BPTP NTB (2009).

A gross margin of 25 million Rp per ha was achieved by SS which despite the lowest yield has an income of Rp 46.5 million per ha due to the high average price for produce sold (Rp 3,736/kg).

Seed is the highest input cost for all of the four provinces representing between 34% and 53% of total costs (Table 6.2). Previously Adiyoga *et al.* (1999) reported seed costs in WJ were 33 – 37% of variable costs. So in 10 years there's been no "improvement". Adiyoga *et al.* (1999) predicted that the new Indonesian public certified seed scheme would change this situation.

Fertilisers are the next highest cost input followed by fungicides and insecticides (pesticides). In CJ pesticides formed 22% of costs, 20% for NTB, 14% for WJ and just 6% in SS (Table 6.2). Adiyoga *et al.* (1999) similarly reported that pesticide costs were the next greatest cost after seed at 20 - 30% of variable costs.

Table 6.1. Average input costs, returns and gross margins for potatoes in four Indonesian provinces.

	NTB	South Sulawesi	West Java	Central Java
Crop Size (ha)	0.22	0.675	0.32	0.55
Yield (t/ha)	21.02	12.45	21.50	14.91
Price (Rp/kg)	2,700	3,736	2,181	2,330
Income	56,757,817	46,518,776	45,444,467	35,838,012
Costs (Rp/ha)				
Seed	21,564,471	7,371,151	11,667,289	8,506,820
Fertiliser	3,716,338	4,283,393	7,480,273	3,399,960
Insecticide	2,245,814	611,817	2,173,201	2,140,840
Fungicide	5,646,093	706,150	1,920,372	2,114,317
Herbicide	48,485	223,497	52,173	
Planting	595,604	514,846	389,940	301,576
Hilling	1,214,708	470,427	220,575	314,935
Weeding	983,738	581,938	340,000	284,234
Labour other	459,948	689,245	475,734	967,394
Harvest	3,004,652	810,861	2,813,268	490,657
Equipment	47,593	1,236,306	424,907	325,215
Other	1,156,168	3,937,590	1,200,397	58,182
Total Costs	40,683,610	21,437,220	29,158,128	18,904,130
Gross margin (Rp/ha)	16,074,206	25,081,556	16,286,339	16,933,883
Benefit/Cost ratio (Income/expense)	1.40	2.17	1.56	1.90

Table 6.2. Average costs by percentage for potato production in four Indonesian provinces.

Item	NTB	South Sulawesi	West Java	Central Java
Seed	53%	34%	40%	45%
Fertiliser	9%	20%	26%	18%
Insecticide	6%	3%	7%	11%
Fungicide	14%	3%	7%	11%
Herbicide	0%	1%	0%	0%
Planting	1%	2%	1%	2%
Hilling	3%	2%	1%	2%
Weeding	2%	3%	1%	2%
Labour other	1%	3%	2%	5%
Harvest (family, outside labour, contract labour)	7%	4%	10%	3%
Equipment	0%	6%	1%	2%
Other	3%	18%	4%	0%

6.2 Sensitivity analysis

Using the Sensit Add-in in Excel a sensitivity analysis was conducted to gauge the impact of percentage changes in input costs on the gross margin returns in SS (Fig 6.1). In this graph the higher the gradient for each input the greater the impact it has on gross margin returns. The slope downwards from left to right indicates a negative relationship. In SS seed represents the largest cost at 34% and so the gross margin is most sensitive to changes in the cost of seed (price or volume of seed used). A 20% increase in seed costs from the base case sees the gross margin fall from Rp 25.1 million per ha to Rp 23.6 million per ha. Fertiliser and other costs are the next most important in terms of impact on gross margin returns.

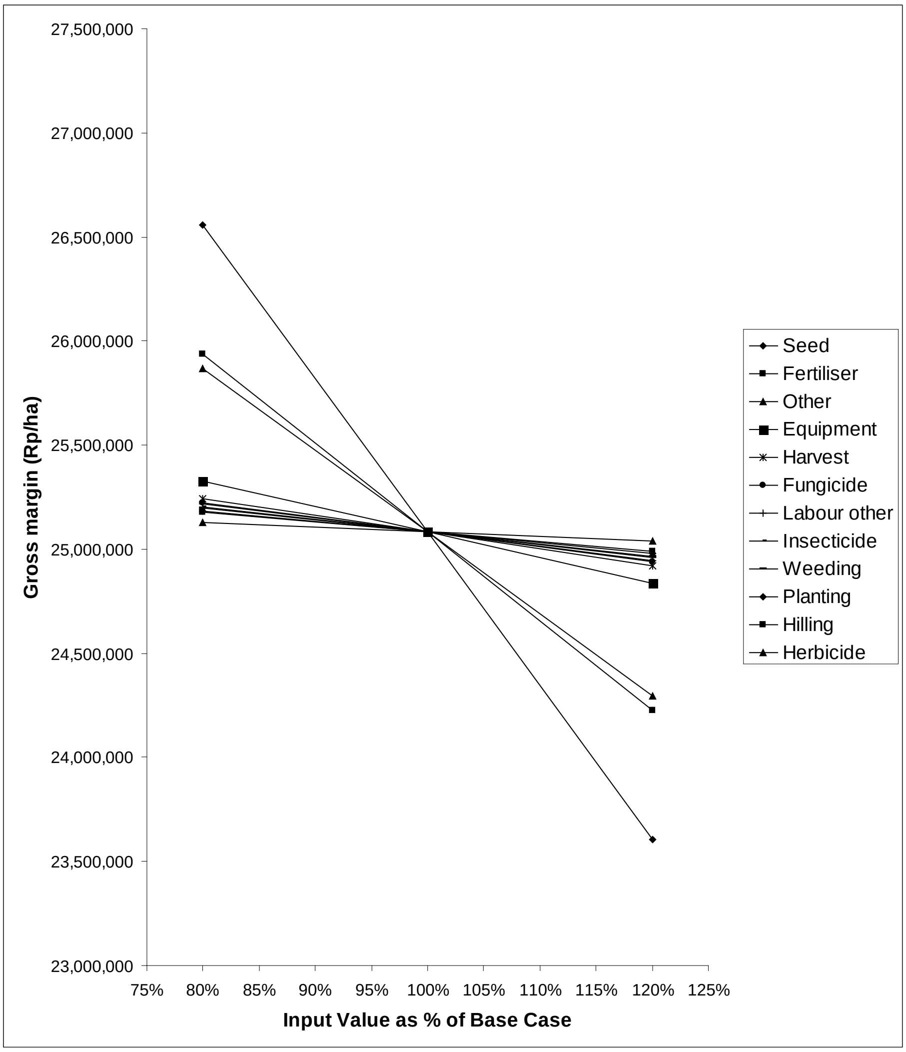

Figure 6.1. Sensitivity Analysis Sensitivity for South Sulawesi of gross margin returns to changes in input values.

Most agricultural enterprises are highly sensitive to factors affecting returns – prices received, gross yield and waste. A sensitivity analysis was conducted using price and yield to measure their impact on the gross margin for SS (Table 6.3). This table demonstrates the large fluctuations in gross margins resulting from 10% or 20% changes in yield and price per kg. A 10% increase in yield and 10% increase in price leads to a 39% increase in gross margin from 24 million Rp per ha to 35 million Rp per ha. Accordingly it is worthwhile investigating the effect of various inputs and practices on yields, average prices and gross margin returns.

The sensitivity analysis showed that potato is a low risk crop for SS because even at low yields and prices in the sensitivity analysis the gross margin remains positive.

Table 6.3. Sensitivity analysis for South Sulawesi of gross margin returns to changes in yield and average price received.

			Yield (tonnes/ha)				
			- 20%	- 10%	0%	+ 10%	+ 20%
			9.96	11.21	12.45	13.70	14.94
Price (Rp/kg)	- 20%	2,989	8,496,969	12,137,385	15,777,801	19,418,217	23,058,633
	- 10%	3,362	12,218,471	16,324,075	20,429,678	24,535,282	28,640,886
	0%	3,736	15,939,973	20,510,765	25,081,556	29,652,348	34,223,139
	+ 10%	4,110	19,661,475	24,697,454	29,733,434	34,769,413	39,805,392
	+ 20%	4,483	23,382,977	28,884,144	34,385,311	39,886,478	45,387,645

6.3 Regression analysis

Regression analysis was used to investigate whether there was a relationship between practices and grower yields, prices and gross margin returns. Where no graph is presented there is no significant correlation found between the variables.

6.3.1 Yield and gross margin

The correlation of gross margin to yield was investigated to:

- Confirm that there is a correlation between yield and gross margin
- Determine whether the Indonesian potato farmers can increase their gross margin by aiming to produce higher yields, i.e. that they are not at the point of diminishing returns
- Determine indicative break-even yield

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Indicative breakeven yields for the four provinces were:

Central Java	9.8 t/ha
West Java	10.1 t/ha
NTB	12.9 t/ha
South Sulawesi	4.4 t/ha

Growers in CJ and WJ require similar yields in order to breakeven (income = costs). NTB growers require a yield of 12.9 t/ha to break even. The analysis indicates that growers in SS achieving over 4.4 t/ha can break even, covering their costs, this seems unrealistically low and may be a result of the relatively small sample size.

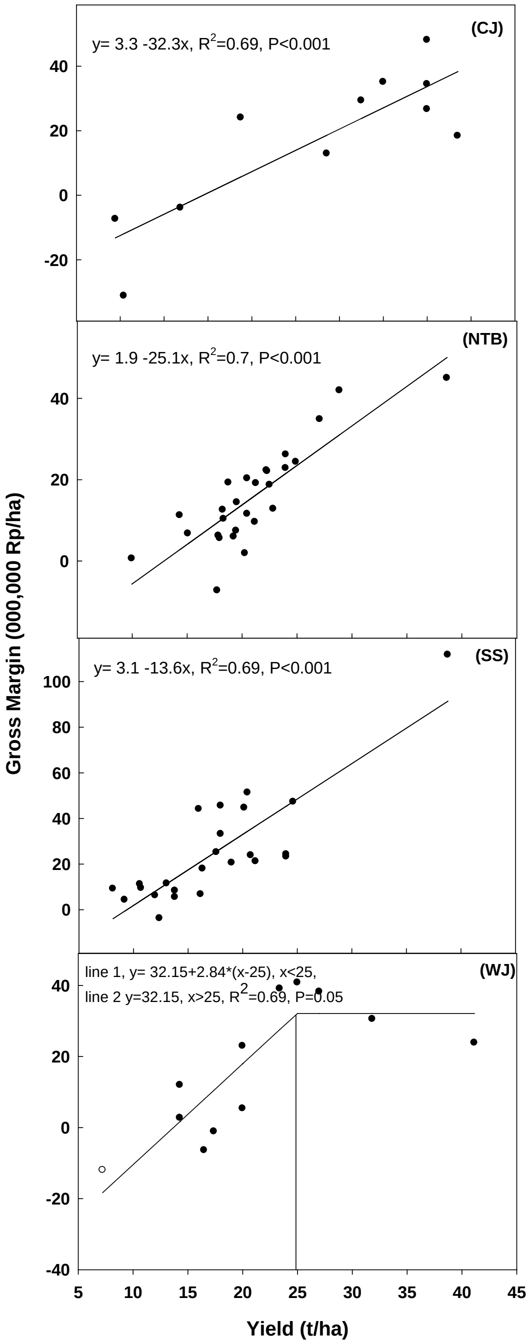

Figure 6.2. Linear Regression of yield with gross margin in Central Java, NTB, South Sulawesi and West Java.

R^2 values for CJ, NTB and SS were all 0.69 or 0.68 showing that the regression equation was able to account for 68 - 69% of the variation (Fig 6.2). However in WJ the R^2 value for a linear relationship was only 0.47 which indicated this relationship wasn't as good a fit as the relationships for the other provinces. A better fit was found with two straight lines with a flat relationship between yield and gross margin after 25 t/ha. With this relationship the R^2 value increased from 0.47 to 0.69 (Fig 6.2) lower graph). This may indicate that some growers in WJ have reached the point of diminishing returns whereby the cost of inputs required to increase yield is not covered by the additional returns generated or that the gross margin returns are starting to decrease when the extra input costs exceeds the extra returns above 25t/ha. This may indicate more inefficient production compared with the other provinces. This could be due to inputs being poorly targeted and as a results wasteful application of inputs. Yields above 25 t/ha may be able to be reached without this inefficiency as shown by the regressions for NTB and SS which increase linearly up to 40 t/ha and 35 t/ha respectively (Fig 6.2).

The correlations between gross margin and yield for NTB, WJ and CJ provinces shows that there is scope to increase gross margin through improved agronomic efficiency as gross margin continues to increase directly with yield (Fig 6.2).

Most growers in all the provinces produce a positive gross margin from their potato crops: numbers of respondents with positive gross margins were 26 out of 27 in NTB, 22 out of 23 in SS, 9 out of11 in WJ and 8 out of 11 in CJ (Fig 6.2). The majority of farmers earn a return from their potato crop and this may influence them to spend heavily on inputs as they are confident their investment will be returned.

6.3.2 Price received for produce and gross margin

The sensitivity analysis (Table 6.3) indicated that price changes have a significant impact on gross margin returns. Accordingly the data was analysed to confirm whether this relationship holds true in the field with growers (Fig 6.3).

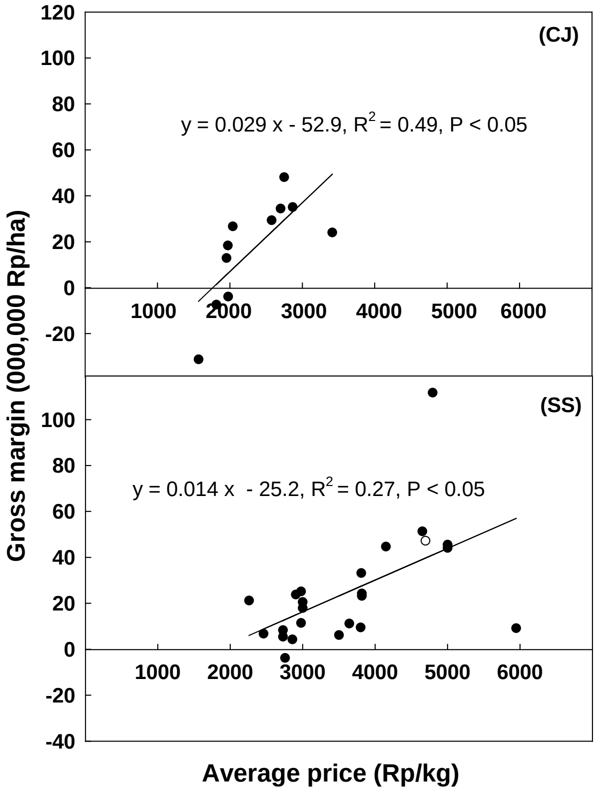

Figure 6.3. Linear regression of price received and gross margin for Central Java and South Sulawesi.

SS and CJ saw a positive correlation ($P < 0.05$) between price received for produce and gross margin. There is a wide spread of prices received for both sets of growers reflecting differing standards of quality.

Most NTB growers sell their product to Indofood Fritolay for processing and their prices are fixed at Rp 2,700 per kg. As there is no variation in price there was no correlation between price received and gross margin. It may be of benefit to the farmer – Indofood Fritolay partnership if price bonuses for quality are introduced to reward the farmers who produce better quality processing potatoes. This is normal practice in Australia with bonuses above the contract prices being paid for high starch levels (measured as specific gravity), lighter fry colour and fewer defects. However the small scale of individual Indonesian farmers may make the additional measurement and grading costly.

For WJ there was no correlation between prices received per kg and gross margin. The average price received for WJ's growers at Rp 2,181/kg was the lowest of all four provinces whilst the yield at 21.5 tonnes/ha was the highest. Yield may be more important than price as a determinant of returns for growers in WJ.

6.3.3 Impact of quantity of seed used on yield

Both NTB and SS have a positive correlation at $P < 0.05$ for the quantity of seed used and the yield achieved (Fig 6.4). The seed used by NTB growers is provided by Indofood Fritolay at a standard cost of Rp 10,500 per kg and would be expected to be of uniform quality. More of the variation in the relationship between seed quantity and yield was accounted for by the NTB regression equation than for SS. Respective R^2 values were 0.50 and 0.38. This may be because the variety grown in NTB is Atlantic which sets much fewer tubers than Granola which was grown in SS (McPharlin and Lancaster 2005) and the production is during the dry season. This means that increasing seed rate of Atlantic may increase tubers produced per hectare while not hindering potato late blight (PLB) control through too dense foliage.

CJ and WJ do not have a correlation between seed amount and yield.

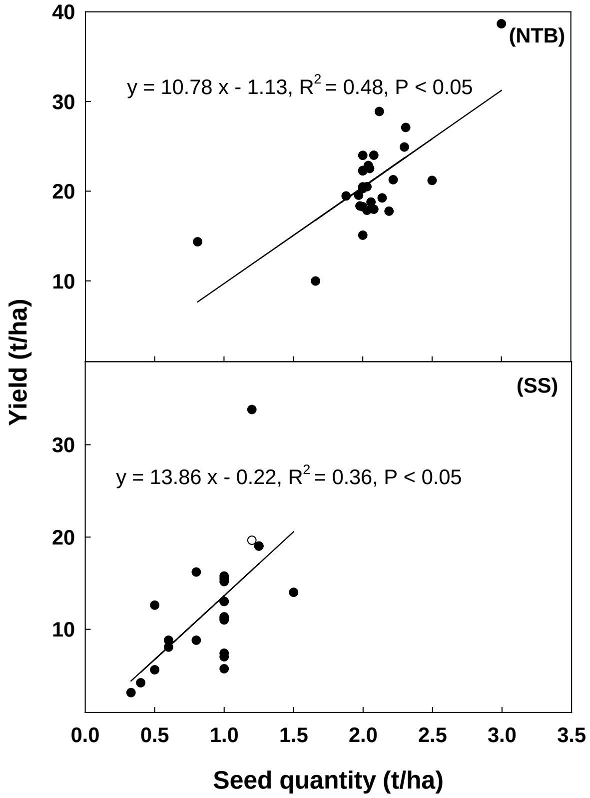

Figure 6.4. Linear regression of yield & quantity of seed used in NTB & South Sulawesi.

6.3.4 Impact of quantity of seed used on gross margin

In NTB there was a positive correlation at (P < 0.05) between the amount of seed used per ha and gross margin (Fig 6.5). This was to be expected as there was correlation with yield and seed rate in that province. Most growers use just over 2 tonnes of seed per hectare. Reasons for this increase in gross margin may be the same as those discussed for yield increases above. This finding indicates that Atlantic growers in NTB should investigate higher seeding rates.

Figure 6.4 indicates that SS's growers achieve higher yields with increased quantities of seed but there was no correlation between seed quantity and gross margin so additional seed does not generate the returns required to offset additional expenditure.

WJ has a negative correlation at P < 0.05 between seed quantity and gross margin. Possible explanations for investigation include:

- WJ crops possibly grown in wetter season than other areas. The higher seed rate leads to higher density foliage which increases the difficulty in controlling PLB.
- In relatively low yielding areas the crop is limited by factors other than seeding rate, for example soil moisture.

WJ growers should investigate optimum seed rates to improve their cropping efficiency.

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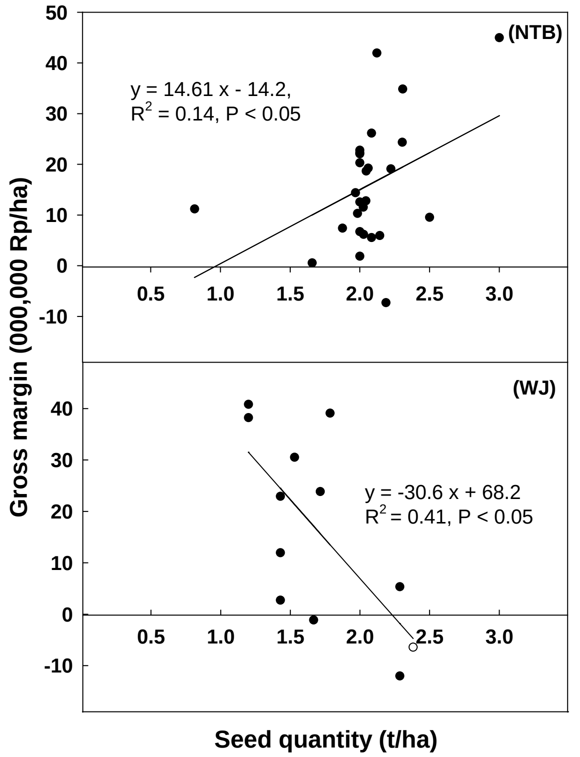

Figure 6.5. Linear regression of gross margin with quantity of seed used in NTB and West Java.

6.3.5 Impact of seed expenditure yield

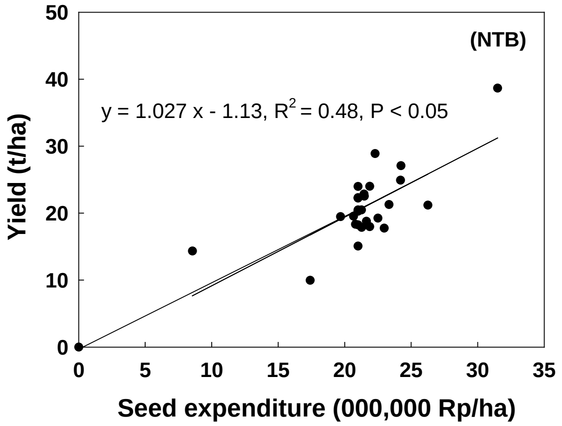

Figure 6.6. Linear regression of seed expenditure on yield in NTB.

As discussed above in Section 6.3.3 NTB Atlantic growers may benefit from increased seed rates. Figure 6.6 shows that yield increases almost 300% from 9 t/ha to 29 t/ha when seed expenditure increases from 10 million Rp/ha seed/ha up to 30 million Rp/ha. In NTB seed expenditure is directly related to seed rate as the price of seed was the same for all growers.

6.3.6 Impact of insecticide expenditure on yield

CJ has a negative correlation between insecticide expenditure (including labour costs to apply the insecticide) and yield (Fig 6.7). The additional expenditure on insecticides and their application is ineffective in raising yields.

6.3.7 Impact of insecticide on gross margin

CJ also had a negative correlation at $P < 0.05$ between insecticide expenditure (including labour costs to apply the insecticide) and gross margin. The additional expenditure on insecticides is ineffective in raising yields and income while increasing expenditure (Fig 6.8).

There is a positive correlation between insecticide expenditure and gross margin at $P < 0.05$ for SS (Fig 6.8). However for SS there is no positive correlation between insecticide expenditure and yield or insecticide expenditure and average price for produce.

The control of leafminer is a major issue for growers and insecticides represent between 3% and 11% of costs across the province averages (6.2). There was often no correlation between these inputs and yields and gross margins. Growers are over-applying agro-chemicals in the hope of controlling pest such as leafminer. WJ sees a negative correlation between insecticide expenditure and yield and insecticide expenditure and gross margin. WJ's growers are over-using insecticides and not

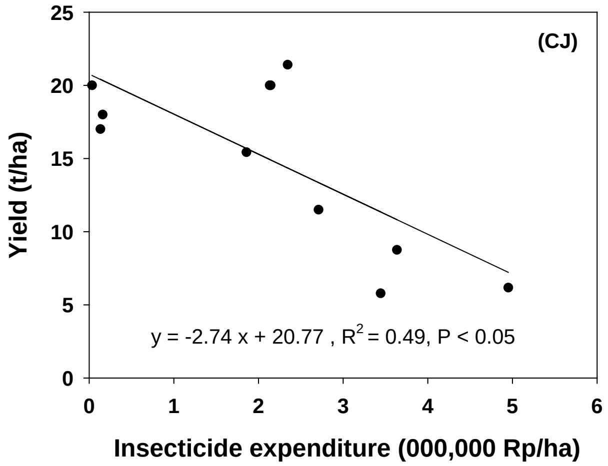

Figure 6.7. Linear regression of yield with insecticide expenditure (including labour to apply) in Central Java.

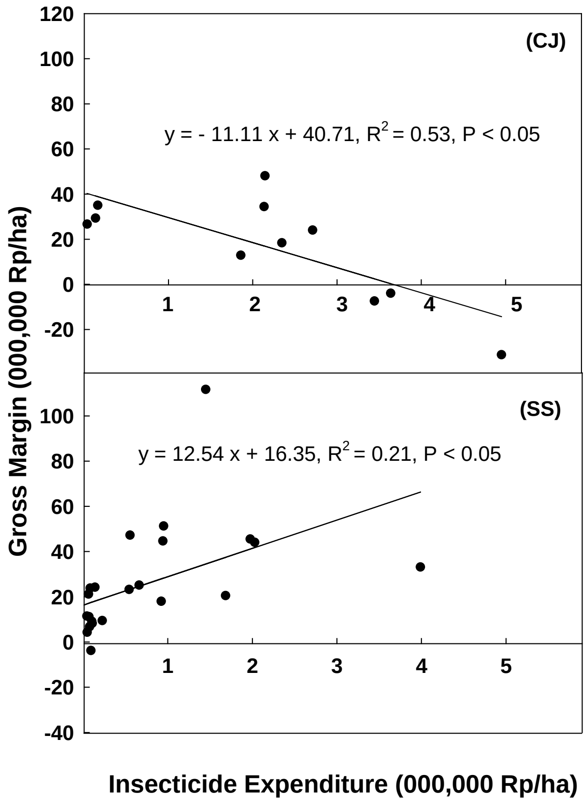

Figure 6.8. Linear regression of gross margin with insecticide expenditure (including labour to apply) in Central Java.

achieving returns for this additional expenditure. This supports the findings of the ACIAR funded *Liriomyza huidobrensis* leafminer: developing effective pest management strategies for Indonesia and Australia (Ridland *et al.* 2000) project that showed 90% of the pesticides applied to potatoes for leafminer control did not control the pest so it was an expense with no benefit. In SS there is a positive correlation at $P < 0.05$ between insecticide expenditure and gross margin (Fig 6.8). SS with an average expenditure on insecticides of 3% of total cost spends much less than the other three provinces. Interestingly there is no significant correlation between yields and insecticide expenditure in SS. There is no significant correlation between insecticide expenditure and average price received for any of the provinces.

6.3.8 Impact of herbicide expenditure on yields

There is a positive correlation at $P < 0.05$ between herbicide expenditure (including labour costs) and yield for SS. SS was the only province with any substantial use of herbicide (See Table 6.2). Herbicide expenditure is only significant in SS and there is represents only 1% of costs.

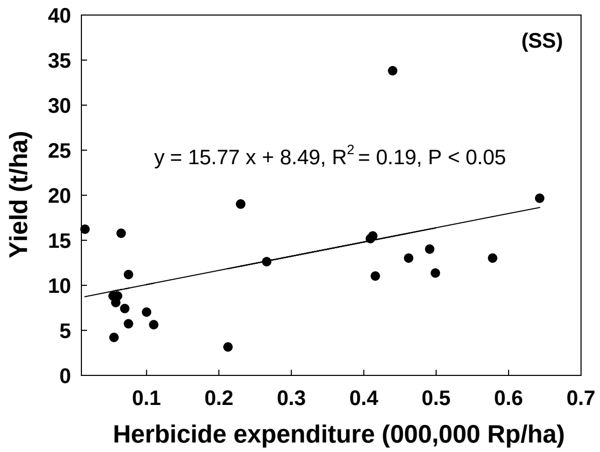

Figure 6.9. Linear regression of yield with herbicide and weedicide expenditure (including labour application costs) in South Sulawesi.

6.3.9 Impact of herbicide expenditure on gross margin

Of the four provinces only in SS was there a correlation between herbicide expenditure (including labour application costs) and yield and gross margin at $P < 0.05$ (Fig 6.10). The other provinces use herbicides at very low quantities if at all (Table 6.2).

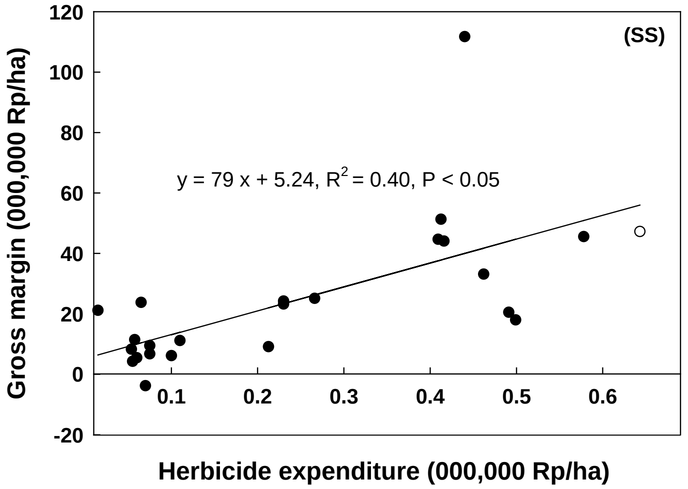

Figure 6.10. Linear regression of gross margin with herbicide expenditure (including labour costs to apply) in South Sulawesi.

6.3.10 Impact of fungicide expenditure on gross margin

Fungicide expenditure represents between 3% and 14% across the province averages (Table 6.2). However there is no positive correlation for any of the provinces between fungicide expenditure and yields or fungicide expenditure and average prices for product sold. There is often no correlation between these inputs and yields and gross margins. Growers are over-applying agro-chemicals in the hope of controlling diseases such as PLB. CJ sees a negative correlation between fungicide expenditure and gross margin (Fig 6.11).

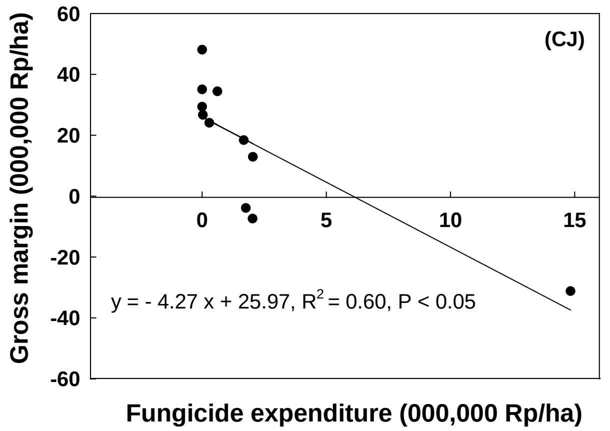

Figure 6.11. Linear regression of gross margin with fungicide expenditure (including labour costs to apply) in Central Java.

6.3.11 Impact of total pest and disease expenditure on yield

CJ has a negative correlation between pest and disease control expenditure and yield at p<0.05 (Fig 6.12).

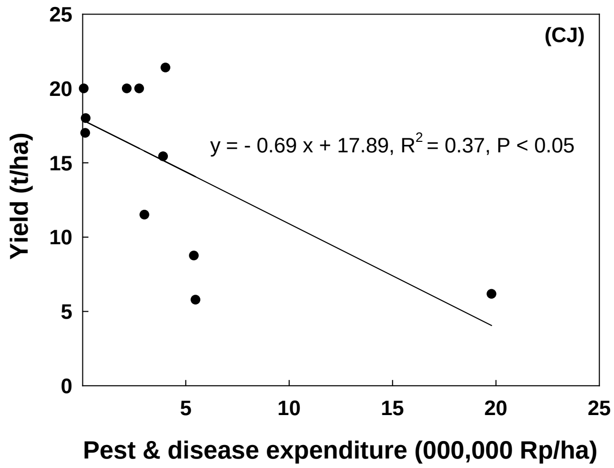

Figure 6.12. Linear regression of yield with pest and disease expenditure in Central Java.

6.3.12 Impact of total pest and disease expenditure on gross margin

SS has a positive correlation between pest and disease control expenditure and gross margin at $P < 0.05$ (Fig 6.13).

CJ has a negative correlation between pest and disease expenditure and gross margin at $P < 0.05$ (Fig 6.13). Growers in CJ are wasting money on chemicals which are not effectively controlling pest and disease problems.

This analysis of expenditure across all pest and disease management costs indicate they have no correlation with yield, average prices for product or gross margin for NTB and WJ.

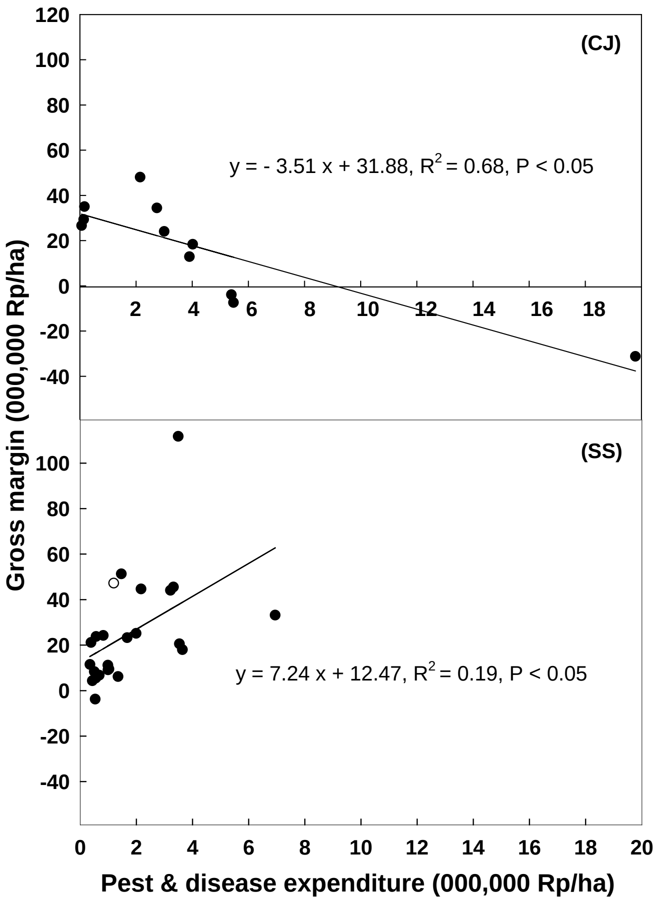

Figure 6.13. Linear regression of gross margin with pest and disease expenditure in South Sulawesi.

6.3.13 Other variables

The analysis also looked at correlation between scale and yields, gross margin and average price and found no correlation. Adiyoga *et al*. (1999) found larger growers had much higher gross margins which they thought indicated a relationship between input-use efficiency and farm size does occur. There appears to be greater uniformity in production systems between growers of different scale than there was 12 years ago. Despite the systems being flawed (over-application of fertiliser and agro-chemicals) growers of differing scale are profitable.

7 Impacts

7.1.1 Scientific impacts – now and in 5 years

The baseline survey identified that insecticides, fertiliser, herbicides and fungicides were often being used ineffectively. Farmers were wasting money over-applying inputs. This may be because the farmers are receiving little or no scientific advice on crop inputs. This finding and the FIL methodology devised by the project will enable growers to optimise their inputs in the future to maximise profits.

Now that growers and researchers have a better understanding of the economics of potato production they can use the information to prioritise their research requirements and then justify these priorities to research organisations. In 5 years time growers will have a greater involvement in prioritising and then evaluating research and development work.

7.1.2 Capacity impacts – now and in 5 years

Researchers now have the capacity to design, undertake and analyse a baseline survey. The researchers have the capacity to tailor the baseline survey to the project needs and to train enumerators in how to interview growers and collect data. Researchers also have learnt how to cost the staff time and transport required to undertake a baseline survey and this can then be used in future proposal development.

The growers and trainers involved now have the capacity to analyse the profitability of their crop production and marketing systems. The impact of adjustments to those systems can be quantified through economic analysis.

In 5 years time it is envisaged that farmers will have a much better understanding of the key economic drivers in the production of potatoes and other important crops. This information can then be fed into research and development organisations whose projects can then be better aimed at improving the production and marketing of crops. The baseline survey can be used to measure the impact of research, development and extension work providing before and after figures. This project is an example of how such work could be conducted with the baseline survey identifying areas for further research work on improving the efficiency of the use of inputs particularly fertilisers, insecticides, herbicides and fungicides.

The results of the economics baseline survey provides the basis for measuring improvement in profitability and economic efficiency of potato production in the four provinces. It can be used to assess advances in crop management made through Farmer Initiated Learning groups.

7.1.3 Community impacts – now and in 5 years

The baseline survey will enable the grower community to gain insight into their production systems. A key finding of the PCN research work was that NTB is free of PCN and can act as a seed producing area for Indonesia. The economics work undertaken will enable growers of multi purpose (seed and processing potatoes) to quantify the financial returns from the production mix.

The growers in NTB currently sell their crop to Indofood Fritolay the main crisp processor in Indonesia. The growers receive a standard price of Rp 2,700/kg and have limited opportunity to improve the price received. The baseline survey has identified the NTB growers as the least profitable due in part to their commercial arrangements with Indofood

Fritolay who provide the main input, seed and receive the product dictating the prices charged and received.

Economic impacts

The baseline survey has identified problem areas for growers across the four provinces. The follow on work of the Farmer Field School Learning-by-Doing program then enabled the growers to work together undertaking trials based on recommendations provided by the project team to improve yields, prices and returns and in so doing reduce risk.

Growers face three main forms of risk:

- Production risk related to crop management which affects yields, quality and costs.
- Market risk related to price fluctuations for product sold
- Financial risk related to the cost of borrowing to finance land rental and inputs.

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The baseline survey and follow on Farmer Initiated Learning program reduce risk for growers through:

- Improved technical knowledge reducing production risk
- A better understanding of cost structures leads to better informed decisions regarding the impact of variations in prices. Those selling their crop pre harvest have a better understanding of the "real price" they are receiving.
- A better understanding of the impact of borrowing on the financial performance of the production system identifying how much debt the enterprise can carry.

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PCN freedom in South Sulawesi

A key recommendation of the project is the establishment of a partial seed potato scheme system based in the Sembalun Valley of NTB. The Sembalun Valley was surveyed by the project and no PCN was found. The advantages of this system are described in ACIAR Final Report Project AGB/2005/167 Appendix 7 Alternative potato seed supply system for Indonesia. This system will provide a source of PCN free seed that could help to prevent the spread and introduction of PCN to areas where currently the pet is not found. The bulk of domestically produced seed is produced in Indonesia comes from Java which has PCN and so a risk of spreading the pest on potato seed. If the project recommendations regarding establishing seed production in NTB are implemented and the NTB seed is used by SS grower then this province may remain free of the pest. This analysis aims to quantify the benefits of maintaining SS's freedom from PCN. The analysis is based on the gross margin developed for SS (Table 6.1).

<u>Assumptions</u>
SS has 1,433 ha of potatoes harvested per annum (Badan Pusat Statistik 2011). In the analysis it is assumed that the area of production will remain the same. This is a conservative estimate as the likely spread of PCN across Java will reduce productivity for Javanese growers and lead to increased production in areas free from PCN such as SS. The SS yield of 12.45 t/ha determined from this baseline survey is used rather than the 8.24 t/ha reported by Badan Pusat Statistik (2011). PCN has a number of impacts on potato production: reducing yields, increasing costs due to the use of nematicides and reducing returns as areas suffering from PCN reduce sales of ware and seed. In this analysis only the reduction in yield due to PCN is analysed as it is difficult to accurately quantify the interplay between increased costs, reduced returns and increased prices due to reduced supply. The analysis compares two scenarios – the without the project scenario "PCN infestation" has PCN entering SS and the with project scenario "PCN freedom" has SS remaining free from PCN due to use of clean seed from NTB. The rate of spread of PCN in the "PCN infestation" scenario is shown in Table 7.1 .Likelihood of success for the project (chance of keeping PCN out of SS) is 90% while the attribution of benefits to the project are 80%. The project has identified the need to produce seed in

NTB and begun the process of establishing systems to achieve this. However there is a need for policy development and effective implementation by the Indonesian authorities and accordingly the project can only claim 80% of project benefits. The discount rate is 7%.

The present value of the project is in avoiding yield losses. A yield loss of 55% resulting from the spread of PCN leads to growers only breaking even. If this were the case growers would most likely switch to producing other crops not susceptible to PCN or where possible move their production area. Moving production to another part of SS would only be a short term solution as PCN would rapidly spread through any new production areas. The protection of SS from PCN provides a PV of benefits of 33,566,061,230 or $AUD 3,836,121 (Table 7.1).

The project finds that the establishment of an appropriate seed potato production system based in NTB will provide significant benefits for the potato growers of SS. The protection afforded by producing seed potatoes in an area free from PCN ensures continued production in SS.

Conclusions

Without the implementation of NTB seed scheme growers and their families in SS would experience:

- Reduced yields;
- Reduced income;
- Reduced employment opportunities;
- Eventually the possible destruction of the SS potato industry;
- Reduced nutrition levels for growers, their families and those buying potatoes;
- Increased prices for imported potatoes;
- Movement into other less profitable crops which are less susceptible to PCN.

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Social impacts

Increasing the profitability of growing potatoes will provide growers with higher incomes and reduce risk. Improved potato production systems and increased profits lead to improved nutrition for growers' families, the generation of employment opportunities and investment on farm and off farm.

Environmental impacts

The baseline survey indicates that with some exceptions the growers are over-using chemical inputs and fertilisers. The optimisation of chemical inputs will not only lead to reduced costs but also reduce harmful environmental impacts from agro chemicals. Of particular importance will be the reduced use of insecticides which will see larger populations of beneficial predatory insects.

Table 7.1. Value of project PCN free seed supply for South Sulawesi. With the project adoption of PCN free seed from Lombok commences in year 1 and the current gross margin of 25 million Rp/ha is maintained. Without the project South Sulawesi becomes infected with PCN via informal seed from Java. The rate of infestation is shown in columns 2 and 3. Infested areas have only a break-even gross margin of -0.05 million Rp/ha. The annual benefits due to the project are shown in the last column. These are applied to the NPV function in Excel with the discount rate shown to determine the discounted benefits. These are adjusted for project attribution and chance of success in the lower section of the table.

Assumptions and constants:			
Yield before PCN (t/ha)	12.45	Yield loss	55%
Area of potato production (ha)	1,433	Discount interest rate	7%
GM without PCN (Rp/ha)	25,081,555	Ex rate (Rp/AUD)	8750
GM with PCN (Rp/ha)	-57,798		

Year	PCN infestation			PCN freedom		Project benefits
	Area affected		Gross margin A	Area affected	Gross margin B	= B - A
	%	ha	Rp/1,433 ha	%	Rp/1,433 ha	Rp
1	0	0	35,941,868,315	0	35,941,868,315	0
2	0	1	35,905,843,622	0	35,941,868,315	36,024,693
3	0	2	35,887,831,275	0	35,941,868,315	54,037,040
4	0	3	35,860,812,755	0	35,941,868,315	81,055,560
5	0	5	35,820,284,975	0	35,941,868,315	121,583,340
6	1	7	35,759,493,306	0	35,941,868,315	182,375,009
7	1	11	35,668,305,801	0	35,941,868,315	273,562,514
8	1	16	35,531,524,544	0	35,941,868,315	410,343,771
9	2	25	35,326,352,658	0	35,941,868,315	615,515,657
10	3	37	35,018,594,830	0	35,941,868,315	923,273,485
11	4	55	34,556,958,088	0	35,941,868,315	1,384,910,227
12	6	83	33,864,502,974	0	35,941,868,315	2,077,365,341
13	9	124	32,825,820,303	0	35,941,868,315	3,116,048,012
14	13	186	31,267,796,298	0	35,941,868,315	4,674,072,017
15	19	279	28,930,760,289	0	35,941,868,315	7,011,108,026
16	29	418	25,425,206,276	0	35,941,868,315	10,516,662,039
17	44	628	20,166,875,257	0	35,941,868,315	15,774,993,058
18	66	941	12,279,378,728	0	35,941,868,315	23,662,489,587
19	99	1412	0	0	35,941,868,315	35,941,868,315
20	99	1412	0	0	35,941,868,315	35,941,868,315
PV						Rp 46,619,529,487
PV with attribution 80%						Rp 37,295,623,589
PV with chance success 90%						Rp 33,566,061,230
PV AUD						$3,836,121

Improved fungicide efficiency for potato late blight control

The value of the projects *systemic-contact-systemic* recommendations for PLB control were assessed. This should provide a benefits to growers as fungicides represent a major cost for growers (3% – 14% of total costs). Efficacy of the project's *systemic-contact-systemic* PLB recommendations were seen from results from the two NTB FIL sites, Koang Londe and Mentagi (ACIAR Final Report Project AGB/2005/167 Appendix 10 Table 6.4.1). Yields for both project PLB treatment and conventional treatment were similar at 18.0 t/ha and 19.5 t/ha respectively. The farmers' management included average pesticide costs of 10.95 million Rp/ha while the ACIAR method was slightly lower at 10.56 million Rp/ha. The ACIAR treatment produced a gross margin of 10.83 million Rp/ha which was significantly greater, by 4.04 million Rp/ha, than the farmers' treatment gross margin. Growers from Central and WJ confirmed the efficacy of the ACIAR PLB recommendations at the project final workshop. Expenditure for the growers on pesticides averaged Rp 9.4 million per hectare using conventional practices and growers were experiencing improved PLB control using the ACIAR practices which cost Rp 6.2 million per hectare.

Assumptions
The analysis is based on benefits experienced controlling PLB during the wet season. It is assumed that 50% of total production per province is grown during the wet season. Whilst the LBD trial in NTB generated increased yields of 8.3% this was for very high use of fungicides (> Rp 10 million per hectare). Accordingly the analysis focuses on the benefits of reduced costs to control PLB rather than increased yields. The anecdotal evidence provided by the WJ and CJ growers pointed to savings of 34% in pesticide costs and these savings are assumed to be manly due to fungicides for PLB control using project recommendations. A with and without project scenario for the four provinces was developed and annual benefits calculated from the savings multiplied by the area grown in the wet season and the appropriate adoption rate. WJ and CJ were only assessed as they will accrue the major benefits as individually their potato areas are an order of magnitude larger than NTB and SS combined. Adoption rates are shown in Table 7.2. It is assumed that without the project the improved practices would be adopted at a much slower rate than with the project. The analysis is conservative assuming there is no increase in the area of potato grown across both despite increased profits resulting from reduced costs. Likelihood of success for new systems developed and demonstrated by the project is 80%. Attribution of benefits to the project is 80%. The discount rate = 7%. The present value of project benefits for improved efficiency in PLB control was Rp 18.1 billion $AUD 2 million) for both provinces. For CJ the PV was Rp 10.4 billion ($AUD 1,183,022) while for WJ it was Rp 7.7 billion ($AUD 883,795) (Table 7.2).

The project findings regarding the improved PLB management systems have provided significant financial benefits for the potato growers of CJ and WJ. The cost savings in fungicide vary from Rp 653,744 to Rp 719,767 per hectare. The savings will lead to increased gross margins and will provide growers with the opportunity to expand their operations and to invest in growing other crops which may be higher risk than potatoes.

Table 7.2. Value of project PLB fungicide savings for Central and West Java. With the project adoption PLB management costs are reduced by around Rp 0.65 million per ha. The project management is adopted according to the rates shown in the table. Without the project PLB management also changes but at a slower rate. The annual benefits due to the project are shown in the last column. These are applied to the NPV function in Excel with the discount rate shown to determine the discounted benefits. These are adjusted for project attribution and chance of success in the lower section of the table.

Central Java			Without project			With project		Project annual value
ha total			18,655					
ha wet season			9,328					
Fungicide costs/ha pre project				Rp 2,114,317			Rp 2,114,317	
Fungicide savings (%)			34%					
Fungicide costs/ha with project				Rp 1,394,550			Rp 1,394,550	
Fungicide cost savings/ha with project				Rp 719,767			Rp 719,767	
	Year	Adoption rate	ha	savings/9,328 ha	Adoption rate	ha	savings/9,328 ha	
	1	0%	0	Rp -	0%	0	Rp -	Rp -
	2	0%	0	Rp -	5%	466	Rp 335,681,563	Rp 335,681,563
	3	0%	0	Rp -	10%	933	Rp 671,363,126	Rp 671,363,126
	4	0%	0	Rp -	25%	2,332	Rp1,678,407,814	Rp 1,678,407,814
	5	3%	280	Rp 201,408,938	66%	6,156	Rp4,430,996,630	Rp 4,229,587,692
	6	5%	466	Rp 335,681,563	75%	6,996	Rp5,035,223,443	Rp 4,699,541,880
	7	13%	1,213	Rp 872,772,063	75%	6,996	Rp5,035,223,443	Rp 4,162,451,379
	8	33%	3,078	Rp2,215,498,315	75%	6,996	Rp5,035,223,443	Rp 2,819,725,128
	9	38%	3,544	Rp2,551,179,878	75%	6,996	Rp5,035,223,443	Rp 2,484,043,565
	10	38%	3,544	Rp2,551,179,878	75%	6,996	Rp5,035,223,443	Rp 2,484,043,565
Discount rate		7%						
PV								Rp16,174,128,275
PV after attribution		80%						Rp12,939,302,620
PV after success		80%						Rp10,351,442,096
Exchange rate (Rp/AUD)				Rp 8,750				
Total PV AUD								Rp 1,183,022
West Java			Without project			With project		Project annual value
ha total			15,344					
ha wet season			7,672					
Fungicide costs/ha pre project				Rp 1,920,372			Rp 1,920,372	
Fungicide costs/ha with project				Rp 1,266,628			Rp 1,266,628	
Fungicide cost savings/ha with project				Rp 653,744			Rp 653,744	
	Year	Adoption rate	ha	savings/7,672 ha	Adoption rate	ha	savings/7,672 ha	
	1	0%	0	Rp -	0%	0	Rp -	Rp -
	2	0%	0	Rp -	5%	384	Rp 250,776,068	Rp 250,776,068
	3	0%	0	Rp -	10%	767	Rp 501,552,136	Rp 501,552,136
	4	0%	0	Rp -	25%	1,918	Rp1,253,880,339	Rp 1,253,880,339
	5	3%	230	Rp 150,465,641	66%	5,064	Rp3,310,244,095	Rp 3,159,778,454
	6	5%	384	Rp 250,776,068	75%	5,754	Rp3,761,641,017	Rp 3,510,864,949
	7	13%	997	Rp 652,017,776	75%	5,754	Rp3,761,641,017	Rp 3,109,623,241
	8	33%	2,532	Rp1,655,122,048	75%	5,754	Rp3,761,641,017	Rp 2,106,518,970
	9	38%	2,915	Rp1,905,898,115	75%	5,754	Rp3,761,641,017	Rp 1,855,742,902
	10	38%	2,915	Rp1,905,898,115	75%	5,754	Rp3,761,641,017	Rp 1,855,742,902
PV								Rp12,083,130,973
PV after attribution		80%						Rp 9,666,504,778
PV after success		80%						Rp 7,733,203,822
Total PV AUD								Rp 883,795
Total								
PV								Rp28,257,259,247
PV after attribution		80%						Rp22,605,807,398
PV after success		80%						Rp18,084,645,918
Total PV AUD								Rp 2,066,817

7.2 Communication and dissemination activities

Table 7.2. Potato economic survey communication and dissemination activities.

Date	Personnel	Organisation & Position	Location	Activities
Sep 06	Ian McPharlin Peter Dawson Julie Warren Peter Ridland Elske van de Fliert Bruce Tomkins	Potato Agronomist Potato Seed Specialist Economist Potato Entomologist Extension Specialist Post Harvest Specialist	Lembang	Preparation of final version of economic survey questionnaire. Presentations on GAP for potato production. Training in techniques for components of survey.
Oct 06	Peter Dawson Fiona Goss	Potato Seed Specialist Youth Ambassador	Lembang	Practical training in techniques for components of survey.
Jan 07	Ian McPharlin Roger Jones Fiona Goss	Potato Agronomist Potato Virologist Youth Ambassador	W and C Java	Practical training in survey techniques in WJ and CJ potato crops
Feb 07	Mieke Ameriana Julie Warren	Economist Economist	W and C Java	Economic survey results presented. Agreement on findings incorporated into next round of FFS
Aug 07	Ian McPharlin	Potato Agronomist	Pangalengan	Training in analysis of survey results, presentation of preliminary results in WJ at TOT Workshop.
Dec 07	Andrew Taylor	Potato Pathologist	Kledung (C Java)	Presentation of CJ potato crop survey findings
Feb 08	Ian McPharlin Peter Dawson Andrew Taylor	Potato Agronomist Potato Seed Specialist Potato Pathologist	Bandung	Presentation of CJ and WJ (combined) potato crop survey findings
March 08	Mieke Ameriana Julie Warren	Economists	SS and NTB	Presentation of results from WJ economic baseline survey. Agreement on training and incorporation into economic survey in NTB and SS
Aug 08	Mieke Ameriana Julie Warren	Economists	Lembang	Presentation of Potato & Brassica Economic survey results to facilitators
Aug 08	Ian McPharlin Andrew Taylor Dolf De Boer Peter Ridland	Potato Agronomist Potato Pathologist Potato Pathologist Potato Entomologist	Kledung	Cabbage baseline and preparation of LBDs for potatoes and cabbage FFS
Oct 09	Andrew Taylor	Potato Pathologist	Bandung	Review field sites for upcoming LBD plots. Training of facilitators of LBD in WJ including experimental design, PLB monitoring, seed, gross margin and insect control. Questionnaire on the effectiveness of the training program,

Table 7.2 continued. Potato economic survey communication and dissemination activities.

Date	Personnel	Organisation & Position	Location	Activities
Dec 09	Julie Warren Terry Hill	Economist Project Leader	WJ, NTB, SS	Communication methods established with farmer groups. Prefer DVD's, posters, booklets, website
Jun 10	Julie Warren Terry Hill Peter Dawson	Economist Project Leader Potato Seed Specialist	Farmer workshop Pangandaran	Presentations by farmers to farmers on LBD plot results. Highlighted economic benefits of FIL recommendations

8 Conclusions and recommendations

This economics baseline survey was effective in identifying links between production inputs and yields, prices received for products and hence gross margin returns. The economics baseline survey also looked at the management of these key issues to see whether growers were optimising their inputs.

Optimising inputs recommendation

Clearly there is an overuse of agro-chemicals and fertiliser particularly in NTB, CJ and WJ. The Farmer Initiated Learning Learning-by-Doing Plots provide the growers with the opportunity to trial alternative application rates for inputs.

NTB, CJ and WJ grower groups should investigate more efficient use of agro-chemicals through the simple experiments provided in the Potato Technical Toolkit developed by this project (DAFWA 2010b). FIL learning-by doing plot simple experiments on PLB control and integrated pest management for leafminer and other pests have been prepared.

Seed diversification recommendation

The province with the most potential for improved returns is NTB which spends an average of Rp 40.7 million per ha on inputs and achieves a gross margin of Rp 16.1 million per ha. The NTB system is a high input/high output system with large amounts spent on the management of pests and diseases. Given these conditions and NTB's freedom from PCN, its isolation and the cooperation shown within the community for developing potatoes, it could be argued that this system enables higher quality seed to perform well. A 5% reduction in inputs costs for NTB would see a Rp 2 million increase in gross margin returns. Also an increase in sale, for example by producing seed potatoes, would increase income markedly.

The NTB grower group should investigate the potential for seed production to increase returns.

Seed quantity recommendation

The quantity of seed used by growers was seen to have a positive correlation on yield for NTB and SS and on gross margin for NTB. NTB's growers receive their seed from Indofood Fritolay at a standard price of Rp 10,500/kg and the seed can be thought of as being of a uniform quality. WJ sees no correlation between seed quantity and yield and seed expenditure and yield. There is a negative relationship between the seed quantity and gross margin. The additional seed used by some growers in WJ is not providing additional returns.

NTB and WJ growers should investigate optimum seed rate. There appears to be potential for NTB grower to increase their gross margin with increasing seed rate. WJ growers may also be able to improve their profitability by reducing seed rate.

Economic impact

The economic impact of the diversification of NTB processing potato growers into seed potato production has economic benefits beyond that province. The development of a PCN free potato seed supply in Lombok could provide PCN free seed to SS. An assessment of the value of keeping SS potato crops free from PCN through use of PCN free seed from NTB was estimated to be Rp 89 million or $AUD 10 million. **Add PLB**

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10 Annexes

10.1 Economic survey questionnaire

South Sulawesi and West Nusa Tenggara – 2008 version

10.1.1 Pertanyaan umum

Identitas Responden

- Nama :

- Dusun:

- Kel :

No	PERTANYAAN	JAWABAN
1.	Berapa luas usaha tani (kentang) yang bapak jalankan sekarang ?	Kentang = ……… are……
2.	Bagaimana status kepemilikan lahannya ?	a) Tanah milik sendiri b) Sewa c) Gadai d) lainnya
3.	Tenaga kerja siapa yang dipakai ?	a) Tenaga kerja keluarga b) Tenaga kerja sewa /buruh c) Tenaga borongan d) Lainnya ....
4.	Berapa upah tenaga kerja	a) T. kerja sewa pria Rp ..../hari b) T. kerja sewa wanita Rp ..../hari c) Tenaga borongan Rp................. d) Lainnya Rp .... Keterangan ....
5.	Tanaman apa saja yang biasa bapak tanam dan pola tanamnya bagaimana?	
6.	Tanaman yang sekarang sedang ditanam ?	
7.	Tanaman sebelumnya dan sumber benihnya berasal dari mana?	
8.	Musim tanam yang akan datang rencananya menanam apa dan sumber benihnya berasal dari mana?	
9.	Sumber modalnya dari mana?	a) Modal sendiri b) Pinjaman c) Lainnya ....

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No	PERTANYAAN	JAWABAN
10.	Jika ada pinjaman bentuk, pinjamannya apa dan bentuk, besar(nilai) serta lama pengembaliannya bagaimana?	a) Uang tunai, sebesar Rp .... b) Sarana produksi, yaitu .... c) Lainnya, ...
11.	Sumber pinjaman tersebut dari mana ?	....
12.	Berapa bunga yang harus dibayar ?	Rp ....

10.1.2 Biaya input

No	PERTANYAAN	JAWABAN
2.1. BENIH		
1.	a. Jumlah benih kentang yang dipergunakan b. Varietas yang digunakan	.... kg ....
2.	Harga benih	Rp ..../kg
3.	Perlakuan benih	a) Tidak ada b) Ada, yaitu ....
4.	Biaya untuk zat kimia (pestisida) untuk perlakuan benih	Jenis zat kimia .... Jumlah zat kimia yang digunakan .... Harga zat kimia Rp ....
5.	Tenaga kerja yang dipakai untuk pengobatan (selama pembibitan)	Jumlah tenaga kerja .... Upah tenaga kerja Rp ....
6.	Bagaimana anda menyimpan benih ?	a) Gudang biasa b) Gudang gelap/Difuse light storage c) Ruang pendingin d) Lainnya .... Keterangan ....
7.	Biaya sewa untuk gudang penyimpanan dalam ruang pendingin.	Rp ...... /kg
8.	Jumlah benih yang disimpan	.... kg
9.	Apakah umbi untuk benih dibelah ?	a) Ya b) tidak

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<table>
<tr><th>No</th><th>PERTANYAAN</th><th colspan="3">JAWABAN</th></tr>
<tr><td rowspan="2">10.</td><td rowspan="2">Jika ya (benih dibelah), berapa tenaga kerja yang digunakan ?</td><td>T.k sewa pria
.... org, ... hari
.... jam/org/hari</td><td colspan="2">T. k klg pria
.... org, ... hari
.... jam/org/hari</td></tr>
<tr><td>T.k sewa wanita
.... org, ... hari
.... jam/org/hari</td><td colspan="2">T.k klg wanita
...........org, ... hari
.... jam/org/hari</td></tr>
<tr><td colspan="5">2.2. PUPUK</td></tr>
<tr><td>1.</td><td>Pupuk kandang yang digunakan pada lahan kentang bapak</td><td colspan="3">Jenis : ....
Jumlah : .... kg
Sumber/Asal :</td></tr>
<tr><td>2.</td><td>Harga pupuk kandang</td><td colspan="3">Rp ..../ kg/ton/...........</td></tr>
<tr><td rowspan="2">3.</td><td rowspan="2">Tenaga kerja untuk pemberian pupuk kandang</td><td>T.k sewa pria
.... org ..... hari
.... jam/org/hari</td><td colspan="2">T. k klg pria
.... org .... hari
.... jam/org/hari</td></tr>
<tr><td>T.k sewa wanita
.... org ....hari
.... jam/org/hari</td><td colspan="2">T.k klg wanita
.... org ...... hari
.... jam/org/hari</td></tr>
<tr><td rowspan="10">4.</td><td rowspan="10">Berapa jumlah pupuk buatan yang digunakan ?</td><td>Jenis</td><td>Jumlah</td><td>Harga (Rp/kg)</td></tr>
<tr><td>Urea</td><td>................ kg</td><td>Rp ....</td></tr>
<tr><td>ZA</td><td>................ kg</td><td>Rp ....</td></tr>
<tr><td>TSP</td><td>................ kg</td><td>Rp ....</td></tr>
<tr><td>KCl</td><td>................ kg</td><td>Rp ....</td></tr>
<tr><td>NPK</td><td>................ kg</td><td>Rp ....</td></tr>
<tr><td>.............</td><td>................ kg</td><td>Rp ....</td></tr>
<tr><td>.............
......</td><td>................ kg</td><td>Rp ....</td></tr>
<tr><td>.............
......</td><td>................ kg</td><td>Rp ....</td></tr>
<tr><td>............</td><td>................ kg</td><td>Rp ....</td></tr>
<tr><td>5.</td><td>Berapa kali pupuk buatan yang diberikan ?</td><td colspan="3">........... kali</td></tr>
<tr><td rowspan="2">6.</td><td rowspan="2">Tenaga kerja setiap kali pemberian pupuk buatan ?
Pupuk dasar...
Pupuk susulan I
Pupuk susulan II</td><td>T.k sewa pria
...... org .... hari
.... jam/org/hari</td><td colspan="2">T. k klg pria
.... org .... hari
.... jam/org/hari</td></tr>
<tr><td>T.k sewa wanita
...... org ....hari
.... jam/org/hari</td><td colspan="2">T.k klg wanita
.... org ...... hari
.... jam/org/hari</td></tr>
</table>

No	PERTANYAAN	JAWABAN		
2.3. PESTISIDA				
1.	Jenis pestisida (insektisida dan fungisida) yang digunakan serta harga masing2 jenis, selama satu musim tanam kentang.	Jenis	Jumlah (botol/cc/ bungkus/gram)	Harga (Rp/botol)
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
2.	Jenis perekat yang digunakan selama satu musim tanam kentang ?	Jenis : .... Jumlah : .... Harga :		
3.	Jumlah penyemprotan pestisida yang dilakukan pada satu musim tanam ?	.... kali		
4.	Tenaga kerja penyemprotan pestisida dalam satu kali penyemprotan	T.k sewa pria .... org .... hari .... jam/org/hari	T. k klg pria .... org .... hari .... jam/org/hari	
		T.k sewa wanita .... org ....hari .... jam/org/hari	T.k klg wanita .... org ...... hari .... jam/org/hari	
2.4. HERBISIDA				
1.	Jenis herbisida yang digunakan selama satu musim tanam kentang ?	Jenis : .... Jumlah: .... Harga :		
2.	Jumlah penyemprotan herbisida yang dilakukan pada satu musim tanam ?	.... kali		
3.	Tenaga kerja penyemprotan herbisida dalam satu kali penyemprotan	T.k sewa pria .... org .... hari .... jam/org/hari	T. k klg pria .... org .... hari .... jam/org/hari	
		T.k sewa wanita .... org ....hari .... jam/org/hari	T.k klg wanita .... org ...... hari .... jam/org/hari	

No	PERTANYAAN	JAWABAN	
2.5. Penyiangan dan Pengguludan (manual)			
1.	Jumlah penyiangan (sasak = ngeder) dalam satu musim tanam?	.... kali	
2.	Tenaga kerja yang digunakan dalam satu kali penyiangan	T.k sewa pria .... org .... hari .... jam/org/hari	T. k klg pria .... org .... hari .... jam/org/hari
		T.k sewa wanita .... org ....hari .... jam/org/hari	T.k klg wanita .... org ...... hari .... jam/org/hari
3.	Jumlah pengguludan (sasak = mbumbun) dalam satu musim tanam?	.... kali	
4.	Tenaga kerja yang digunakan dalam satu kali pengguludan	T.k sewa pria .... org .... hari .... jam/org/hari	T. k klg pria .... org .... hari .... jam/org/hari
		T.k sewa wanita .... org ....hari .... jam/org/hari	T.k klg wanita .... org ...... hari .... jam/org/hari
2.6. Pengairan			
1.	Sumber pengairan.	a. Tadah hujan b. Sungai/air tanah c. Irigasi teknis d. Lainnya	
2.	Jumlah pengairan dalam satu kali musim tanam.	.... kali	
6.	Tenaga kerja yang digunakan untuk satu kali pengairan. Upah pekasih = ...orang./musim	T.k sewa pria .... org .... hari .... jam/org/hari	T. k klg pria .... org .... hari .... jam/org/hari
		T.k sewa wanita .... org ....hari .... jam/org/hari	T.k klg wanita .... org ...... hari .... jam/org/hari

<table>
<tr><th>No</th><th>PERTANYAAN</th><th colspan="4">JAWABAN</th></tr>
<tr><td colspan="6">2.7. Pengolahan tanah</td></tr>
<tr><td>1.</td><td>Bagaimana cara anda mengolah tanah ?</td><td colspan="4">a) Menggunakan traktor
b) Menggunakan tenaga manusia
Menggunakan tenaga hewan, yaitu :</td></tr>
<tr><td>2.</td><td>Berapa biaya untuk traktor ? berapa hari ......</td><td colspan="4">Rp ....
.... hari</td></tr>
<tr><td rowspan="2">3.</td><td rowspan="2">Tenaga kerja (manusia) untuk pengolahan tanah.</td><td colspan="2">T.k sewa pria
.... org .... hari
.... jam/org</td><td colspan="2">T. k klg pria
.... org .... hari
.... jam/org</td></tr>
<tr><td colspan="2">T.k sewa wanita
.... org
.........hari
.... jam/org/hari</td><td colspan="2">T.k klg wanita
.... org ...... hari
.... jam/org/hari</td></tr>
<tr><td>5.</td><td>Jika pengolahan tanah diborongkan, berapa ?</td><td colspan="4">Rp ....(dengan apa, tenaga kerja manusia, traktor, atau hewan)</td></tr>
<tr><td>6.</td><td>Jika menggunakan tenaga kerja hewan , berapa?</td><td colspan="4">Rp.........
.... ekor, ...hari</td></tr>
<tr><td colspan="6">2.8. Penanaman</td></tr>
<tr><td rowspan="2">1.</td><td rowspan="2">Tenaga kerja penanaman</td><td colspan="2">T.k sewa pria
.... org .... hari
.... jam/org</td><td colspan="2">T. k klg pria
.... org .... hari
.... jam/org</td></tr>
<tr><td colspan="2">T.k sewa wanita
.... org ....hari
.... jam/org/hari</td><td colspan="2">T.k klg wanita
.... org ...... hari
.... jam/org/hari</td></tr>
<tr><td colspan="6">2.9. MESIN/PERALATAN</td></tr>
<tr><td rowspan="4">1.</td><td rowspan="4">Mesin/alat yang digunakan selama pertanaman kentang</td><td>Jenis mesin/alat</td><td>Tahun pembelian</td><td>Harga (Rp)</td><td>Biaya perbaikan (Rp)</td></tr>
<tr><td>Pompa air</td><td></td><td></td><td></td></tr>
<tr><td>Handsprayer</td><td></td><td></td><td></td></tr>
<tr><td>………………
……………..
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No	PERTANYAAN	JAWABAN	
2.10. LAIN-LAIN			
1.	Berapa harga sewa lahan per musim tanam ?	Rp ..../ha/are	
2.	Berapa biaya untuk sewa gudang ?	Rp	
3.	Berapa biaya untuk panen dan pemeliharaan umbi (pasca panen) ? Sistem panen ? (Panen sendiri atau beregu ?)	Rp	
5.	Biaya Transport, handling, pengemasan hasil panen (sewa kendaraan, karung,dll)	Rp	
6.	Berapa biaya untuk membeli/menyewa peralatan (handsprayer,cangkul,dll) ?	Jenis	Harga beli (Rp), Harga sewa (Rp),
		Cangkul Tali ravia Ajir Selang	....

10.1.3 Pendapatan

No	PERTANYAAN	JAWABAN			
1.	Produksi total (hasil panen) dari luasan yang ditanam	.... kg/ton			
2.	Hasil panen yang dijual sebagai kentang konsumsi	Kelas umbi Indofood	Kelas umbi untuk Psr Lokal	Jumlah (kg)	Harga (Rp/kg)
		....			
		....			
		....			
		....			
		....			
3.	Jumlah benih yang disimpan untuk dipakai sendiri.	.... kg/ton			
4.	Benih yang dijual.	.... kg/ton, harga Rp .... /kg			
5.	Umbi kentang yang disimpan untuk dimakan sendiri.	.... kg/ton			
6.	Umbi kentang untuk makanan ternak	.... kg/ton			
7.	Umbi kentang yang terbuang	.... kg/ton			

10.1.4 IV . PEMASARAN

1. Dijual kemana....(pasar lokal, antar pulau, mitra pemasaran)
2. Kalau ada kemitraan, bagaimana pola/sistemnya
3. Sistem pembayaran …….(Tunai, Panjar, Tunda… berapa hari)
4. Sistem penjualan (natura, Tebasan(Ijon), Borongan).

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10.2 Annex 2. Sembalun potato social economy

BY

TEAM BPTP NTB

(Translated by Peter Dawson)

DEPARTMENT AGRICULTURE

TECHNOLOGY ASSESSMENT INSTITUTE

BALAI BESAR PENGKAJIAN DAN PENGEMBANGAN TEKNOLOGI PERTANIAN

BALAI PENGKAJIAN TEKNOLOGI PERTANIAN NTB

2009

INTRODUCTION

Potato (*Solanum tuberosum*) is an annual dicotyledonous crop belonging to the Solanaceae family, which has edible tubers. Potato plants form bushes or herbs. There are stems above the ground, coloured green, reddish or dark purple. This stem colour is influenced by plant age and environmental conditions. On good, fertile soil or more barren, usually the crop stem colour is darker and will more striking and the stems can become woody while stems of young plants do not become woody so they are not too hard and easily collapsed (Portal Iptek 2005f). Potato tubers are now one of many important European foods, although they originated from South America (Wikipedia 2007b)

Potatoes have the potential to become a food source besides rice. Potatoes form vegetative tubers that are rich in vitamin C and potassium, as well as carbohydrate and protein. With high nutitional content potatoes suitable to become another food source besides rice. Subsequently there is a good market opportunity for potato. Data indicates, potato consumption and production is tending to increase in developing countries. For example from 315 million tonnes/year world potato production, 162 million tonnes/year were produced in developing countries, where China and India formed one third of world production. Potato consumption as "French fries" and processing industry products in Indonesia is also increasing rapidly and all are still imported. (Sinartani on-line, pekan kentang nasional 2008 di Balitsa, 2008) Tuesday, 30/12/2008.

Potato farming business in Sembalun Lawang village, Sembalun Disctrict, East Lombok Regency, from last two years is showing rapad development, especially from partnership between the Horsela farmers group and PT. Indofood. One side of the partnership facilitates farmers with preparing production means like potato seed of the variety Atlantic, fertiliser and pesticides, and the potato production is received by PT Indofood, where the price is determined by PT Indofood. The area of Atlantic harvested in 2007 was 18 ha with production of 378 tonnes with a yield of 21.0 tonnes/ha, in 2008 the area harvested rose to 150 ha with production of 2,841 tonnes with a yield of 18.9 tonnes/ha.

With farmer production input assistance from the PT Indofood partner and with the farmers' duty to sell their potato production to PT Indofood it was considered that there was a need for more in depth research to be carried out to learn the profitability of farmers and whether it is appropriate for farmers to participate in the Atlantic potato farming business based on the PT Indofood partnership.

MATERIALS AND METHODS

This study forms parto of the adaptive research of BPTP NTB working together with ACIAR in the highland paddy field farming area in the wet climate of Sembalun Lawang village, Sembalun District, East Lombok Regency. Decision area according purposive sampling or intentional because the constitutes the central Atlantic potato production location working with PT Indofood, decisión total repondents according to quota so that got a total of 28 respondents. The study was carried out in the dry season of 2008. The farming business data that was analysed was existing data or that is usually undertaken by farmers in 2008 while introduction of new pest and disease control technology from BPTP NTB and ACIAR was carried out in the dry sesaon of 2009 so that not yet can be analysed the effect of introduced technology from BPTP NTB and ACIAR. This study will discuss Atlantic potato farming business based on the [Kelompok Horsela/Indofood] partnership.

RESULTS AND DISCUSSION

The Atlantic potato forms superior commodity for the Sembalun community after rice, with annual crop rotation that is commonly carried out farmers (1) Rice-potato-bero as much as 71% the remainder (2) Rice-potato-other vegetables 29%. The rice that is planted is a local red rice (Beak Ganggas)

The area of potatoes grown in Sembalun in 2008 was 150 ha with average harvested area owned by farmers of 0,22 ha. Experience in Atlantic potato farm enterprise averaged 2 years because the Atlanic variety commenced growing in 2007, yet potato growing experience in varieties other than Atlantic averaged 3,75 years.

Economic Analysis

1. Analysis of enterprise suitability

According to the analysis already doen of potato farm enterprises carried out by farmers a profit of Rp 18.500.639,14 per ha can be obrtained with a BC ratio or apportioned returns of 1.5 where BC ratio bigger than one means that the Atlantic potato enterprise is appropriate to be carried out. Family labour was not counted because this analysis ini just counts real expenditure or costs that made by potato farmers.

Harvest cost is not based on daily wages but total production where every 100 kg of Atlantic potatoes that was harvested usually averaged Rp10.000.

2. Break Even Point analysis

This analysis to determine break-even point for production and sale price of Atlantic potatoes

Value of yield - variabel costs = 0

Value of yield (Y * P) = variable costs (TVC)

Y * P = TVC

20,390 * P = 38,207,779

P = 1,874

For a production level of 20390 kg/ha, as long as the price is above Rp 1,874/kg, it is appropriate to carry out a potato farm enterprise.

Y * P = TVC

Y * 2,700 = 38,207,779

Y = 14,151

For price level Rp 2,700/kg while potato production is above 14,151 kg/ha it is appropriate to carry out a potato farm enterprise.

Table 1. Potato farming business analysis per ha in the Village of Sembalun Lawang, 2008.

No.	Uraian	Unit	Total	Price (Rp/unit)	Value (Rp)
I.	**Expenses**				
1	Production means:				
	a. Seed	kg	2060.03	10500	21,630,345
	b. Fertiliser :				
	- Sulphate of ammonia	kg	342.76	1414	484,765
	- TSP/SP-36	kg	433.39	2000	866,776
	- KCl	kg	405.76	1736	704,277
	- Manure	kg	3192.28	497	1,587,742
	- Ponska/NPK	kg	580.76	2154	1,250,701
	c. Pesticides:				
	Insecticides				
	- Decis 100 ml	bottle	6.58	9429	62,030
	- petropur	pack	8.55	14250	121,875
	- Victory 80 WP	kg	18.09	53036	959,528
	- promectin 50 ml	bottle	7.89	53571	422,932
	- starmyl 100 gr	pack	15.46	44643	690,202
	- raydent 500 ml	bottle	5.76	43929	252,878
	- cyrotex 25 gr	pack	6.41	46964	301,251
	- winder 25 gr	pack	7.89	14679	115,883
	- Besmor	bottle	19.33	15915	307,566
	Herbicide				
	- Gold	bottle	5.37	27667	148,648
	Total production costs				29907400
2	**Non-family labour:**				
	a. Soil preparation				
	- tractor	days	5.76		959,910
	- Men	days	15.90	30000	477,116
	c. Planting				
	Men	days	5.71	30000	171,388
	Women	days	5.89	12000	70,698
	d. Organic fertiliser				
	Men	days	6.97	30000	209,126
	Women	days	6.47	12000	77,642
	d. Chemical fertiliser				0
	Men	days	4.43	30000	132,813
	Women	days	4.61	12000	55,263
	e. Weeding [by] Men	days	11.07	30000	332,178
	f. Penggguludan Pria	days	14.81	30000	444,151
	g. Irrigation [by] men	days	0.32	30000	9,636
	h. Pesticide spraying	days	66.41	30000	1,992,212
	i. Herbicide spraying	days	2.30	30000	69,079
	j. Harvest (Rp 10,000/100kg)	days	50		2,038,972
	k. Transportation and packaging				697,763
	Total non-fa,mily labour				7,737,947
3	Other expenses:				
	a. depreciation handsprayer and hoe				33,852
	b. Iu[a]ran air				528,580
	Total other expenses:				562,432
4	Total expense				38,207,779
II.	Production/returns				
1	Grade 1	kg	20389.72	2700	55052,237
2	Grade 2				0
	Total returns				55,052,237
III.	Income :				16,844,458
IV.	B/C for cash costs				1.44

NB : Not counting family costs

Labour requirements

From Table 2 it is seen that apart from hired manpower family manpower is also used. It can be seen from the labour used that hired labour is greater than family labour, this shows that growing Atlantic potatoes is already a commercial operation. Cultivation of Atlantic potatoes is needs more intensive maintenance that's seen from pesticide spraying activity that needs labour time that's high compared to other activities, where frequency of spraying averages 15 times per ha. For soil preparation a tractor is used last to make paddy dykes/guludan needing manpower.

Male working hours are greater share of work load compared with women's hours, because womens' hours needed only for planting activity phase, fertilising and weeding, while male worker involved in all activities starting from land preparation up to harvest, even though thre is good family manpower [available family] men or women are not involved in potato harvest, because already handed over to specialist harvest worker section that is already formed by the Horsela [Horticulture Sembalun Lawang] Farmers' Group with members agreement, this situation is intended to guarantee quality or grade of Atlantic potato that will be sent to PT Indofood.

Tabel 2. Family and non-family labour per ha for Atlantic potato business 2008

No.	Activity	Labour days				Total		Total
		Family		Non-family		Labour days		labour
		Men	Women	Men	Women	Men	Women	days
1	Soil preparation + dyke forming							
	- tractor							5.76
	- people	21.88	0.00	15.90	0.00	37.78	0.00	37.78
2	Planting	2.26	2.24	5.71	5.89	7.97	8.13	16.10
3	Fertilising							
	- organic	3.56	3.78	6.97	6.47	10.53	10.25	20.78
	- chemical	3.60	3.37	4.43	4.61	8.02	7.98	16.00
4	Weeding	10.86	13.82	11.07	0.00	21.93	13.82	35.75
5	Hilling	4.58	0.00	14.81	0.00	19.39	0.00	19.39
6	Irrigation	3.82	0.00	0.32	0.00	4.14	0.00	4.14
7	Spraying							
	- Pesticides	42.94	0.00	66.41	0.00	109.34	0.00	109.34
	- Herbicide	6.40	0.00	2.30	0.00	8.70	0.00	8.70
8	Harvest	0.00	0.00	50.00	0.00	50.00	0.00	50.00
	Total labour	99.89	23.20	177.92	16.97	277.81	40.17	323.74

Indofood Partnership

The principle partnership that is being built by the Horsela Farmers' Group can help the group with capital and production inputs from PT Indofood, like Atlantic potato seed from Canada and Australia, and capital to buy chemical fertiliser and pesticides through the Horsela Farmers' Group management, that farmers pay back after harvest. The Horsela Farmers' Group management guarantee in return the quality target that's requested by PT Indofood. Capital that is given apart from paying for production inputs also includes the cost of buying the combined Atlantic potato production of the farmers in the Horsela Farmers' Group and the cost of transportation of sending the Atlantic potatoes PT Indofood in Java. When there is profit or loss in this buying and selling process model responsibility [lies with] the Horsela Farmers' Group management.

PT Indofood decide together with the Horsela Farmers' Group the fertiliser dose for the Atlantic potatoes. The day to day cultivation process of Atlantic potatoes is under the supervision of a team that was formed by the Horsela Farmers' Group management. Whereas PT Indofood management assistance occurs less frequently.

Buying chemical fertiliser from PT Pertani, pesticides are bought from the company Uni Penta Prima that forms the agricultural input division of PT Indofood. Compost is bought from UD Urip Tani batu Jae Mamben East Lombok. For development the Horsela Farmers' Group is building cooperation koperasi to become a distributor of chemical fertiliser so that it is easier for the Horsela Farmers'Group to get the chemical fertilliser subsidy, and to try to produce compos themselves taking advantage of the local natural resources that are available, where Sembalun has many cows that are penned or roaming.

Yet there is a weakness in this partnership as there is not a legal written contact, only having trust between the Horsela Farmers' Group management and PT Indofood. This situatioan is very weak for the Horsela Farmers' Group because PT Indofood at any moment can leave the agreement without the responsibility of continuing the relationship with the potato farmers of Sembalun, East Lombok Regency.

CONCLUSIONS

The conclusions that can be drawn from study are

1. Atlantic potato farm enterprise is appropriate to be carried out based on the partnership with PT Indofood
2. Working hours for men are greater than for womwn in Atlantic potato farm enterprise.
3. The partnership that has been built by PT Indofood with the Horsela Farmers' Group is not yet based on a legally binding written agreement.

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Australian Government

Australian Centre for International Agricultural Research

Final report appendix 3

title	AGB/2005/167 Baseline agronomic survey of cabbages
prepared by	Ian McPharlin and Andrew Taylor
co-authors/ contributors/ collaborators	Dr Mike Furlong, Dr Peter Ridland, Dr Dolf De boer,Dr Eri Sofiari, Dr Mieke Ameriana (dec.), Rofik Sinung Basuki, Ms. Mien Rukmini. Mr Hidayat Sayono, Mr Himawan, Mr Suhari, Mr Mufrodin, Mr Akhmad Arifudin, Mr Frans Silva, Ms Sri Wahyuning Ning Mr Zamzaini.

1 Executive summary

Major limits to cabbage yield were identified in a survey of growing conditions and practices in two provinces of Indonesia from 2007 to 2008. A 'Stratified Cluster Sampling' design was used where the provinces were not randomly selected (i.e. stratified), but chosen because they are important cabbage growing regions. The districts/sub-districts (strata) and farms (sites) were randomly chosen within each province. A total of 50 farmer sites were chosen from the two provinces; 25 in Central Java (CJ) and 25 in West Java (WJ). The main cabbage variety grown and surveyed was Green Coronet.

Some factors were directly measured such as type, incidence and severity of pests, diseases and weeds in the growing crop from monitoring by staff of Dinas Pertanian and soil (texture, macro and micro nutrient concentration and pH prior to planting) and plant fertility (macro and micro nutrient concentration of the leaves at different crop stages) from laboratory analysis. Other factors such as time of planting and harvest, planting density and depth, source, quality and cost of seed/seedlings, types and number of rotation crops, source, method and frequency of irrigation, seeding rate, types and rates of pesticides, fertilisers and amendments, relative importance of pests, diseases, weeds etc were based on answers from grower respondents to a survey questionnaire.

In most cases survey data was related to yield measured from a standard sampling area (50 m^2) at each site (each site = 1 grower 'respondent') using either regression analysis for continuous data (e.g. planting density, soil and plant nutrient concentration) or ANOVA for discrete data (e.g. type of pest, weed or disease, method of irrigation) and the significance recorded for $P < 0.10$. Where it was not possible or appropriate to relate data to yield frequency tables (% of respondents or sites) were used.

Clubroot (*Plasmodiophora brassicae*) was identified as the most important disease limiting yield, based on incidence, from both grower response and crop monitoring in both provinces. Due to its widespread incidence and difficulty in obtaining accurate assessments of severity at each site it was not possible obtain statistical relationships with yield. Assessments of severity were difficult due to differences between the criteria used for severity in each district and missing data.

Diamondback moth (DBM) (*Plutella xylostella*) and cabbage head caterpillar (CHC) (*Crocidolomia pavonana)* were the most prevalent of pests recorded from the survey. Control of these two pests was based on the use of large quantities of broad-spectrum synthetic insecticides. Integrated Pest Management (IPM) programs have previously been developed in Indonesia but not necessarily adopted by farmers. Farmer's use of biological control agents such as *Bacillus thuringiensis* (*Bt*) have increased over time but the beneficial effect of this is outweighed by the use of the broad spectrum insecticides.

Java soils were acidic with WJ more acidic than CJ and lower yields were significantly related with high concentrations of extractable Al and Mn in the soil. The concentration of both these elements increases as soils become more acidic. Related to this was that higher yields were correlated with higher concentrations of Ca in the soil and petioles and Mg in the petioles, the concentration of which increases in the soil with pH, i.e. as soils become less acid. It is also suggested soil acidity would have indirectly contributed to a reduction in yield and quality of cabbage in Java by enhancing the incidence and severity of clubroot. The more acidic WJ soils may have lead to the higher incidence of clubroot there compared with that of CJ. Despite what appeared to be general awareness of the importance of managing acid soils amongst growers for Brassica production there was little use of lime reported in the agronomic baseline survey with only 6% using it. Where it was used it was as dolomite applied at rates from 0.4 to 1.01t/ha. These rates are most likely too low to raise pH adequately to counteract soil acidity and minimise clubroot. Also there was no use of the more reactive forms of lime such as calcium hydroxide reported in the agronomic baseline survey.

2 Background

Vegetables are an important crop in Indonesia due to increasing consumer demand as a result of population growth, improved community awareness of the nutritional benefits and increased government support for infrastructure and facilities (Arsanti and Böhme 2008). Vegetable farming systems in Indonesia differ significantly from one area to another with different crops cultivated and different values on profitability (Arsanti and Böhme 2008)

Brassicas (cabbage +Chinese cabbage) are the most important vegetables on an production basis and second to chilli on an area basis grown in Indonesia (CBS, 2009). Production and area in 2000 was 1,283,747 t from 63,554 ha at an average yield of 20.2t/ha. There was a small increase in area and total production by 2009 to 1,358,113 t from 67,793 ha at an average yields of 20 t/ha (CBS, 2009). Most cabbage is grown in CJ, WJ and East Java (25, 22, 15% of total respectively) followed by North and West Sumatra (15 and 7% of total respectively). Smaller areas are grown in Sulawesi (north and south), Bengkulu, Jambi and Bali with minor plantings across another 10 - 15 provinces. Cabbage is usually grown in the highland areas in the main provinces but there is some also grown in lowlands using varieties adapted to the area (Pemadi 1993). It is important to understand differences between growing regions to determine the best practice for cabbage production.

DBM and CHC were found to be the major pests and clubroot the major disease of cabbage in a survey of 120 respondents in 3 districts of West Java in 2004 (Rauf *et al.* 2004). Simultaneous infestation by these pests and the disease could cause complete yield loss of cabbage crops. Cabbage centre grub (*Hellula undalis*) and black cutworm (*Agrotis ipsilon*) were reported to cause moderate damage but could cause serious damage in some circumstances. For example *H. undalis* was reported to be severely damaging to crops in hot dry conditions in the mid and lowlands and *A. ipsilon* to be most damaging at the seedling stage. Leaf flea beetle (*Phyllotreta vittata*) and bacterial soft rot (*Erwinia caratovora)* were generally considered to cause mild damage but *P vittata* could cause severe damage in hot dry conditions. Other yield limiting factors, such as sub-optimal agronomic practices, were not investigated in the survey.

Clubroot is a major and common disease of cabbage in Indonesia and soil management is an important aspect of its control. The interaction between soil conditions and clubroot are well documented. In particular clubroot severity increases at low soil pH and liming soils to increase pH along with other practices (rotation with non-Brassica crops, farm hygiene, chemical applications, tolerant varieties,) is commonly used worldwide to manage the disease (Rimmer *et al*. 2007, Donald *et al*. 2006). Applications of Ca in addition to that required to change pH also aid in clubroot management (Webster and Dixon 1991). For example the 'neutral' fertilisers calcium nitrate and sulphate can be used to apply extra calcium without increasing pH and both have been used in clubroot management in addition to traditional limes such as calcium carbonate, oxide, hydroxide and dolomite (Donald *et al.* 2006). There is also evidence that cabbage plants which are low in magnesium and boron are more susceptible to clubroot than well fertilised plants; thus, adequate, but not excessive, fertilisation with these elements is essential to minimise clubroot damage. It is generally agreed there is no one single option for clubroot control and an integrated approach, incorporating a number of practices, such as those mentioned and the possible incorporation of resistant varieties is necessary for disease management (Donald *et al*. 2006, Donald and Porter 2009).

Black rot is a major disease of cabbages worldwide and is a major problem in the Indonesian cabbage production system. Management of the disease must focus on both the production of high quality seedlings with low level of infection in the nursery as well as management of the crop after transplanting. Seed-borne infection provides the primary inoculum of this bacterium to spread (Rimmer *et al*. 2007). Sterilisation of nursery soil used either in pots or in soils in field nurseries along with tolerant varieties and hot water treatment of seed are important options for the management of black rot in cabbages (Anon 2000).

Despite the assumption that DBM, CHC and clubroot would be major constraints to cabbage production it was decided to carry out a survey where a wider range of growing conditions and agronomic practices were examined, in addition to pest and disease status. This survey aimed to identify limits to cabbage yield and production in Indonesia at the provincial level in an objective way by relating agronomic factors to yield measured at survey sites. Using this approach important limits to yield were identified by correlating a range of production factors with yield in 2 cabbage producing provinces (CJ and WJ in Indonesia using either ANOVA or regression statistics.

3 Objectives

A primary objective for the first year of the project (2006 to 2007) was to conduct both wet and dry season baseline surveys of cabbage crops in Central and West Java

The aims of these surveys were to identify the main limits to cabbage production (yield and quality) in the two provinces. This was achieved through a statistical analysis of the relationship between growing conditions and practices with yield. These conditions and practices were recorded through answers to questionnaires, crop monitoring and direct measurement. The combination of conditions and practices that resulted in low yield and quality were therefore identified as constraints to production whilst those that resulted in high yield and quality were identified as good agricultural practices.

Personnel conducting the survey (the ‘interviewers’ or ‘assessors’) assisted in the preparation of the questionnaire and were trained in interview techniques, sampling and monitoring procedures and data collection and analysis.

The major constraints to production identified by the survey were targeted in the learning by doing (LBD) activities which were incorporated into the Farmer Field Schools (FFS) in subsequent phases of the project.

4 Methodology

4.1 Survey Design

Agronomic conditions and practices were examined over 2 different plantings (or provinces where 1 province= 1 planting) by farmers and Dinas Pertanian staff in Central (CJ) and West Java (WJ).

A 'Stratified Cluster Sampling' design was used where provinces and districts/sub-districts were not randomly selected, i.e. stratified, but chosen because they are important Brassica growing regions. The districts/sub-districts (strata) and farms (sites) were randomly chosen within each province. A total of 50 farmers were chosen between the 2 provinces.

A total of 50 farmer ('respondent') sites (1 site equals 1 farm) were chosen from the 2 provinces; 25 in both CJ and WJ (Table 4.1). In CJ five farmers were selected from each of five sub-districts (Batur, Pejawaran and Wanasaya sub-districts of Banjarnegara and Kejajar and Garung sub-districts of Wonosobo). Similarly in WJ five farmers were selected from two sub-districts of Bandung (Pangalengan and Kertasari) and from three sub-districts of Garut (Cikajang, Pasir Wangi and Cisurupan). Cabbage (Green coronet) crops were transplanted from June to October in CJ and from March to June in WJ and were considered 'dry season' crops.

Table 4.1. Location and number of grower sites, variety, planting and harvest dates for the survey.

Province	No of sites	Variety	Planting dates	Harvesting dates
Central Java	25	Green coronet	7/6/07 to 2/10/07	12/9/07 to 5/1/08
West Java	25	Green coronet	27/3/07 to 17/6/07	22/6/07 to 17/10/07

Farmer 'respondents' were interviewed over 5 to 6 visits and answered a comprehensive set of questions on their cabbage growing practices and conditions (see questionnaire: Attachment 1). In addition, the interviewers acted as assessors and carried out various sampling (i.e. soil, plant, insect etc) and monitoring activities of the state of the crop (i.e. crop growth and soil moisture status, incidence (% of crops affected) and severity (degree of infection or infestation in each crop of pests and diseases) at each visit. All these crop measurements were made from a consistent $50m^2$ sized plots so variability between growers based on farm size was not an issue in the survey. All 'enumerators' (Dinas Pertanian and other staff) were trained in the monitoring of crops prior to the survey beginning.

4.2 Assessment of Agronomic practices and conditions

4.2.1 Practices & conditions

Agronomic practices such as sowing (rate, depth, date, method), rotation, tillage (method, frequency, depth), irrigation, fertiliser, weed, pest and disease management, selection and treatment of seed, date and method of harvest were recorded from grower responses to the questionnaire. Site elevation, slope, soil moisture and prevailing weather conditions were also recorded.

4.2.2 Soil and Plants

Sampling and analysis of soil for nutrients and particle size.

One to two days before planting 25 individual soil samples (depth 15 cm) were taken with a soil corer in a zigzag pattern across the 50m^2 sampling area at each site.

All soil samples were bulked into a single composite sample in a plastic bag and forwarded to the Indonesian Vegetable Research institute (IVEGRI) laboratory in Lembang. Samples were analysed for pH (H_2O and KCl at 1:2.5), total N% (Kjeldahl) and %C (Walkley and Black 1934), extractable NO_3-N, NH_4-N (both in 10% KCl), Bray P(Bray and Kurtz 1945), Olsen P (Olsen *et al.* 1954), S ,Al, Fe, Mn Cu, Zn (all in $NH_4CH_3CO_2$ at pH 4.8), exchangeable K, Ca , Mg and Na (all in $NH_4CH_3CO_2$ at pH 7.0) and particle size (% sand, silt and clay).

If there was a delay for more than 2 days in despatch, the soil was air dried in an area protected from the rain, or in dried in an oven at 35 °C for 48 hours at a Dinas Pertanian or BPTP office nearest to the sampling site.

Sampling and analysis of plants for nutrients

The youngest mature leaf (the 4th or 5th down from the growing point) was collected from 20 plants (1 per plant) in a grid pattern from the 50m^2 sampling areas over the 25 sites in both provinces 28 to 35 days after transplanting (first sample), the wrapper leaf (outermost leaf around the head) was similarly sampled from 20 plants at the early heading stage (second sample).The number of leaves on plants (crop stage) and the precise sampling date was recorded at both sampling times. All 20 samples at each site were bulked into a single composite sample in paper bags and the 50 samples (at each sampling time) submitted and forwarded to the IVEGRI laboratory in Lembang. Leaves were analysed for total N,P,K,Ca,Mg,S, Na, Cl (all in %DW) and total Al, B, Fe , Mn , Cu and Zn (all in mg/kg DW).

4.2.3 Identification of pest and disease type and assessment of incidence

Farmers recorded the incidence of pests and diseases in the stored seed prior to planting and during the growth of the crop. Independent regular monitoring by trained Dinas Pertanian staff also recorded incidence and severity of pests and diseases in the crop during their five visits throughout growing season. Control measures, such as fertiliser, fungicide and insecticide application and cultural methods practiced before transplanting and during the growth of the crop were recorded by the farmer.

4.2.4 Yield

Total yield, yield of marketable crop and the quantity of the crop which had to be rejected at each site was determined at harvest.

4.3 Data analysis

With most of the data either regression analysis or analysis of variance of the factor with yield was performed using Genstat v 13.0. In some cases it was not possible or relevant to relate the factor statistically with yield so frequency tables were used where % of total to respondent answers (where 1 grower response = 1 site or farm) were presented. For example some factors such as clubroot (CR) were so widespread as to occur on most sites for the incidence to > 70% (i.e. > 70% of grower respondents reporting CR as a major factor limiting yield). In this case statistical relationships between yield and % incidence were not appropriate. Attempts to relate severity of CR, a more relevant measure than incidence, with yield were also of limited value because the data set was incomplete.

Simple linear regression were used to analyse the relationship between the continuous measures of agronomic conditions (i.e. soil and plant nutrient concentrations), practices (i.e. plant spacing, density, rates of applied fertilizer and amendments) versus head yield across all the sites in each of the 4 provinces. Concentrations of nutrients considered deficient, adequate or excessive (toxic) according to Huett *et. al.* (1997) of the youngest mature leaf 28 to 35 days after transplanting were shown as vertical lines on each regression (Attachment 2).

Analysis of Variance (ANOVA) were used to determine the relationship for discrete measures of presence or absence (i.e. pest and disease), education (i.e. sources), irrigation (i.e. type) and weeds versus total yield across all sites in each of the 4 provinces. A probability of $P < 0.10$ was used as the minimum level of significance was used in all analyses as this was considered appropriate for surveys. Combined relative yield was used when the data from both provinces was to be combined together and analysed as a single data set. To produce the combined relative yield each site was presented as a percentage of the highest total yield for that province (i.e. the highest total yield was equivalent to 100%). This was repeated for both provinces and combined into one data set. The data was then analysed as above by simple linear regression and ANOVA versus total yield to determine significance with a minimum significance level of $P < 0.10$.

5 Achievements against activities and outputs/milestones

Objective 1: To Adapt and apply robust integrated crop production, pest management and postharvest handling systems for potato and Brassicas/Alliums suited to Java conditions

no.	activity	outputs/ milestones	completion date	comments
1.2	*Training in survey design, crop monitoring, sampling, data collection and analysis*	*Questionnaire finalised & training completed at workshops*	*CJ &WJ in 2006*	*Training at workshops was complimented by practical demonstrations during field visits to WJ in 2006, CJ in 2007.*
1.3	*Conduct baseline survey for cabbage in CJ, & WJ*	*Summary reports of baseline surveys completed and results presented at workshops*	*CJ &WJ in 2007/08*	*Summary reports all baseline surveys from each province included in annual reports. Results of surveys presented to workshops in WJ and CJ in 2007.*

PC = partner country, A = Australia

6 Key results and discussion

6.1 Yield

Mean head yield was 46.8t/ha in Central Java which was significantly higher than the mean yield 37.5t/ha in West Java. In WJ, but not CJ, there was a significant difference (P<0.10) in head yield between districts and sub-districts (P<0.1) where yields ranged from the lowest of 26.7t/ha in Pasirwangi to the highest of 48.3t/ha in Kertasari (Fig 6.1).

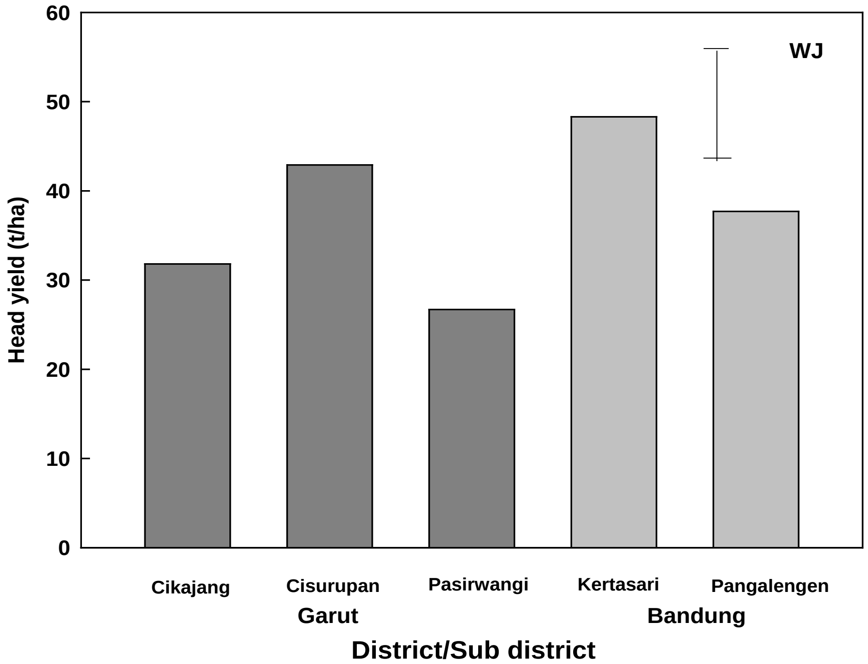

Figure 6.1 Head yield (t/ha) of cabbage in districts and sub-districts of West Java. Vertical bar is LSD for difference (P<0.10) in mean yields between sub-districts from ANOVA.

6.2 Learning

Lower yield was associated with longer farming experience (P < 0.10, from the linear regression) in WJ and for the 2 provinces but not CJ alone (Fig 6.2).

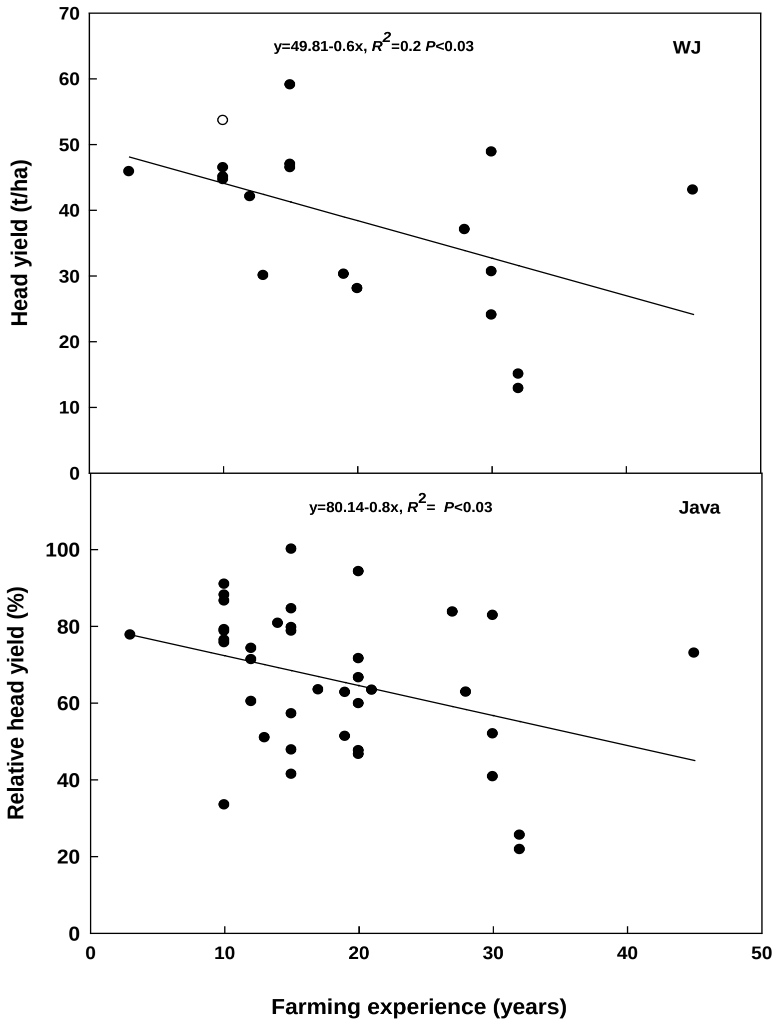

Figure 6.2. Linear regression between head yield (t/ha) of cabbage and farming experience (years) in West Java (WJ) and Java (CJ&WJ).

Higher yield was associated with the use of extension officers in CJ, WJ and on average for both provinces (Fig 6.3). The relationship between head yield and number of sources of education were contradictory. For example higher head yield was associated with higher number of sources of education in CJ ($y = 37.8 + 3.8x$, $R^2 = 0.09$, $P<0.10$) but a lower number of sources was associated with higher %relative head yield in the 2 provinces combined ($y = 80.1 - 0.8x$, $R^2 = 0.10$, $P < 0.05$, plots not shown). There was no significant relationship between head yield and number of sources of education in WJ.

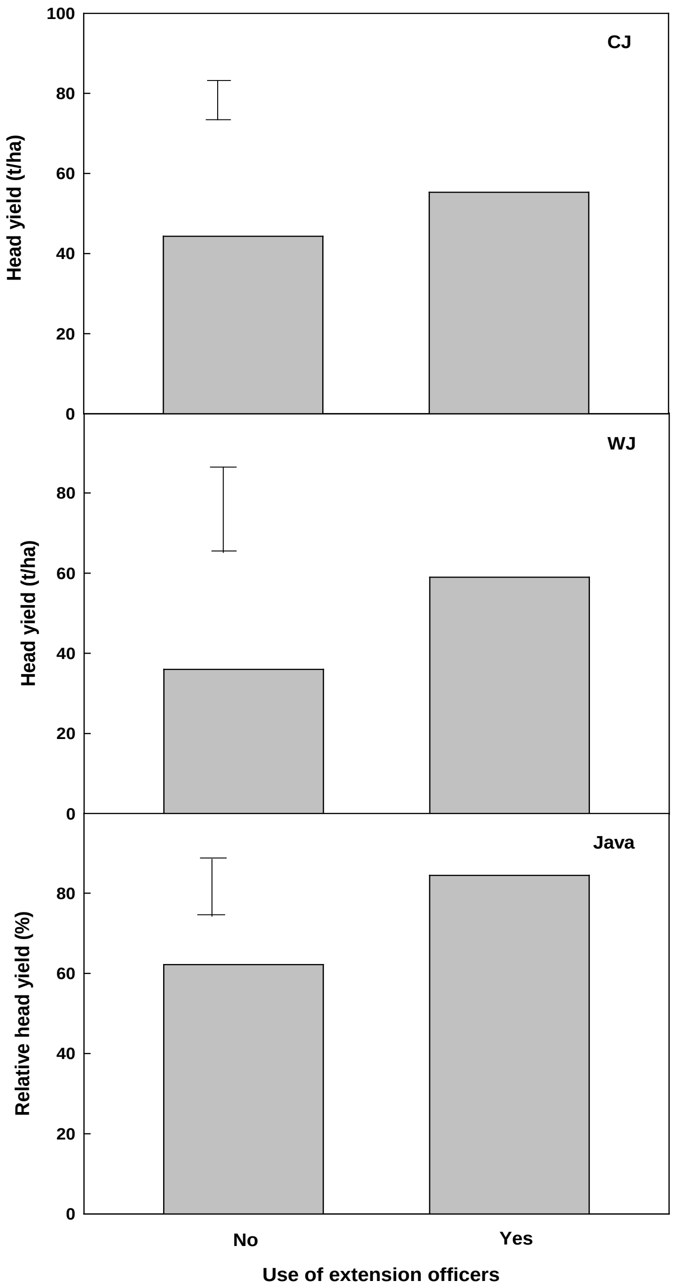

Figure 6.3. Head (t/ha) or relative head yield (%) of cabbage with use of extension officers in central (CJ) west (WJ) Java or from the 2 provinces combined (Java). Bar is LSD (P<0.10) for difference between mean yields from ANOVA.

6.3 Fertiliser and nutrition

6.3.1 Fertiliser

Mean rate of N applied ranged from 111 to 150 kg/ha, P from 29 to 50 kg/ha and K from 15 to 85 kg/ha in CJ, WJ and for the average of the 2 provinces combined (Table 6.1). Higher yield was associated with higher rates of applied N in CJ but not WJ and with lower rates of P and K for the 2 provinces combined. There was little use of lime for soil amendments/pH management with only 6% of respondents reporting its use as Dolomite only from 0.4 to 1t/ha. Urea and ammonium sulphate (ZA), SP36 and muriate of potash (KCl) were the 'single' fertilisers most commonly used to apply nitrogen, phosphate or potassium respectively and NPK 'Ponksa' and 'Mutiara' the most commonly used compound fertilisers.

Table 6.1. Total rates of application of N, P, K and organic fertiliser (mean and range) and significance of linear regression of rates with head yield for cabbage crops in 2 provinces of Indonesia. 'Significance' refers to the relationship between head yield and rate by ANOVA (a) or regression analysis (b).

Province	Nutrient(kg/ha)	Mean (+/-SE)	Range	Significance#
CJ	N	111(+/- 19)	0-484	**(+)b
WJ	N	150(+/-17)	4-357	ns
Java	N	130(+/-13)	0-484	ns
CJ	P	24(+/-12)	0-300	ns
WJ	P	50(+/-30)	0-128	ns
Java	P	37(+/-7)	0-300	**(-)b
CJ	K	15(+/-12)	0-300	ns
WJ	K	85(+/-17)	0-400	ns
Java	K	50(+/-12)	0-400	**(-)b

ns=not significant or '*'= P<0.1, '**'= P<0.05,'***'=P<0.01

6.3.2 Soil nutrients and soil pH

Concentrations of Al in the soil decreased significantly with pH in both CJ, WJ and the 2 provinces combined (Fig 6.4), with Cu, Fe and S in CJ and both provinces combined but not WJ and with Mn in WJ and the 2 provinces combined but not CJ. There was no effect of pH on concentration of Zn in the soil (Table 6.2).

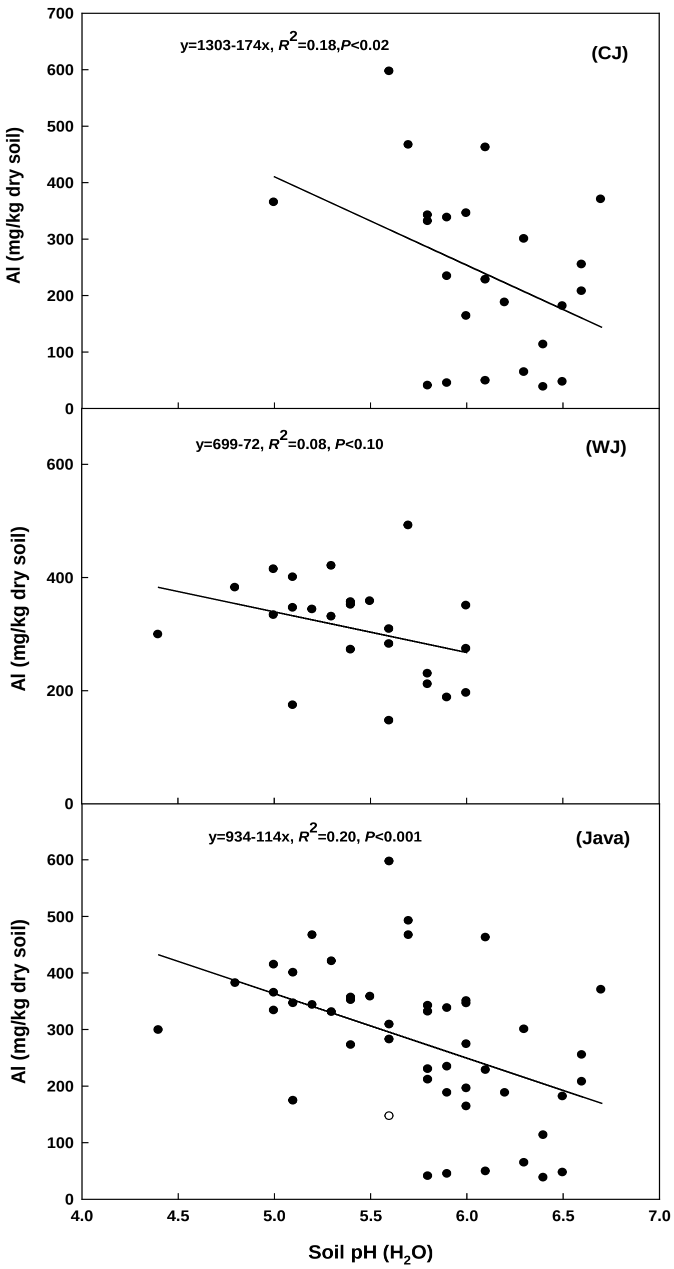

Figure 6.4. Linear regression between extractable Al in cabbage soils (mg/kg dry soil) with soil pH in central (CJ), west (WJ) Java or from the 2 provinces combined (Java).

Table 6.2a. Extractable# micro nutrient concentration in soil and linear regression (- or +) with soil pH.

Province	Nutrient(mg/kg dry soil)	Mean (+/-SE)	Range	Significance##
CJ	Al	249(+/-32)	37-596	** (-)
WJ	Al	310(+/-17)	146-491	* (-)
Java	Al	279(+/-19)	37-596	****(-)
CJ	Cu	0.7(+/-0.2)	0.0-1.2	***(-)
WJ	Cu	2(+/-0.2)	0.6-4.1	ns
Java	Cu	1.4(+/-0.1)	0.0-4.1	****(-)
CJ	Fe	9.3(+/-1.4)	1.3-23	*** (-)
WJ	Fe	14.3(+/-1.5)	4.2-34	ns
Java	Fe	11.8(+/-1.1)	1.3-34	****(-)
CJ	Mn	8.0(+/-2)	3.1-53	ns
WJ	Mn	7.8(+/-1.4)	2.2-38	*** (-)
Java	Mn	7.9(+/-1.2)	2.2-53	*(-)
CJ	Zn	6.2(+/-0.8)	1.2-16	ns
WJ	Zn	5.8(+/-0.4)	2.1-10	ns
Java	Zn	6(+/-0.4)	1.2-16	ns
CJ	pH	6.0(+/-0.08)	5.0-6.7	n.a.
WJ	pH	5.4(+/-0.08)	4.4-6.0	n.a.
Java	pH	5.8(+/-0.07)	4.4-6.7	n.a.

see 4.2.3 for details

*<0.10, **<0.05, ***<0.01, ****<0.001 and ns not significant and (–) and (+) refers to negative and positive linear regressions respectively and n.a. = not applicable.

Exchangeable Ca and Mg increased significantly in the soil with pH in CJ, WJ and both provinces combined (Figs 6.5 and 6.6). There was no effect of pH on concentration of K, Na or N in the soil (Table 6.2a).

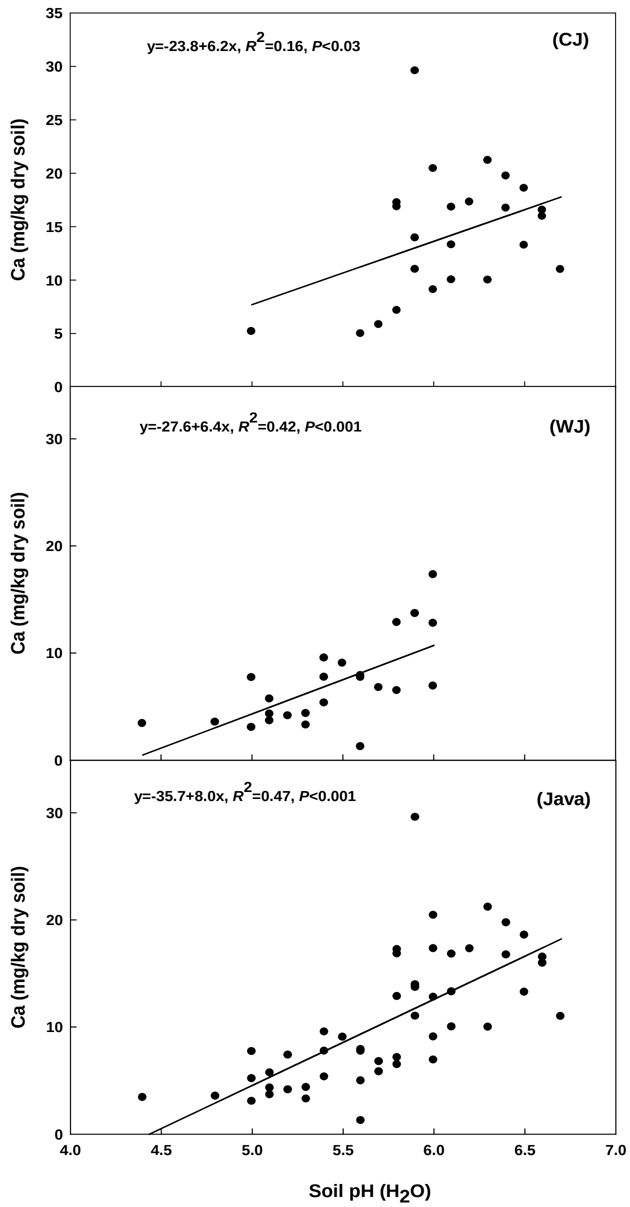

Figure 6.5. Linear regression between extractable Ca in cabbage soils (mg/kg dry soil) and soil pH in central (CJ), west (WJ) Java or from the 2 provinces combined (Java).

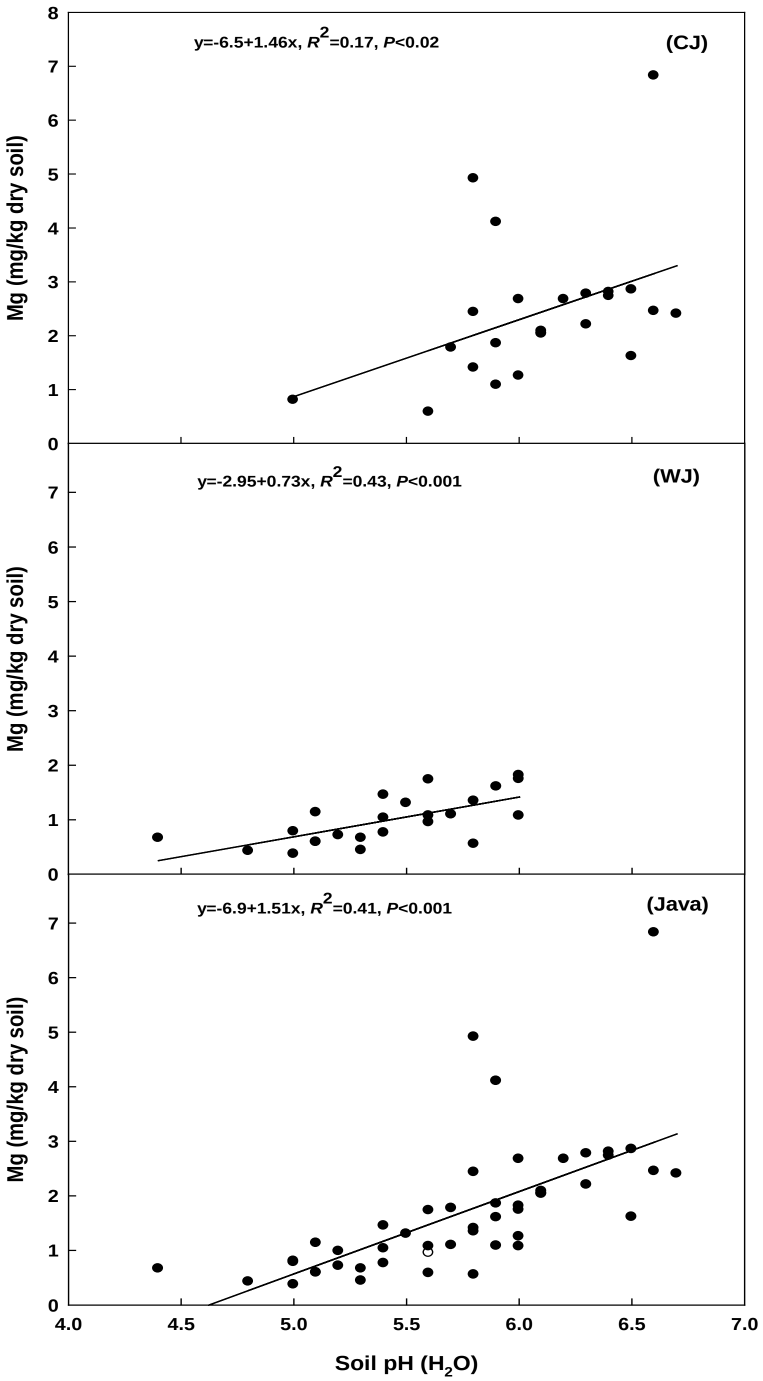

Figure 6.6. Linear regression between extractable Mg in cabbage soils (mg/kg dry soil) and soil pH in central (CJ), west (WJ) Java or from the 2 provinces combined (Java).

Table 6.2b. Extractable or total[#] macro nutrient concentration in soil and linear regression (- or +) with soil pH.

Province	Nutrient(mg/kg)	Mean (+/-SE)	Range	Significance##	Nutrient(mg/kg)	Mean (+/-SE)	Range	Significance##
CJ	Ca (cmol)+/kg	14(+/-1.2)	May-30	** (+)	N(NO_3-N)	44(+/-5)	14-85	ns
WJ	Ca	7(+/-0.8)	1.2-17	****(+)	N(NO_3-N)	66(+/-6)	21-106	ns
Java	Ca	10.5(+/-0.9)	1.2-30	****(+)	N(NO_3-N)	55(+/-4)	14-106	ns
CJ	K	1.4(+/-0.2)	0.39-3.3	ns	%N(total)	0.5(+/-0.04)	0.24-0.84	ns
WJ	K	0.7(+/-0.1)	0.34-1.6	ns	%N(total)	0.5(+/-0.03)	0.13-0.74	ns
Java	K	1.1(+/-0.01)	0.34-3.3	ns	%N(total)	0.5(+/-0.02)	0.13-0.84	ns
CJ	Mg	2.4(+/-0.3)	0.58-6.8	** (+)	P(Bray)	54(+/-17)	0.8-299	ns
WJ	Mg	1(+/-0.09)	0.37-1.8	****(+)	P(Bray)	64(+/-14)	3.4-311	ns
Java	Mg	1.7(+/-0.2	0.37-6.8	****(+)	P(Bray)	59(+/-11)	0.8-311	ns
CJ	Na	0.3(+/-0.03)	0.03-0.9	ns	P(Olsen)	366(+/-75)	38-1369	ns
WJ	Na	0.2(+/-0.02)	0.01-0.4	ns	P(Olsen)	104(+/-28)	5-463	ns
Java	Na	0.3(+/-0.02)	0.01-0.9	ns	P(Olsen)	238(+/-44)	5-1369	***
CJ	N(NH_4-N)	1.4(+/-0.24)	0.3-4.5	ns	S	194(+/-44)	10-664	**(-)
WJ	N(NH_4-N)	1.0(+/-0.07)	0.6-1.9	ns	S	467(+/-74)	27-1488	ns
Java	N(NH_4-N)	1.2(+/-0.13)	0.3-4.5	*(-)	S	328(+/-47)	10-1488	****(-)

see 4.2.3 for details

*<0.10, **<0.05, ***<0.01, ****<0.001 and ns not significant and (–) and (+) refers to negative and positive linear regressions respectively.

6.3.3 Soil nutrients and yield

Lower yield was associated with higher concentration of extractable Al and Mn (Fig 6.7 and 6.8) and lower concentration of extractable Ca (Fig 6.9) in the soil in CJ but not WJ or both provinces combined. Lower yield was also associated with higher concentrations of extractable NH_4-N in the soil in CJ and both provinces combined and with extractable NO_3-N in the soil in CJ only. By contrast higher %N in the soil was associated with higher yield in WJ but not CJ or both provinces combined (plots not shown).

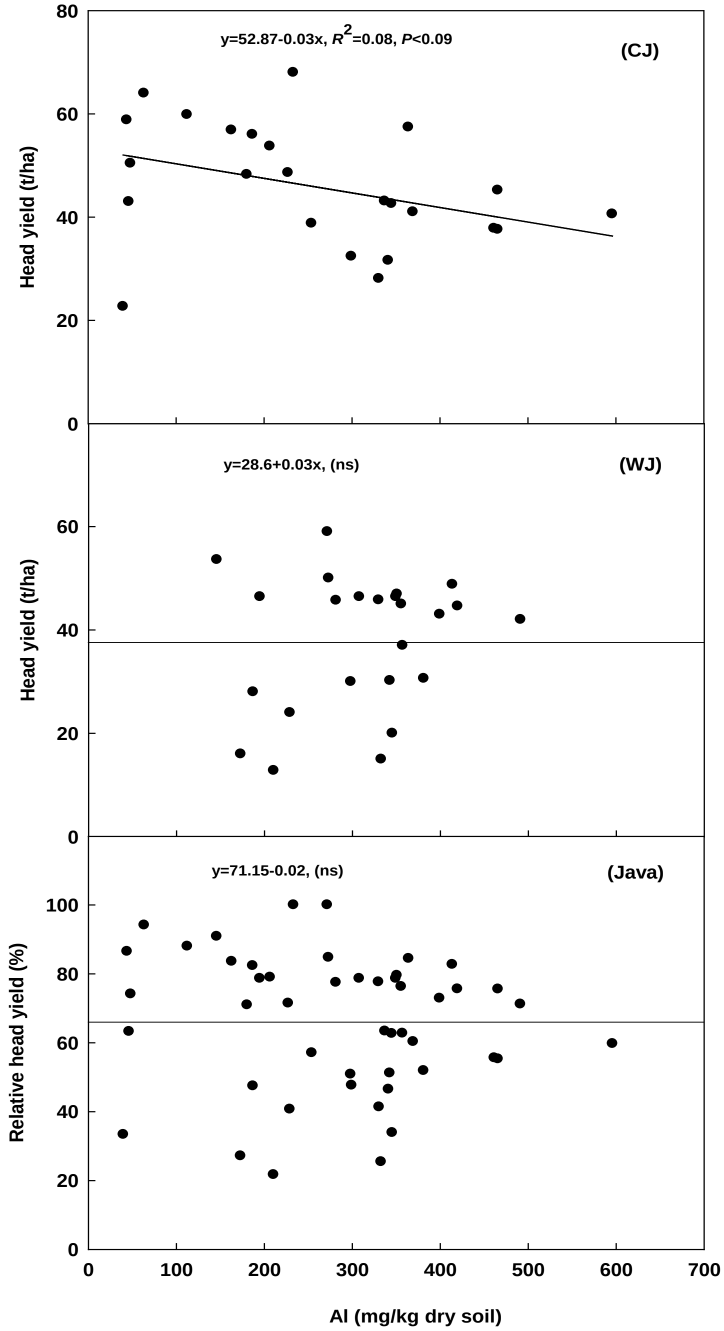

Figure 6.7. Linear regression between extractable Al in soil (mg/kg dry soil) and head yield of cabbage in central (CJ) and west (WJ) Java or from the 2 provinces combined (Java).

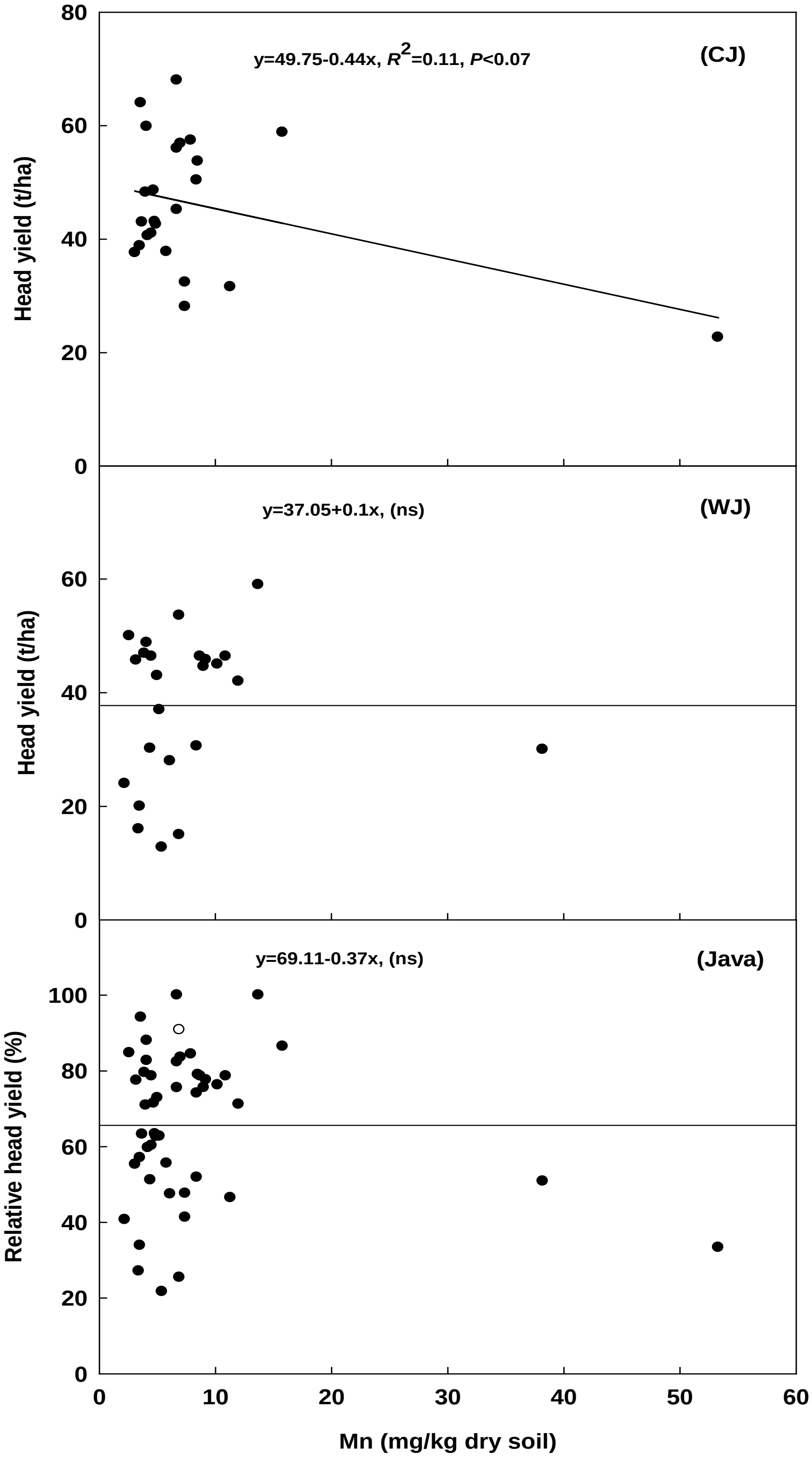

Figure 6.8. Linear regression between extractable Mn in soil (mg/kg dry soil) and head yield of cabbage in central (CJ) and west (WJ) Java or from the 2 provinces combined (Java).

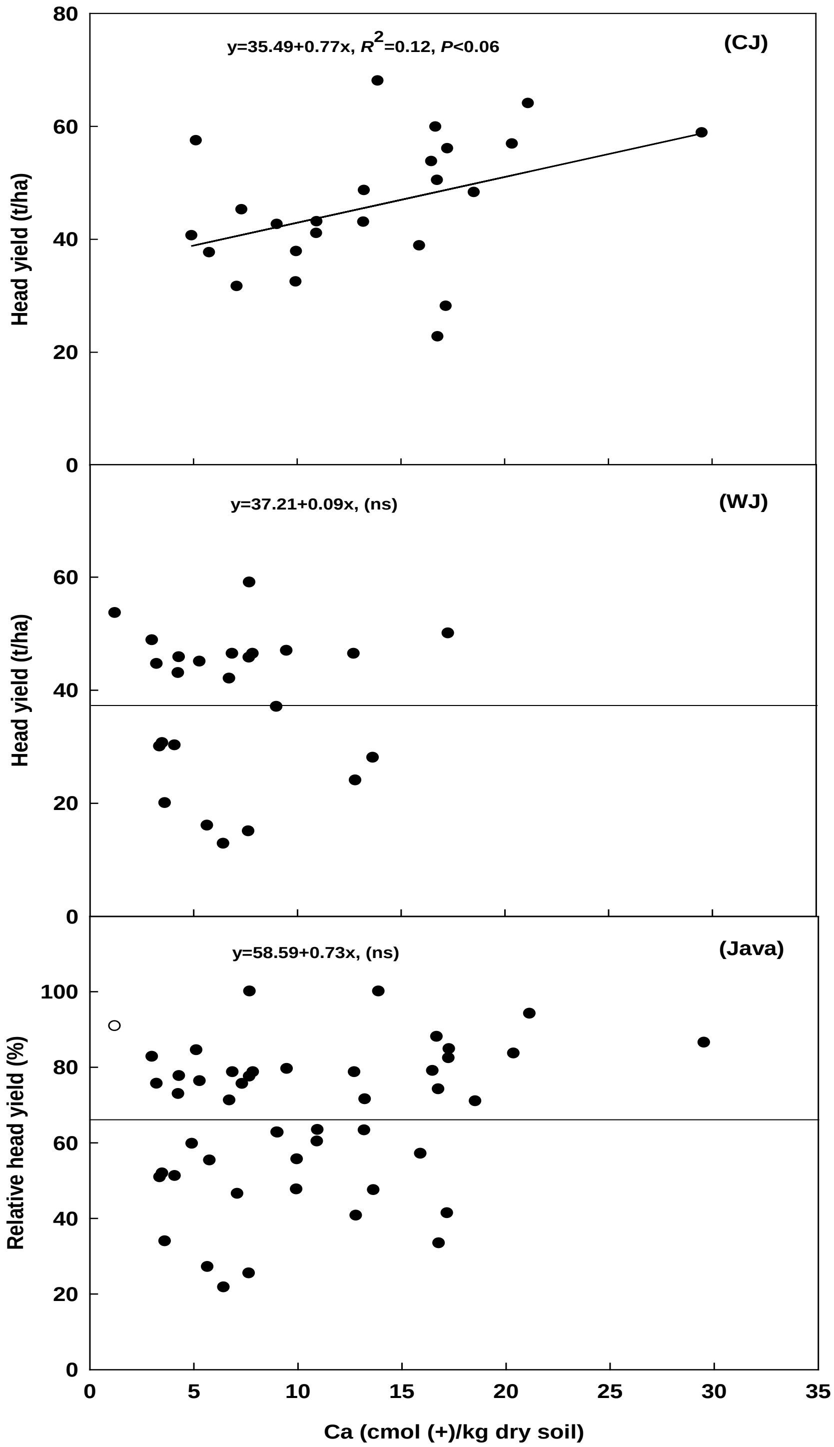

Figure 6.9. Linear regression between extractable Ca in soil (cmol (+)/kg dry soil) and head yield of cabbage in central (CJ) and west (WJ) Java or from the 2 provinces combined (Java).

Table 6.3a. Linear regression between concentration of extractable micro-nutrients in the soil and head yield of cabbage (CJ&WJ) or % relative yield (Java).

Province	Nutrient	Regression	R^2	P
CJ	Al	y=52.9-0.03x	0.09	*
WJ	Al	y=28.6+0.03x-	-	ns
Java	Al	y=71.2-0.018x	-	ns
CJ	Cu	y=48.2-2.8x	-	ns
WJ	Cu	y=39.11-0.7x	-	ns
Java	Cu	y=69.3-0.7x	-	ns
CJ	Fe	y=49.4-0.34x	-	ns
WJ	Fe	y=30.21+0.53x	-	ns
Java	Fe	y=63.8+0.2x	-	ns
CJ	Mn	y=49.83-0.44x	0.11	*
WJ	Mn	y=37.05+0.10x	-	ns
Java	Mn	y=69.1-0.37x	-	ns
CJ	Zn	y=45.80+0.04x	-	ns
WJ	Zn	y=30.8+1.2x	-	ns
Java	Zn	y=63.1-0.51x	-	ns

*<0.10, **<0.05, ***<0.01, ****<0.001 and ns not significant.

Table 6.3b Linear regression between extractable macro nutrient concentration in soil and head yield (CJ & WJ) or % relative yield (Java).

Province	Nutrient	Regression	R^2	P	Nutrient	Regression	R^2	P
CJ	Ca	y=35.5+0.77x	0.12	*	%N(total)	y=50.0-7.5x	-	ns
WJ	Ca	y=37.21+0.09x	-	ns	%N(total)	y=22.5+30.5x	0.10	0.09
Java	Ca	y=58.6-0.73x	-	ns	%N(total)	y=59.1+13.8x	-	ns
CJ	K	y=40.9+3.7x	-	ns	P(Bray)	y=45.5-0.011x	-	ns
WJ	K	y=35.85+2.8x	-	ns	P(Bray)	y=37.6+0.003x	-	ns
Java	K	y=60.2+5.6x	-	ns	P(Bray)	y=65.6-0.09x	-	ns
CJ	Mg	y=44.6+0.64x	-	ns	P(Olsen)	y=46.1-0.0001x	-	ns
WJ	Mg	y=30.33+7.52x	-	ns	P(Olsen)	y=35.8+0.02x	-	ns
Java	Mg	y=62.4+2.2x	-	ns	P(Olsen)	y=64.8-0.006x	-	ns
CJ	Na	y=40.5-17.7x	-	ns	S	y=50.4-0.02x	0.12	*
WJ	Na	y=26.7+46x	-	ns	S	y=40.2-0.005x	-	ns
Java	Na	y=56.3+35.4x	-	ns	S	y=70.9-0.014x	0.04	0.09
CJ	$N(NH_4\text{-}N)$	y=52.1-4.3x	0.16	**	pH	y=35.1+1.81x	-	ns
WJ	$N(NH_4\text{-}N)$	y=42.2-4.3x	-	ns	pH	y=-7.0+8.3x	-	ns
Java	$N(NH_4\text{-}N)$	y=73.2-0.6x	0.05	0.06	pH	y=26.5+6.9x	-	ns

*<0.10, **<0.05, ***<0.01, ****<0.001 and ns not significant.

6.3.4 Leaf nutrient concentration and head yield

Micro-nutrients

Mean and range of micro-nutrient concentrations in leaves (average of 2 samples) and significance of linear regressions are presented in Table 6.4a. In only one case was there a significant linear relationship between yield and concentration and that is where higher yield was associated with higher leaf Fe in WJ and both provinces combined but not CJ (Fig 6.10). Based on standards for deficient, adequate or excess concentration of micro-nutrient in the youngest mature leaves (YML), 28 to 35 days after transplanting, for maximum yield there was little evidence of micronutrient deficiency, with the exception of Fe in WJ, in cabbage crops in either province (Attachment 2). For example concentrations of B, Cu, Fe and Mn in YML in almost all cases ranged from slightly low to either adequate or excessive (Fig 2, 4, 5 and 6 Attachment 2). Cl and Zn concentrations were high on all sites. Al concentrations were excessive in all crops and possibly toxic (lowered yield) in some crops (Fig 1 Attachment 2).

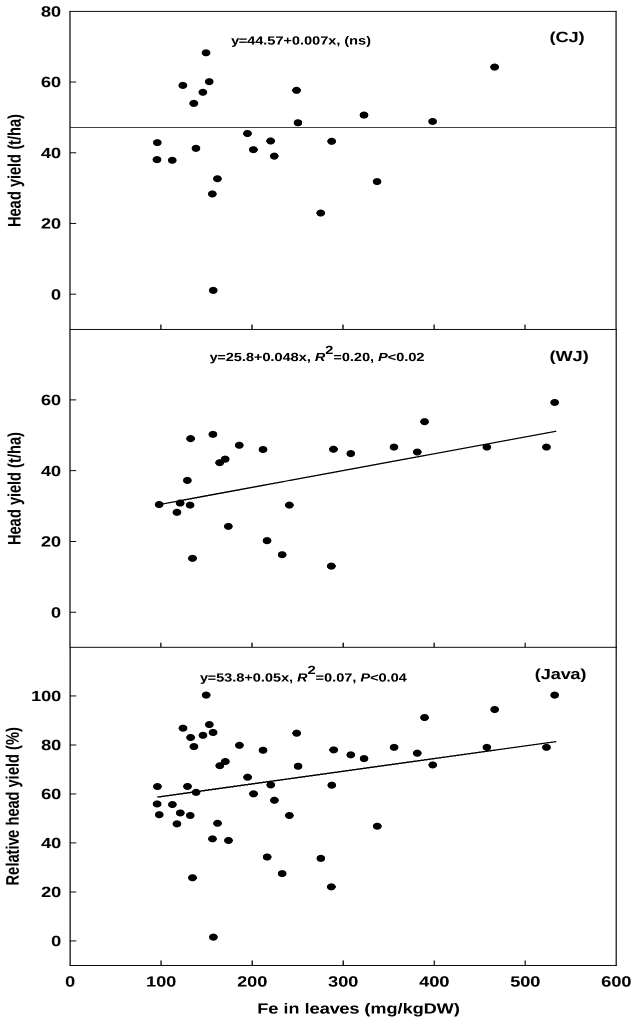

Figure 6.10. Linear regression between cabbage head yield with total Fe in leaves (mg/kg DW) in Central (CJ), West (WJ) Java or from the 2 provinces combined (Java).

Leaf concentration was average of 2 samples at 28 to 35 days after transplanting (youngest mature leaf) and at early heading (wrapper leaf).

Macro-nutrients

The mean and range of macro-nutrient concentrations in leaves (average of 2 samples) and significance of linear regressions are presented in Table 6.4b.In only one case was there a significant linear relationship between yield and concentration and that is where higher yield was associated with higher concentrations of Mg in the leaves (average of 2 samples) in WJ but not CJ (Fig 6.11). Based on standards for deficient, adequate or excess concentration of macro-nutrient in the YML at 28 to 35 days after transplanting, maximum yield most sites seemed adequate in macro-nutrients (Attachment 2). For example concentrations of Ca, N and P in the YML ranged from low to high with most sites adequate (Figs 8, 11 and 13, Attachment 2). K in the YML was adequate on all sites and S was high on most sites (Fig 9 and 14, Attachment 2). Na in the YML was not excessive on any site (Fig 12, Attachment 2) although lower yield was associated with higher leaf Na in WJ and the 2 provinces combined but not CJ (Table 6.4b).

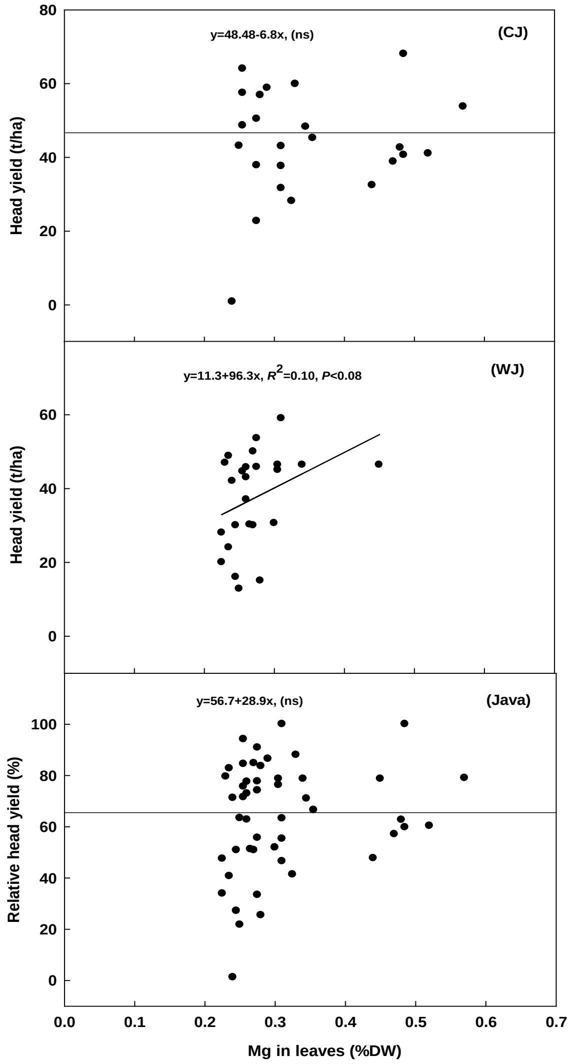

Figure 6.11. Linear regression between cabbage head yield and total Mg in leaves (mg/kg DW) in Central (CJ), West (WJ) Java or from the 2 provinces combined (Java). Leaf concentration was average of 2 samples at 28 to 35 days after transplanting (youngest mature leaf) and at early heading (wrapper leaf).

Table 6.4a. Total micro-nutrient concentration in leaves (ave) and linear regressions with head yield. Leaf concentration was average of 2 samples at 28 to 35 days after transplanting (youngest mature leaf) and at early heading (wrapper leaf).

Province	Nutrient (mg/kg)	Mean (+/-SE)	Range	Regression	R^2	P
CJ	Al	679	80.5-1922	y =45.33 + 0.001x	ns	ns
WJ	Al	692	76.0-4957	y = 38.9 - 0.002x	ns	ns
Java	Al	686	76.0-4957	y = 67.1 - 0.002x	ns	ns
CJ	B	18	11.5-44	y = 36.7 + 0.52x	ns	ns
WJ	B	27	15.0-46	y = 48.74 - 0.42x	ns	ns
Java	B	22	11.5-46	y = 68.34 - 0.12x	ns	ns
CJ	Cu	9	7.5-13.5	y = 60.0 - 1.56x	ns	ns
WJ	Cu	10	4.0-20.5	y = 32.16 + 0.54x	ns	ns
Java	Cu	9	4.0-20.5	y = 62.4 + 0.35x	ns	ns
CJ	Fe	212	97-468	y = 44.57 + 0.007x	ns	ns
WJ	Fe	247	99-534	y = 25.77 + 0.048x	0.19	**
Java	Fe	229	97-534	y = 53.76 + 0.052x	0.07	**
CJ	Mn	41	23-91	y = 54.49 - 0.20x	ns	ns
WJ	Mn	99	38-188	y = 37.54 - 0.0005x	ns	ns
Java	Mn	70	23-188	y = 69.19 - 0.0505x	ns	ns
CJ	Zn	47	27-68	y = 35.7 + 0.22x	ns	ns
WJ	Zn	52	27-83	y = 48.4 - 0.21x	ns	ns
Java	Zn	49	27-83	y = 66.5 - 0.02x	ns	ns

*<0.10, **<0.05, ***<0.01 and ns not significant

Table 6.4b. Total macro-nutrient concentration in leaves (ave) and linear regression with head yield. Leaf concentration was average of 2 samples at 28 to 35 days after transplanting (youngest mature leaf) and at early heading (wrapper leaf).

Province	Nutrient (%)	Mean (+/-SE)	Range	Regression	R^2	P
CJ	Ca	1.94	1.0-1.94	y = 53.98 - 4.0x	ns	ns
WJ	Ca	1.58	1.0-4.03	y = 29.89 + 4.8x	ns	ns
Java	Ca	1.76	1.0-4.03	y = 62.56 + 1.7x	ns	ns
CJ	K	3.70	2.9-4.80	y = 37.0 + 2.5x	ns	ns
WJ	K	3.50	2.7-5.60	y = 56.7 - 5.5x	ns	ns
Java	K	3.59	2.7-5.60	y = 75.7 -2.8x	ns	ns
CJ	Mg	0.34	0.23-0.60	y = 48.48 - 6.8x	ns	ns
WJ	Mg	0.27	0.23-0.50	y = 11.3 + 96x	0.10	*
Java	Mg	0.31	0.23-0.60	y = 56.7 - 29x	ns	ns
CJ	Na	0.20	0.075-0.77	y = 49.97 - 19x	ns	ns
WJ	Na	0.24	0.1-0.49	y = 52.0 - 61x	0.17ns	**
Java	Na	0.22	0.075-0.77	y = 76.06 - 47x	0.10	**
CJ	N	4.26	2.2-5.55	y = 46.4 - 0.07x	ns	ns
WJ	N	4.9	3.75-6.72	y = 62.6 - 5.1x	ns	ns
Java	N	4.58	2.2-6.72	y = 85.0 - 4.2x	ns	ns
CJ	P	0.53	0.34-0.76	y = 40.0 + 11.5x	ns	ns
WJ	P	0.57	0.38-0.72	y = 54.8 - 30.5x	ns	ns
Java	P	0.57	0.34-0.76	y = 76.1 - 19.2x	ns	ns
CJ	S	0.89	0.485-1.35	y = 40.0 + 11.5x	ns	ns
WJ	S	1.29	0.825-1.82	y = 18.4 + 14.8x	ns	ns
Java	S	1.09	0.485-1.82	y = 67.7 - 1.93x	ns	ns

*<0.10, **<0.05, ***<0.01 and ns not significant

6.4 Agronomy

6.4.1 Planting density

Higher yield was associated with higher planting density in CJ, WJ and the 2 provinces combined (Fig 6.12). Closer row (between row) spacing was associated with higher yield in WJ and for the 2 provinces combined but not in CJ (Fig 6.13). Closer plant spacing (within-row) was associated with higher yield in WJ but not CJ or the 2 provinces combined (plot not shown).

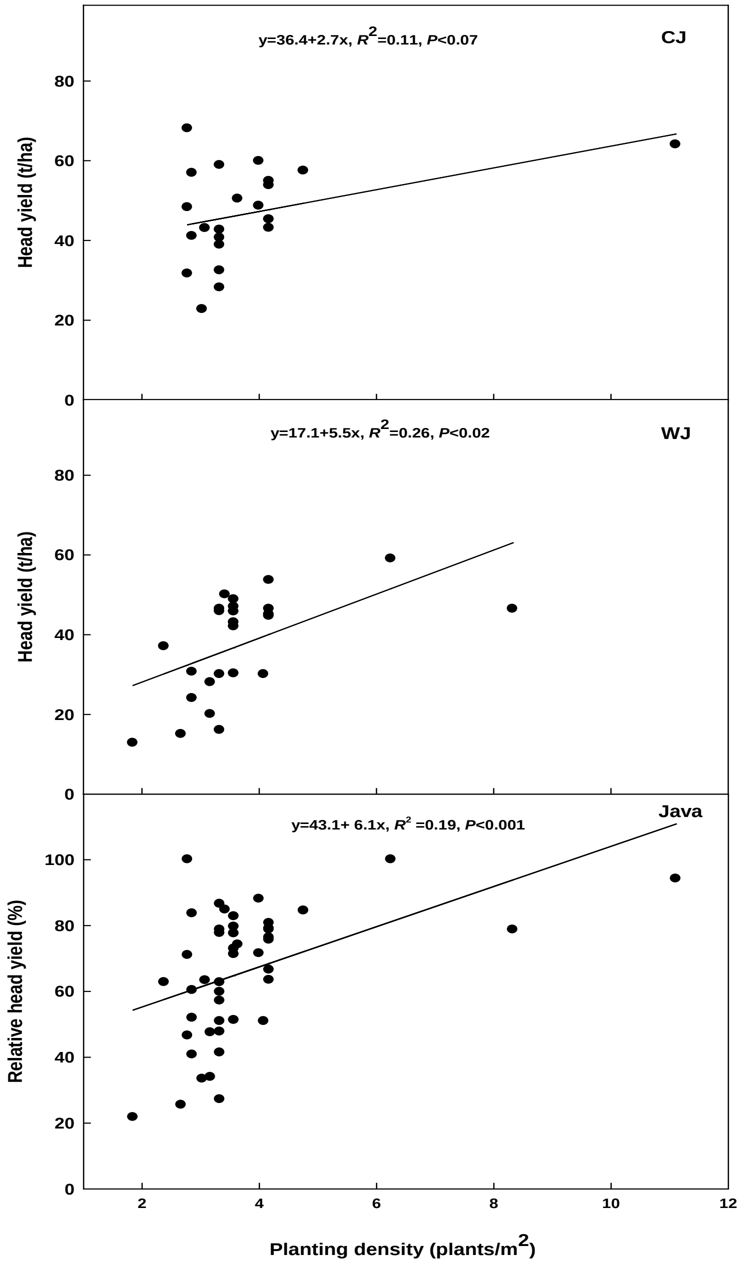

Figure 6.12. Linear regression between head (t/ha) or %relative head yield of cabbage and planting density (plants/cm^2) in central (CJ), west Java (WJ) or both provinces combined (Java).

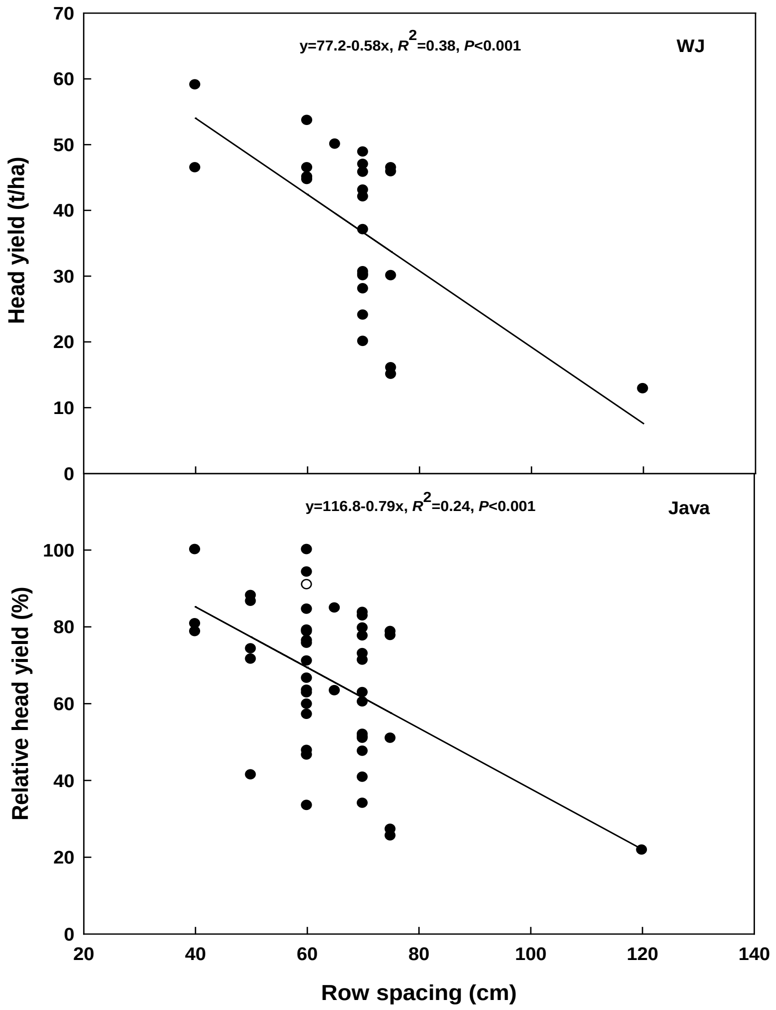

Figure 6.13. Linear regression between row spacing (cm) and head (t/ha) or relative head yield (%) of cabbage in West Java (WJ) and both provinces combined (Java).

6.4.2 Mulch and irrigation

Higher yield was associated with use of mulch in CJ and for the 2 provinces combined but not WJ (Fig 6.14). Higher irrigation frequency was associated with lower yield in CJ and the 2 provinces combined but not WJ (Fig 6.15). Higher yield was also associated with dry/wet or wet compared with dry soil in WJ and the 2 provinces combined but not CJ. Higher yield was not associated with source of irrigation water (river, well, dam etc) in either province (plot not shown).

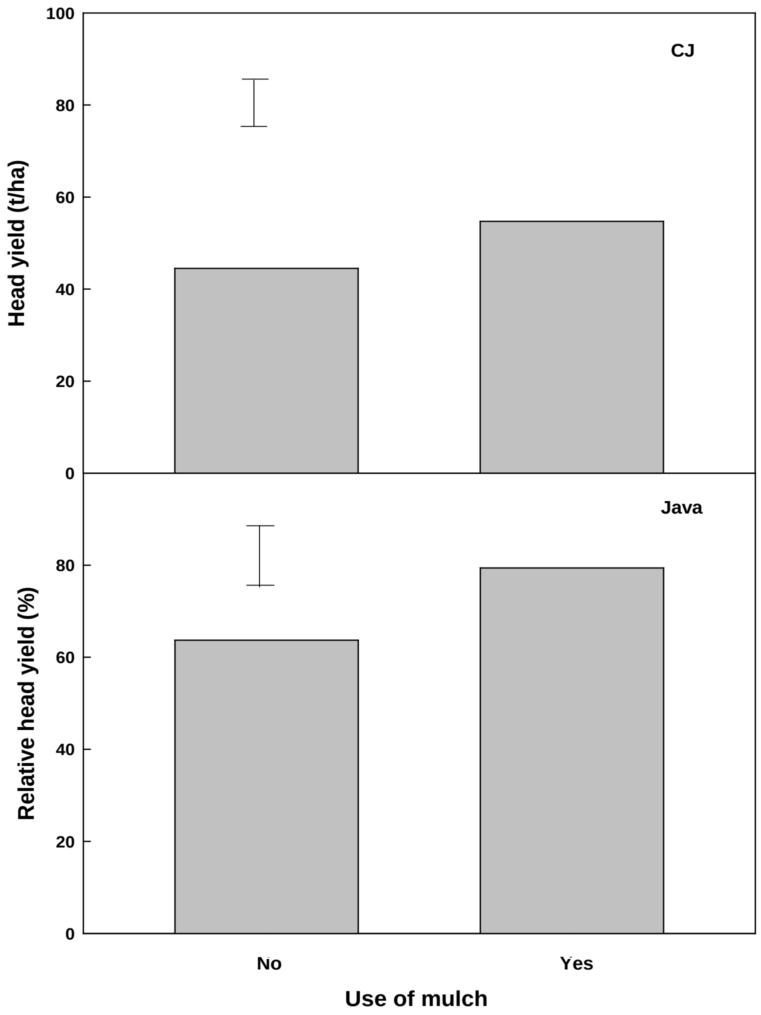

Figure 6.14. Head (t/ha) or relative head yield (%) of cabbage with use of mulch in central (CJ) or from the 2 provinces combined (Java).Bar is LSD (P<0.10) is for difference between mean yields from the ANOVA.

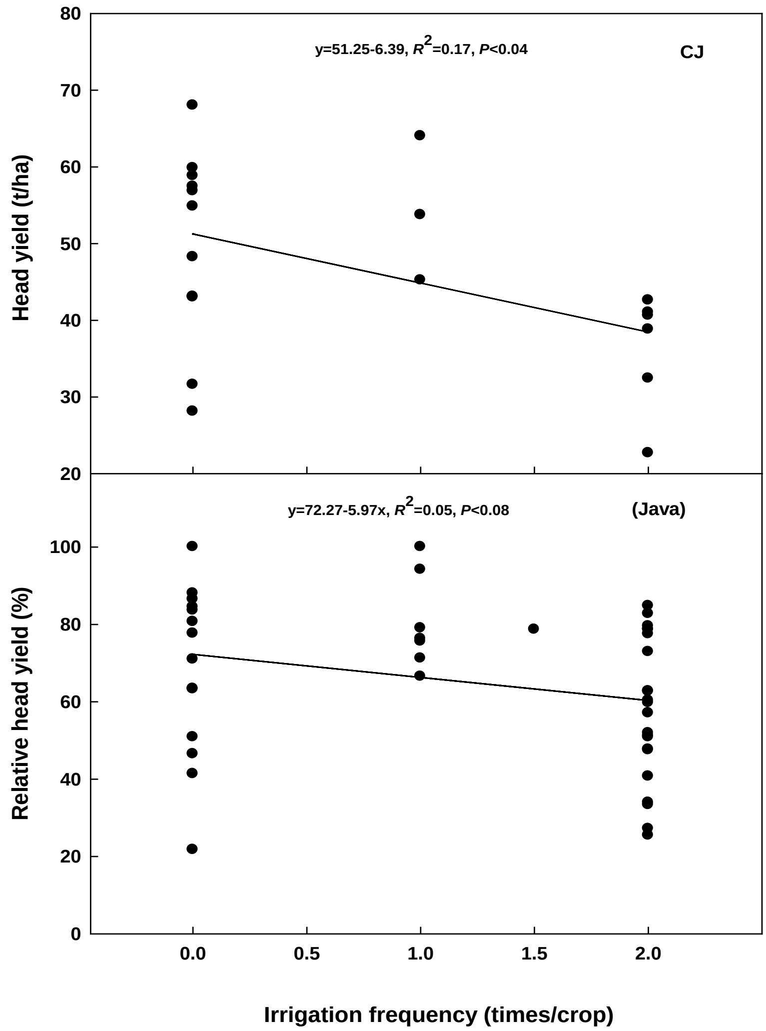

Figure 6.15. Linear regression between number of irrigations/crop and head yield (t/ha) of cabbage in Central Java (CJ) or relative head yield (%) of the 2 provinces combined (Java).

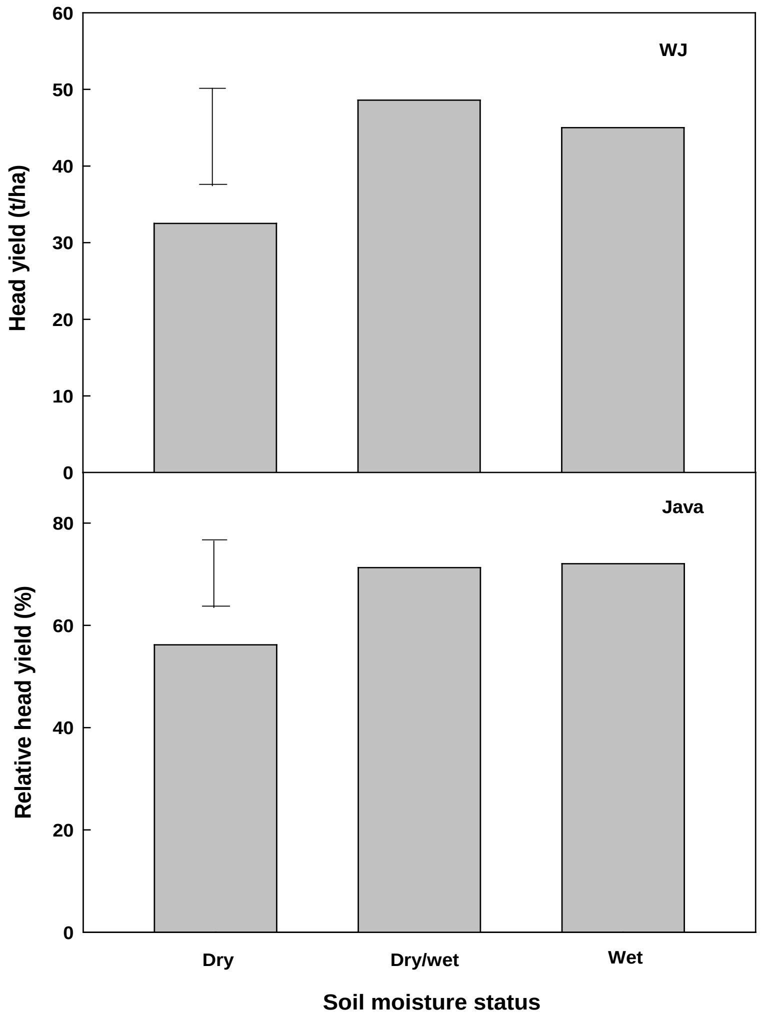

Figure 6.16. Head (t/ha) or relative head yield (%) of cabbage with soil moisture status in West Java (WJ) or from the 2 provinces combined (Java).Bar is LSD (P<0.10) is for difference between mean yields from the ANOVA.

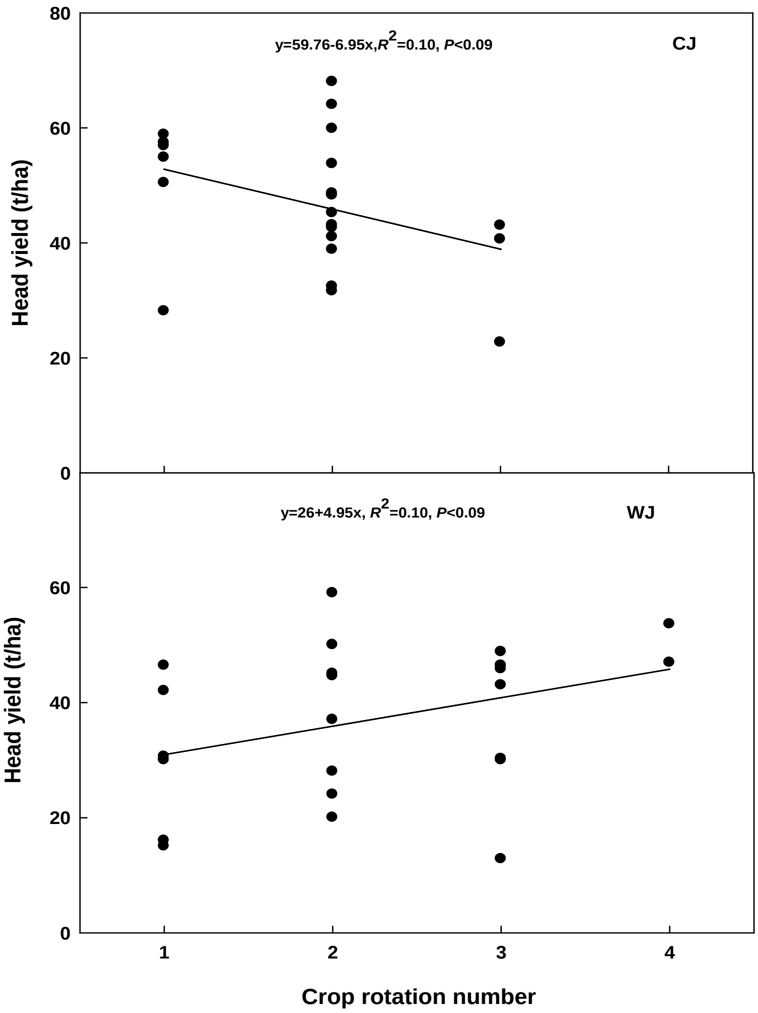

Figure 6.17. Linear regression between number of crops in rotation and head yield (t/ha) of cabbage in Central (CJ) and West Java (WJ).

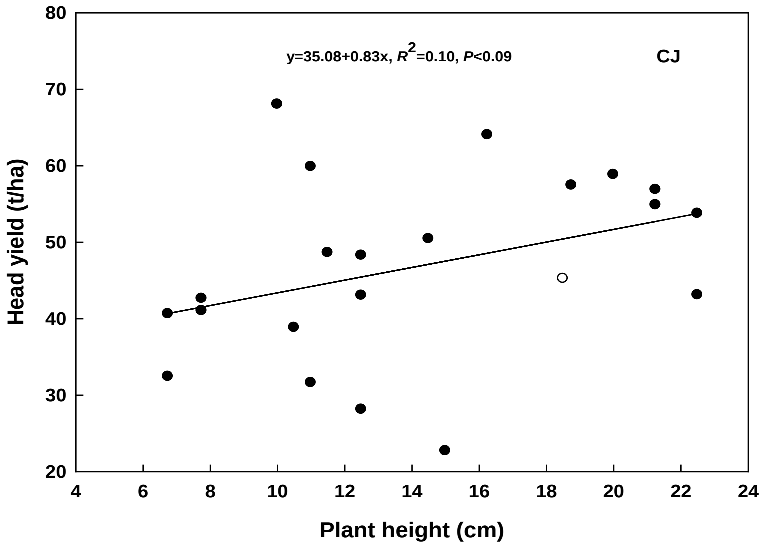

Figure 6.18. Linear regression between plant height (cm) and head yield (t/ha) of cabbage in Central Java (CJ).

6.5 Pests and Diseases

6.5.1 Nursery

Growers in CJ who used insecticides and hormones on the seedlings in the nursery had higher yields (64 t/ha) than those who only used insecticides (40 t/ha), who didn't know whether pesticides were used on the seedlings (51.5 t/ha) and those who did not use any pesticides in nurseries (48.6 t/ha) (Fig 6.19). This association was not found in WJ or when the 2 provinces are combined. No other pest and disease management practices in nurseries significantly affected cabbage yields.

Figure 6.19. Head yield (t/ha) with use of pesticides on seedlings in nurseries in CJ. Bar is LSD for differences ($P<0.10$) in yield between pesticides from the ANOVA.

6.5.2 Diseases

The highest average disease incidence was that of clubroot (CR, *Plasmodiophora brassicae)* with 73% of respondents reporting the disease in their fields (Table 6.5). Nematodes were recorded at 49% of the sites with the respondents either indicating root knot (*Meloidogyne* sp.) or Sugarbeet cyst nematode (*Heterodera schachtii)* (not shown) as being the main nematodes present. Black rot *(Xanthomonas campestris*) was another disease with an average disease incidence of 43%, with WJ farmers reporting a higher incidence (64%) than CJ farmers (22%).

Table 6.5. Incidence of disease (% of sites) in the field in West Java (WJ) and Central Java (CJ).

Disease	WJ	CJ	Average
Clubroot	88	57	73
Black rot	64	22	43
Ringspot	24	9	17
Damping off	16	0	8
Nematode	68	30	49

Cabbage yields were positively correlated with the number of diseases in the crop in WJ (y=20.7 +8.2x) but not in CJ. When the data from both provinces was combined the relative maximum yield % was also positively correlated with the number of diseases in the crop (y= 55.10 + 6.7x) (plots not shown).

The presence of black rot on the plants in the field was associated with higher yields (43 t/ha) than when not present (27 t/ha) in WJ but not CJ (Fig 6.20).

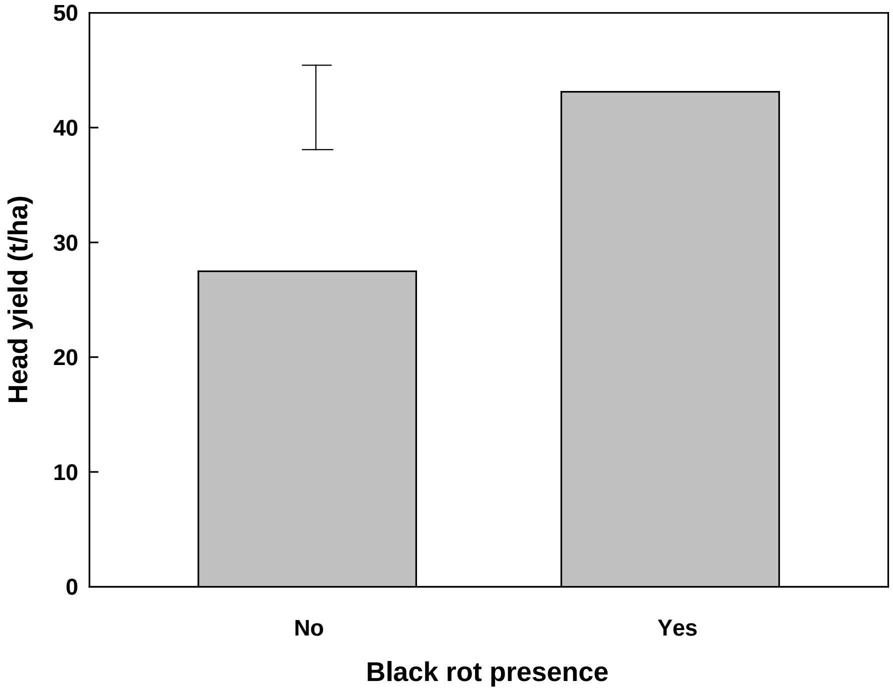

Figure 6.20. Head yield (t/ha) versus presence of black rot in the field in WJ. Bar is LSD for differences (P<0.10) in yield between black rot presence from the ANOVA.

In CJ one grower used carbofuran on the field to reduce the impact of nematodes. The use of carbofuran was associated with higher yields (57 t/ha) compared with the use of Rugby (cadusafos) (22.7 t/ha) but yield was not significantly higher when not using any nematicide (47.5 t/ha) (Fig 6.21). By contrast in WJ there was no significant differences in yield associated with type of nematicide used (plot not shown).When nematicides were compared on a yes or no basis there was no significant difference between using a nematicide or not in either province (plots not shown).

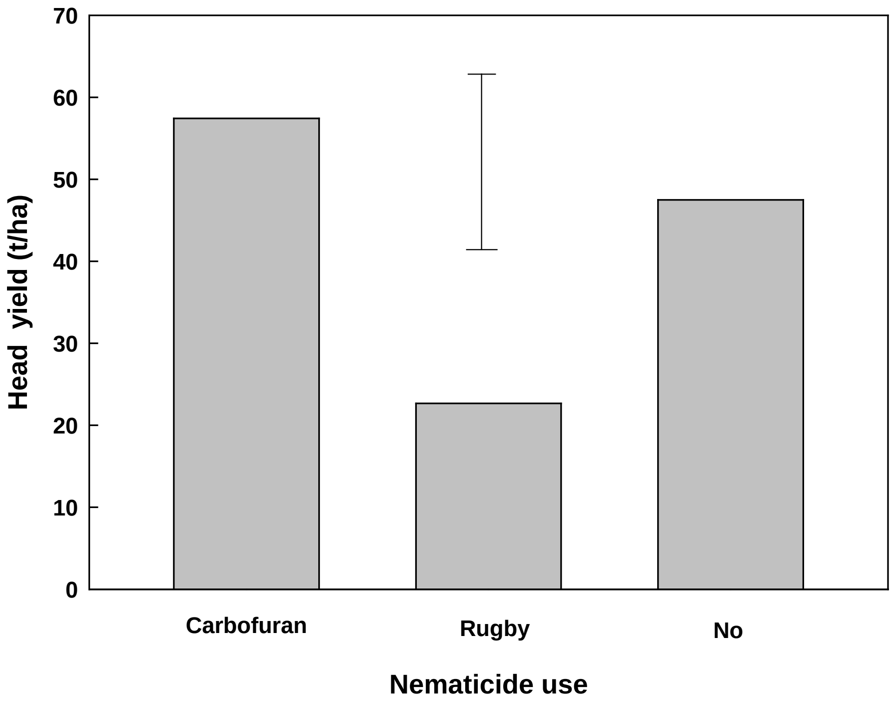

Figure 6.21. Type of nematicide used with head yield (t/ha) in CJ. Bar is LSD for differences ($P<0.10$) in yield between nematicides from the ANOVA.

6.5.3 Pests

DBM was the most reported pest (62%) from growers in WJ and CJ (Table 6.6). Black cutworm (CW, *Agrotis ipsilon*) and CHC were also frequently reported in cabbage crops with 59% and 58% of sites recording the presence of the pests respectively.

Table 6.6. Incidence of pests (% of sites) in the field in West Java (WJ) and Central Java (CJ).

Pest	WJ	CJ	Average
Cabbage head caterpillar	72	43	58
Diamondback moth	76	48	62
Cluster caterpillar	20	35	28
Black cutworm	92	26	59

Many different pest combinations were reported from the field. The combination of *C. pavonana*, *A. ipsilon*, *P. xylostella*, and aphids had the highest yield of 59t/ha. When these pests were analysed separately the presence of *C. pavonana* on the cabbage crop was associated with higher yields (Fig 6.22). After analysing the number of pests in the WJ crops via regression analysis the more pests on the crop the higher the yield (y= 23.4

+ 4.9x, *P*<0.05, plot not shown). In CJ there was no pest information that had a significant effect on yield.

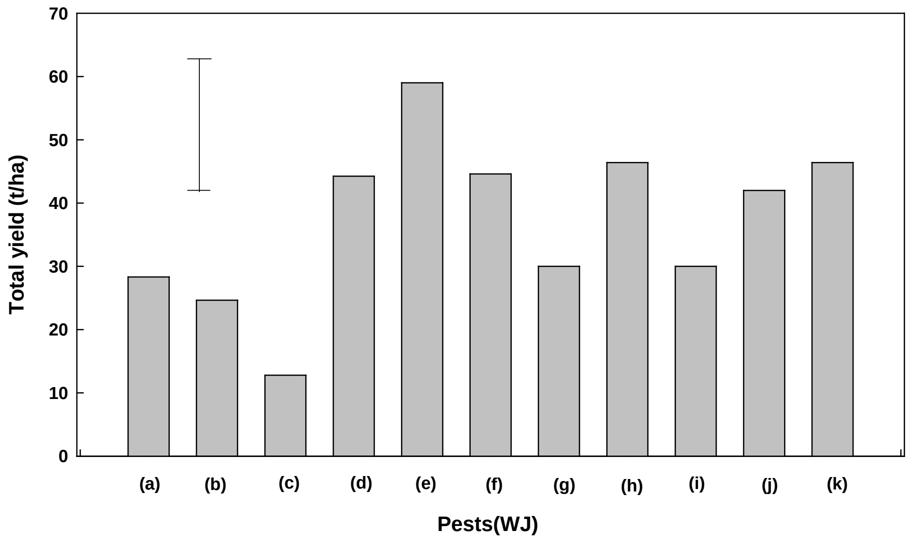

Figure 6.22. The combinations of pests found in the cabbage crops of WJ. (a) A. ipsilon (b) A. ipsilon and P. xylostella (c) C. pavonana (d) C. pavonana, A. ipsilon, P. xylostella (e) C. pavonana, A. ipsilon, P. xylostella, aphids (f) C. pavonana, A. ipsilon, P. xylostella, Liriomyza sp. (g) C. pavonana, A. ipsilon, P. xylostella, S. litura (h) C. pavonana, A. ipsilon, P. xylostella, S. litura, aphids (i) C. pavonana, A. ipsilon, P. xylostella, S. litura, beetles (j) C. pavonana, A. ipsilon, S. litura (k) C. pavonana, S. litura. Bar is LSD for differences (P < 0.10) in yield between combinations of pests from the ANOVA.

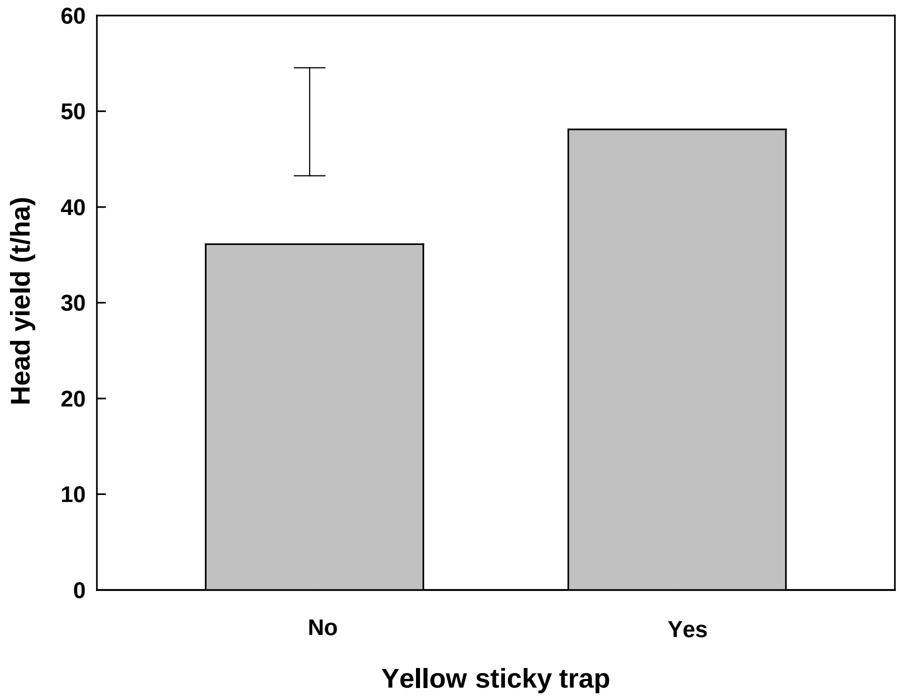

Figure 6.23. The use of yellow sticky traps and head yield T/ha. Bar is LSD for differences (P<0.10) in yield between yellow sticky trap use from the ANOVA.

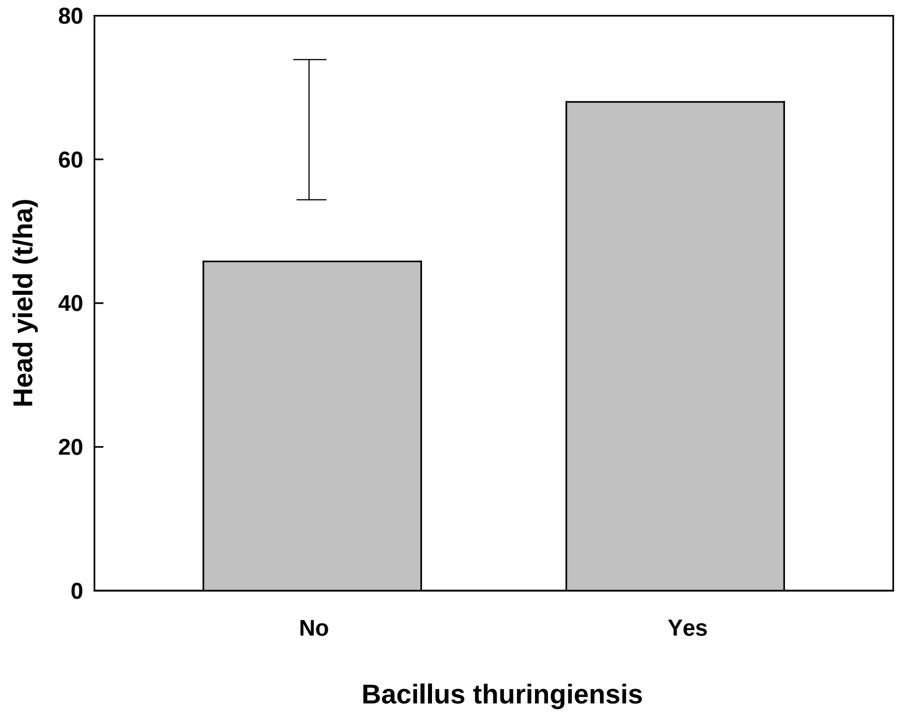

Figure 6.24. The use of biological control agent *Bacillus thuringiensis* and head yield (t/ha). Bar is LSD for differences (P<0.10) in yield between *B. thuringiensis* use from the ANOVA.

The use of yellow sticky traps was associated with higher yields (Fig 6.23) in WJ with those who used them recording an average yield of 48t/ha compared with 36t/ha for those who didn't. In contrast no growers in CJ used sticky traps. The use of the biological control agent *Bt* in CJ was associated with higher yields but not in WJ (Fig 6.24). The use of wetting agents had no significant influence on yield across both provinces.

6.5.4 Protective clothing

Most respondents (60%) in WJ and a high percent in CJ (40%) did not use any item of protective clothing when applying pesticides to cabbages (Table 6.7). In CJ 52% and in WJ 36% of respondents used at least one item (coat, gloves or mask) of protective clothing. Only 4% used all 3 items of clothing in CJ and none used all 3 in WJ.

Table 6.7. The use of items of protective clothing (% of respondents) when applying pesticides to cabbages in central (CJ) and west Java (WJ).

Item	Province		
	Central Java	West Java	Average
Coat (C)	4	0	2
Gloves (G)	16	4	10
Mask (M)	16	4	10
C+G	0	4	2
G+M	12	20	16
C+M	0	4	2
C+G+M	4	0	2
None	40	60	50
Unknown	8	4	6

6.6 Discussion

The aim of the survey was to identify the most important constraints to cabbage production for which improved management techniques could offer a solution. These improved management techniques would be tested in LBD plots run by the FIL groups.

The first section of results reports yields from districts and provinces, as well as the sources of learning and information. This is provided as background information and is not discussed in detail.

6.6.1 Diseases, crop and soil nutrition

Clubroot (*Plasmodiophora brassicae*) was the most prevalent disease, based on incidence reported, of cabbages across both provinces. As a result of its presence in both high and low yielding farms there was no significant relationship between yield and incidence. In this case an accurate assessment of severity at each site would have been more useful. In-field crop losses worldwide caused by clubroot range from 10-15% with a mean loss of 11% (Dixon 2009). Disease pressure is considered the major production constraint to cabbages in Indonesia (Darmawan and Pasandaran 2000), with clubroot considered one of the major diseases (Sastrosiswojo 1994). Clubroot severity and symptom expression increases with the intensity and frequency of crop production (Dixon 2009), with high moisture content and soil temperatures above 20°C (Rimmer *et al*. 2007). Indonesian vegetable production revolves around short crop rotations with average mountain air temperatures around 22°C (Darmawan and Pasandaran 2000) and therefore it is not surprising clubroot is a significant constraint to production.

The major role of clubroot in limiting the yield of cabbage needs to be viewed in light of other agronomic factors. Worldwide, several techniques are used to manage clubroot, including resistant varieties, liming, long crop rotations, trap cropping, soil solarisation and fungicide application (Rimmer *et al*. 2007, Donald *et al*. 2006). Currently in Indonesia the favoured cabbage varieties show no resistance to clubroot and given the ability of clubroot spores to survive in the soil for up to 20 years (Rimmer *et al*. 2007) there is a constant build up of inoculum leading to greater crop loss. Chemicals used in Indonesia for clubroot are dominated by bio-pesticides that are promoted by chemical resellers and have not been proven to work in scientific studies. These bio-pesticides add significant production costs to the farmers without providing any increase in yield or quality.

Soil condition is a major factor in the ability of clubroot to develop and spread with the disease favouring acidic soils (Rimmer *et al*. 2007). Raising soil pH through liming has been practiced for many years as one of the main techniques for managing clubroot (Donald and Porter 2009). The mean pH for both CJ and WJ soils were acidic with WJ farms being more acidic than those from CJ. The more acidic WJ soils may have lead to the higher incidence of clubroot in that province compared with that of CJ. Liming is a common practice in Indonesia but it is generally performed only a short time before planting and therefore often has little effect on the severity of clubroot. Apart from this there was very little use of lime reported in this survey; dolomite was applied at rates from 0.4 to 1.01t/ha. These rates are most likely too low to raise pH adequately to counteract soil acidity and minimise clubroot. For example to raise the pH of a loam soil from 6.5 to 7.0 to 20cm depth assuming 3% Organic carbon and 20% clay (typical of soils in the survey) requires 3.7t/ha of lime as calcium carbonate /ha or a similar quantity of good quality dolomite (Aitken *et al*. 1990).

Apart from the interrelationship between clubroot and soil acidity lower yield was associated with higher concentrations of Al and Mn in the soil, elements that are increasingly more available in the soil as pH declines. Related to this was the finding that higher yields were associated with higher concentrations of Ca in the soil and Mg in the leaves. Higher soil and plant Ca and Mg appears to inhibit clubroot over and above the effect of increased soil pH alone (Webster and Dixon 1991). Ca (limestone, calcium oxide and hydroxide) and Mg (dolomite) is applied in liming materials but sources of calcium that don’t change pH such as calcium sulphate and nitrate have inhibitory effects on clubroot due presumably to the Ca and/ or the anion. In any case a combination of both high Ca and high pH is more inhibitory to clubroot than either effect alone. The effect of Mg by itself has not been as well studied as Ca but is assumed to be equally beneficial or it maybe indirectly beneficial in reducing K uptake by plants as high soil/plant K appears to promote clubroot.

The role of B in minimising clubroot damage has not been thoroughly studied but it appears to exert its effect mainly within the cell as it doesn’t appear to inhibit the number of root hairs infected like Ca does. Applications of lime may fail to control clubroot where plants are deficient in B. Although there was no significant relationship between head yield and B concentration in the leaves B fertilisation did not appear adequate across all sites. For example crops from about 30% of sites appeared inadequate in B in CJ from concentrations in the youngest mature leaves.

The identification of clubroot and associated soil acidity issues of high soil and plant Al and low B and Ca is important for sustainable cabbage production. These issues may be easily solved through varietal selection, liming of acid sites and appropriate fertiliser management. Clubroot and soil pH should be a focus of FIL learning-by-doing plots in the next phase of the project.

Black rot is another disease of prominence in the Indonesian cabbage production system. Seedborne infection provides for the primary inoculum of this bacterium to spread (Rimmer *et al*. 2007). Hot-water treatment of seeds at 50°C is common practice to reduce the level of seed infection but this is not performed at all in Indonesia and illustrates a lack of understanding about how this disease progresses. In addition to this the production of seedlings next door or in close proximity to actual field sites means that any seedling infection is easily spread to the crop.

6.6.2 Agronomy

Higher yields appear to be associated with higher planting density (>4.0 plants/m^2) in both provinces. Growers may be inclined to plant at low density to increase cabbage head size and reduce the impact of pests and diseases (Anon 2000). For example higher planting density resulted in more plants damaged (2.5 plants/single egg mass) by cabbage cluster caterpillar compared with lower densities (0.8 plants/single egg mass) in SE Queensland (Nolan 2007). However there maybe opportunities to increase yield by increasing planting density in some situations. A spacing of 45 cm x 45 cm is recommended as the best planting arrangement for maximum yield of cabbages in tropical countries (Anon 2000). Similarly maximum yield per ha and per plant was achieved at 45 x 45cm spacing (4.9 plants/m^2) compared with lower (3.3) or higher (11.1 plants/m^2) densities with cauliflowers in Pakistan (Mujeed-ur-Rahman *et al*. 2007). Cabbage head yield appears to be sensitive to planting density in this survey but higher returns from higher yield must be offset against increased seedling costs at higher densities. On most sites in CJ (96%) and WJ (92%) planting density was lower than the 4.9/m^2 suggested as optimum.

There was no consistent evidence that higher yield was related to irrigation practices even though the crops were grown in the dry season. For example in CJ higher irrigation frequency was associated with lower yield in CJ and the 2 provinces combined but there was no relationship between irrigation frequency and yield in WJ or method of irrigation in either province. However higher yield was associated with both the use of mulch and the assessment of the soil as ‘wet/dry’ or ‘wet’ and lower yield with a ‘dry’ assessment. Properly applied mulch should reduce weed growth and improve soil moisture conditions.

6.6.3 Pests

DBM is considered the most important pest of crucifers in Indonesia (Sastrosiswojo and Setiawati 1992) and the results from this survey confirm that it is widespread across all growing regions. The use of synthetic insecticides is still the most commonly used strategy for controlling insect pests of cabbage, particularly DBM, with applications beginning within one week after planting and total per crop season ranging from 4 (Rauf *et al*. 2005) to 26 applications (Shepard & Schellhorn 1997). The number of pesticide applications recorded in this survey, 2 to 15/crop, was of a similar range. This excessive use of synthetic insecticides not only leads to personal and environmental damage but for 70% of Indonesian farmers this accounts for 25-30% of total production input costs (Dadang *et al.* 2009). Furthermore excessive use of insecticides increases the probability of the evolution of insecticide resistance.

National integrated pest management programs (IPM) for highland vegetables in Indonesia were established in 1992 with the highest priority being to develop manpower capabilities (Sastrosiswojo 1994). Despite having IPM programs in place Rauf *et al*. (2005) found 90% of growers still carried out pesticide application on a scheduled basis or on the presence of the pest and not on economic threshold levels. The use of the biological control agent *Diadegma semiclausum* for the control of DBM is common in Indonesia but with the high use of broad spectrum insecticides its efficacy and that of other natural predators are badly disrupted (Shepard & Schellhorn 1997, Rauf *et al*. 2005).

Bt is another biological option available to Indonesian farmers for control of DBM and CHC. The results of this survey indicate that the use of *Bt* products was associated with higher yields than when not used. The use of yellow sticky traps was also associated with higher yields but it is not possible to determine whether the traps had an impact by themselves. Results such as these may be expressing a relationship that shows better farmers tend to use such tools and obtain higher yield because of this and other factors rather than a simple cause and effect relationship between one of two factors and yield. There does appear to be an increase in use of *Bt* products over the last 5 years if the results of this survey are compared with a previous one. For example Rauf *et al*. (2005) found that only 5% growers they interviewed used *Bt* products; in this study 23% of growers reported using *Bt* products. This suggests that the IPM program has educated farmers on the benefits of using *Bt* as a control option but maybe not on the effect broadspectrum insecticides have on biocontrol agents such as *D. semiclausum* and endemic generalist predators. Of concern though is the reported resistance to *Bt* in areas of Indonesia where the insecticide has been used for some time, however reported susceptibility of a standard strain was not included and therefore further studies are required before any comments regarding the resistance status of field populations of DBM can be reliably made (Rauf *et al*. 2005).

CHC was another pest present in the majority of cabbage crops surveyed. CHC is not generally considered as an important a pest as DBM but there are few biological control options available for its control in Indonesia (Sudarwohadi and Sastrosiswojo 1992, Shepard & Schellhorn 1997, Rauf *et al*. 2005). In the dry season when DBM is successfully controlled by natural predators CHC damage becomes more significant meaning growers begin using broad spectrum insecticides; this in turn leads to the destruction of the beneficials controlling DBM and the cycle continues (Shepard and Schellhorn 1997, Rauf *et al*. 2005). Further education in the use of “soft” chemicals and IPM management for both DBM and CHC is therefore an important requirement. Elswhere (eg Fiji and Samoa) Bt has been shown to be an effective control option for CHC and it offers the advantage that it does not disrupt parasitoid and predator mediated biological control of DBM (Furlong pers. com.).

7 Impacts

7.1 Scientific impacts

The survey identified clubroot, black rot, DBM, CHC and soil acidification/crop nutrition, both on its own and interacting with diseases such as clubroot, as major limits to the production of good quality cabbage in Indonesia.

Identification of clubroot as the major disease limiting yield supports general observations of farmer and scientific support staff that it is a major limit to cabbage production in Indonesia. Results showed there are opportunities to improve the management of clubroot. For example there were limited fungicide options for its control and the introduction of effective fungicides needs to be considered as part of an integrated control of the disease. Often growers reported using fungicides that did not have any effect on clubroot due to recommendations of chemical resellers promoting quick fix solutions. This indicates a lack of understanding of the disease and represents opportunities to educate growers further on the disease cycle and control of clubroot.

There was general awareness that cabbage performed poorly on acidic soils, clubroot was more damaging in these circumstances and lime needed to be applied to cabbage crops regularly. In this respect lime use was common both for general nutrition and growth of cabbage, mitigating the acidifying effects of some fertilisers and to minimise clubroot severity. However it was evident that farmer knowledge of some aspects of lime use could be enhanced and information regarding the relative effectiveness of different lime sources (carbonates, oxides and hydroxides) and quality (neutralising value, fineness, moisture content), and the role of organic carbon as well as soil texture (particle size), in addition to initial soil pH, in determining the quantity of lime required to raise soil pH. There did not appear to be any cabbage varieties tolerant to clubroot available in Indonesia at the commencement of the project, at least to the knowledge of any of the project staff, and therefore there was no use of them by farmers recorded in the baseline survey. The introduction of clubroot tolerant varieties was addressed via LBD plots in a subsequent phase of the project. By contrast black rot tolerant cabbage varieties were available and their use recorded in the baseline survey.

A large number of growers from both provinces grew their own seedlings before transplanting them to the commercial field. When growing their own seedlings farmers usually plant their nursery in the land directly next to the commercial crop and this is likely to cause issues with transfer of disease, particularly that of black rot and clubroot. Improving the sanitation and quality of the nursery production of seedlings is needed to improve yields. Introducing the hot water technique to control black rot in susceptible varieties is an important area for nursery development.

The identification of soil acidity and associated crop nutrition issues such as high soil Al and Mn and low Ca in the soil and Mg in the plant being associated with low yield supports the general view that cabbage grows poorly at low soil pH. It highlights the continuing problem of soil acidity in high rainfall/leaching environments such as Indonesia. Although scientific staff and farmers were aware of the issue (e.g. limes are used regularly to counteract the acidifying affect of fertilisers) the problem of soil acidification may be underestimated in some situations. Soil pH management requires that the needs of other crops in the rotation be taken into account (e.g. potatoes usually require lower soil pH than brassicas as higher pHs may exacerbate diseases such as common scab). In respect of lime use there was an increased capacity of trainers and farmers to more accurately determine lime requirements and a greater appreciation of some aspects of lime quality (neutralising value, particle size) needed to make the most efficient use of it.

These results were incorporated into LBDs in FIL to assess the agronomic and economic benefits of the use of tolerant varieties with more efficient use of lime in the management of clubroot. Other LBDs tested integrated pest management with conventional farmer practices in a subsequent phase of the project.

7.2 Capacity impacts

Conducting the survey increased the capacity of the project staff (enumerators or assessors) in survey design, procedures, identification of pests and diseases and other crop disorders, assessment of crop growth, collection and analysis of data. The survey differed from traditional surveys that depended on ranking of limits to yield by expert staff as answers to questionnaires. This survey aimed to be more 'objective' by statistically relating growing practices and conditions to yield. This approach required the use of direct measurements of some of the growing conditions such as soil and plant nutrient status as well as monitoring of crops for type and incidence of pests and diseases and crop growth and development. Staff understanding and skill in these areas was improved as the results of the surveys attest. Staff needed to take and submit soil and plant samples correctly as well as monitor pests and diseases and assess crop growth according to detailed protocols in the sampling area at each grower site. These tasks were very demanding as the enumerators had to not only collect a large amount of data on practices from interviews but also follow strict protocols for collection of samples and identification of pests and diseases as described. Cabbage crops in the tropics are commonly infested with multiple pests and diseases. Identification of diseases by visual symptoms is difficult due to the damage caused by the interaction of other pests and diseases and can be further complicated by factors such as poor nutritional conditions. It takes skill to make accurate assessments at each site in these circumstances compared with, for example, experiments where factors are controlled. The enumerators performed exceptionally well, and the respondent farmers were very generous and co-operative, in coping with a very demanding survey in terms of the data collected. The analysis of soil and cabbage plant samples at the IVEGRI in WJ appears to be of a high standard.

As monitoring and direct measurements are more costly than questionnaire only surveys, they necessitate use of a smaller number of sample sites as a trade off for more detailed and reliable data at each site. However site numbers were adequate for appropriate statistical analysis ($P<0.10$) especially when data from both provinces were combined. The direct measurements and monitoring by staff was a useful cross check on answers in the questionnaire. For example it was possible to cross check rankings of types and incidence of pests and diseases from monitoring with answers from farmer respondents to the questionnaire. Similarly respondent answers to type and rates of applied fertiliser could be evaluated against measures of soil and crop nutrient status.

7.3 Community impacts

The involvement of the community via the farmer respondents in the survey as well as enumerators increased the knowledge of participants in the wide range of factors and their relevant importance in determining cabbage yield. The main limits to yield identified by the baseline survey formed the main focus of the LBD plots in the FFS in the two provinces. These LBD aimed at improving the sustainability and profitability of cabbage production in the relevant areas. For example in integrated pest management practices which recommend insecticides that do not disrupt natural enemies but which are effective against the target pests can maximise profit and minimise the input of broad spectrum insecticides into the environment. Important health and safety information in dealing with agricultural chemicals and their correct disposal was presented to farmers to minimise contamination of individuals, the community and the environment. This was the aim of all LBD activities arising from the survey related to pest management.

Management of clubroot and associated soil pH is a persistent sustainability issue which is common in wet tropical areas such as Indonesia and must be managed for all crops in the rotation. With greater knowledge and skill in assessing lime requirements and selecting the most appropriate lime on specific quality parameters farmers will be able to make more effective decisions in the use of lime.

7.4 Communication and dissemination activities

Table 7.4. Cabbage baseline survey communication and dissemination activities.

Date	Personnel	Organisation & Position	Location	Activities
Sep 06	Ian McPharlin Peter Dawson Julie Warren Peter Ridland Elske van de Fliert Bruce Tomkins	Cabbage Agronomist Economist Cabbage Entomologist Extension Specialist Post Harvest Specialist	Lembang	Preparation of final version of survey questionnaire. Presentations on GAP for potato production. Training in techniques for components of survey.
Jan 07	Ian McPharlin	Agronomist	W and C Java	Practical training in survey techniques in West and Central Java Cabbage crops.
August 07	Ian McPharlin	Agronomist	Pangalengan	Training in analysis of survey results, presentation of preliminary results in WJ at TOT Workshop.
August 08	Ian McPharlin Andrew Taylor Dolf De Boer Peter Ridland	Agronomist Pathologist Pathologist Entomologist	Kledung	Cabbage baseline presentation and preparation of LBDs for cabbage FFS

Fig 7.1. Harvesting cabbage in West Java.

8 Conclusions and recommendations

8.1 Conclusions

The survey was successful in identifying major growing conditions and practices associated with low or high yield. Whilst the survey identified numerous limits to production it was thought prudent to focus on 3 major areas (Clubroot, IPM of pests and soil acidity) as it was more likely that improvements could be made if effort was focussed on fewer areas than trying to address all possible limits. These 3 areas subsequently formed the basis of the learning by doing plots (LBD) in the farmer field schools. Clubroot and soil acidity management were combined in the LBDs as it was logical to do this given the central role of soil pH management in clubroot control.

In some instances the major limits were expected from the findings of previous surveys and general farmer knowledge for example pests and diseases such as DBM, CHC and clubroot. With factors such as clubroot, the incidence of which is widespread, it is difficult to derive relationships between disease incidence and yield as it is often recorded on all or most of the sites. Such relationships with yield can be derived if there is an accurate assessment of severity at each site. This was not possible here due to the variability in the skills of the assessors and the visual appearance of the above ground plant which can have an appearance which reflects other common yield limiting factors.

Other limits identified were high soil Al and Mn, associated with low soil pH, contributing to low yield in Java. Related to this was that higher yield was associated with high soil Ca and high leaf Mg both expected under less acidic conditions These findings confirm the general understanding that Brassica have poor tolerance to acid soils.

This survey educated Indonesian farmers and scientists in the process of undertaking scientific assessment and evaluation. Farmers were empowered to take their own samples, including soil, pH and petiole, whilst also educated in processes of the scientific method despite there being a vast difference in education levels between districts. Highlighting the fact that many variables are involved in producing high yielding cabbages the capacity of those involved in the survey was improved.

8.2 Recommendations

Clubroot is a serious issue for cabbage growers in Indonesia, it is a widespread problem which causes serious declines in yield. Control or management of clubroot is achieved via an integrated approach including the use of tolerant or resistant varieties with appropriate soil and fertiliser management strategies. Given the difficulty in increasing rotation times in Indonesia (where available land is at a premium) it is recommended that the continual evaluation of tolerant or resistant varieties occurs in Indonesia to combat clubroot.

The national IPM program for vegetables was introduced in 1992 but this survey suggests that it was not widely adopted by growers. This indicates that continual targeted education on the benefits of IPM is required in Indonesia to present new research to farmers which can be incorporated into their own research in LBD plots in FIL to reinforce the message that broad spectrum insecticides are both detrimental to yields and the environment.

Despite agricultural land being at a premium in Indonesia it is recommended to spatially separate the nursery production of seedlings from the commercial production of the crop. Most growers in the survey grew their seedlings in the plot or field next to where the commercial crop was being grown. This means the seedlings are likely to be grown in contaminated soil and are already infected with disease when transplanted into the field.

This practice will undoubtedly lead to a build up of pest and disease problems over time. The effect of black rot in particular can be reduced by appropriate nursery hygiene. Nursery areas need to be raised with sterilised growing media and separated to provide clean seedlings for the production area.

Hot water treatment of seed is a relatively simple technique that can be used to minimise the impact of black rot. Black rot is a bacterium that infects seeds and reduces the quality of seedlings. Training and reinforcing the techniques behind the hot water treatment will enable farmers to better maximise the efficiency of seeds to seedlings and therefore produce greater yields.

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10 Attachments:

10.1 Annex 1: Baseline survey questionnaire for cabbage

OBJECTIVES:

- To identify cabbage cropping and post-harvest practices capable of providing maximum yield, quality and profit in Central and West Java.

Characteristics of selected farmers:

- Large and small-scale farmers
- Farmers cultivating potato and brassicca
- Farmers who had yet to plant cabbage crops at the time of selection

Location code/identification (Province/District/Subdistrict/Village) and name of farmer determined by Balitsa staff member for the purpose of analysis.

Province :.. (Filled in by staff member).

District :...

Subdistrict :......................................; Village ....

Farmer's Name :..

FIRST VISIT – Prior to planting cabbage crop

Name of staff member/interviewing officer:	
Date of the first visit:	

1) Crops grown at an elevation of: ……………….metres above sea level

2) Soil sample taken:

Day: ………………..…../Date:…………………..…/Month: …………………..…

3) How steep is the gradient of the land?

(1) flat (0 – 10 %)

(2) gentle slope (11 – 30 %)

(3) steep slope (> 30 %)

4) How deep is the soil layer?

(Measure soil depth: in 3 places to a depth 40 cm)

Soil analysis

Collect 25 soil sub-samples, mix them into one composite sample and send to Balitsa for analysis.

To be filled in by Soil Laboratory officer at BALITSA:

5) Analysis covering/ soil texture

1. Loam
2. Sandy-loam
3. Clay

6) Soil nutrient analysis:

NUTRIENTS	VALUE	UNITS/ NOTES
pH		
N-total		
NO_3-extractable		
NH_4-extractable		
P		
K		
Mg		
Ca		
S		
Na		
Fe		
Mn		
Cu		
Zn		

Agronomic practices

To be answered by farmer:

7) How many years have you been growing cabbages?

8) Where did you learn to grow cabbages?

1. From father or family member
2. Self taught
3. Formal training (please state details)..
4. PHT field school
5. Other (please state details..

(9) Do you have a crop plan?

1. yes
2. no

10) Where do your seedlings come from?

1. commercial nursery
2. farmer grown

(11) What variety did you grow?

1. one
2. two
3. three

12) Were the seedlings damaged by pests or diseases prior to planting if so name them?

1. No
2. Diamondbackmoth
3. Club root
4. Damping off
5. Cabbage head caterpillar
6. Black cut worm
7. Potato leaf miner
8. Weevils
9. Beetles
10. Other

13) What were the seedlings treated with in the nursery/farm?

1. 1 nil
2. don't know
3. chlorothanonil
4. other

Planting

14) What was the spacing?

(a) within the row ………… cm

(b) between rows ………… cm

15) What mulch was used?

1) none
2) plastic
3) other (please state)

16) What was the date of planting?

Crop rotation

17) How many crops were grown a year on this site?

18) How many cabbage crops were grown a year on this site?

198) What crops other than cabbages were grown on this site?

20) Distance to nearest crop of cabbages?

Tillage

21) What method of tillage was used prior to planting?

1. Plough and till by small tractor
2. Plough by small tractor and till by hand
3. Entirely by hand

22) How many times was the ground tilled?

23) Describe tillage method?

1. 20 cm with machine
2. 12-15 cm by hand
3. Other

Pest & disease control

24) What soil treatments were used for pest and disease control before planting?

1. None
2. Bleaching Powder
3. Formalin
4. Other (specify)

25) What nematodes were present?

1. none
2. sugar beet
3. root knot
4. don't know

26) Were nematicides used to control nematodes before planting? If so, give names

1. None
2. Carbofuran
3. Other (specify)

27) What insects were problems in your cabbage crop?

1. Don't know
2. Aphids
3. Spodophera
4. Cabbage head caterpillar
5. Potato leaf miner
6. Cutworm
7. Thrips
8. Diamond Backmoth
9. Mites
10. Weevils
11. Beetles
12. Snails
13. Other (specify)

28) How were insects controlled prior to planting?

1. Neem
2. Tea waste
3. Tobacco waste
4. Chemical (specify)

29) What diseases, if any, were in the crop?

1. None
2. Club root
3. Black rot
4. Downey Mildew
5. Ringspot
6. Sclerotinia
7. Don’t know

30) What weeds a problem in your crop?

1. none
2. grasses
3. broad leaf weeds
4. other

31) How were weeds controlled before planting?

1. Chemical : rate …………..
2. Gramoxone (Paraquat): rate …………..
3. Other (specify)

32) How were weeds controlled after planting?

1. hand
2. mulch
3. other

Fertiliser

32) List names of fertilizers (e.g. urea) and amendments (e.g. compost, dolomite, manure) applied both before and after planting

DATE	NAME	RATE/HA	UNITS	COMMENTS
before				
after				

Irrigation

33) What method was used to irrigate the crop?

1. none
2. furrow
3. watering can
4. furrow & watering can
5. sprinkler
6. hose & nozzle

34) How many times was the crop irrigated?

35) Did you have enough water for irrigation?

1. Yes

2. No

36) What was the source of irrigation water?

1. dam
2. stream
3. tank
4. none

Monitoring crop

To be done fortnightly until four sets of data have been collected.

3 single row plots, each 5metres long are to be assessed. Plots to be chosen at random at each visit. Leaf analysis - Collect a total of 30 leaves (one per plant) in a zigzag patter across the 50m^2 SU at each visit. Choose the youngest mature leaf (before heading) or wrapper leaf (after heading). Submit intact leaf samples for analysis.

Monitoring growth & soil moisture

	Criteria	Sub plot 1	Sub plot 2	Sub plot 3
37)	Date of first visit :			
38)	Rainfall since planting (mm)			
39)	Number of plants			
40)	Leaf number			
41)	Plant height (cm)			
42)	Head size (cm)			
43)	Soil moisture (dry, wet, too wet)			
44)	Date of second visit :			
45)	Rainfall since planting (mm)			
46)	Number of plants			
47)	Leaf number			
48)	Plant height (cm)			
49)	Head size (cm)			
50)	Soil moisture (dry, wet, too wet)			
51)	Date of third visit :			
52)	Rainfall since planting (mm)			
53)	Number of plants			
54)	Leaf number			
55)	Plant height (cm)			
56)	Head size (cm)			
57)	Soil moisture (dry, wet, too wet)			
58)	Date of fourth visit :			
59)	Rainfall since planting (mm)			
60)	Number of plants			
61)	Leaf number			
62)	Canopy height (cm)			
63)	Is canopy cover 100% (Yes/No)			
64)	Button(curd) size			
65)	Soil moisture (dry, wet, too wet)			

Insect monitoring & control

66) Insect monitoring & control

Criteria	Sub plot 1	Sub plot 2	Sub plot 3
Date			
Insect			
Number per plant			
Severity (light/medium/heavy)[1]			
Control applied by farmer[2]:			
Date			
Insect			
Number per plant			
Severity (light/medium/heavy)			
Control applied by farmer:			
Date			
Insect			
Number per plant			
Severity (light/medium/heavy)			
Control applied by farmer:			
Date			
Insect			
Number per plant			
Severity (light/medium/heavy)			
Control applied by farmer:			

[1]For aphids > 20 per plant = Heavy, for leaf miner use published scale

[2]Describe chemical, number of applications and rate

Criteria	Sub plot 1	Sub plot 2	Sub plot 3
Date			
Insect			
Number per plant			
Severity (light/medium/heavy)[1.]			
Control applied by farmer [2]:			
Date			
Insect			
Number per plant			
Severity (light/medium/heavy)			
Control applied by farmer :			
Date			
Insect			
Number per plant			
Severity (light/medium/heavy)			
Control applied by farmer :			
Date			
Insect			
Number per plant			
Severity (light/medium/heavy)			
Control applied by farmer :			

[1]For aphids > 20 per plant = Heavy, for leaf miner use published scale

[2]Describe chemical, number of applications and rate

60) Disease monitoring & control

Criteria	Sub plot 1	Sub plot 2	Sub plot 3
Date			
Disease			
Number of plants affected			
Severity (light/medium/heavy)			
Control applied by farmer[1]:			
Date			
Disease			
Number of plants affected			
Severity (light/medium/heavy)			
Control applied by farmer:			
Date			
Disease			
Number of plants affected			
Severity (light/medium/heavy)			
Control applied by farmer:			
Date			
Disease			
Number of plants affected			
Severity (light/medium/heavy)			
Control applied by farmer:			

[1]Describe chemical, number of applications and rate

Criteria	Sub plot 1	Sub plot 2	Sub plot 3
Date			
Disease			
Number of plants affected			
Severity (light/medium/heavy)			
Control applied by farmer[1]:			
Date			
Disease			
Number of plants affected			
Severity (light/medium/heavy)			
Control applied by farmer:			
Date			
Disease			
Number of plants affected			
Severity (Light/Medium/Heavy)			
Control applied by Farmer:			
Date			
Disease			
Number of plants affected			
Severity (light/medium/heavy)			
Control applied by farmer:			

[1]Describe chemical, number of applications and rate

67) Other damage monitoring & control

Pesticide safety

68) What protection do you use when spraying?

1. none
2. mask
3. plastic coat
4. water proof gloves
5. other

69)Do you use yellow sticky traps to monitor leaf miner fly?

1 no

2 yes

70)Where do you get your information on pest and disease control

1. other farmers
2. government extension officers
3. chemical store
4. company field officers
5. other (specify)

71) How do you apply pesticide sprays ?

1. back pack sprayer
2. motorised sprayer
3. watering can
4. other (specify)

72) Do you use BT (Bacillus thuringensis) to control Diamond back moth?

1. no
2. yes

73) What beneficial insects are in your crop?

1. none
2. don't know
3. Other

74) What wetting agents do you use for pesticide application?

1. none
2. agral

3. oil

75) Harvest date:

76) What time of day do you harvest?

1. morning
2. afternoon
3. all day
4. evening

77) Why was this date chosen?

1. market
2. weather
3. other

78) Weeks of growth left if crop harvested early:

79) Yield: weigh and record 5 single row plots, each 3 metres long

Curd/head	Number	Weight (g)
Reject		
Reason for most rejects *		

* Choose from: diseased, pest damage, mechanical damage, oversize, other

10.2 Annex 2. Nutrients in youngest mature leaves with cabbage head yield.

Micro-nutrients

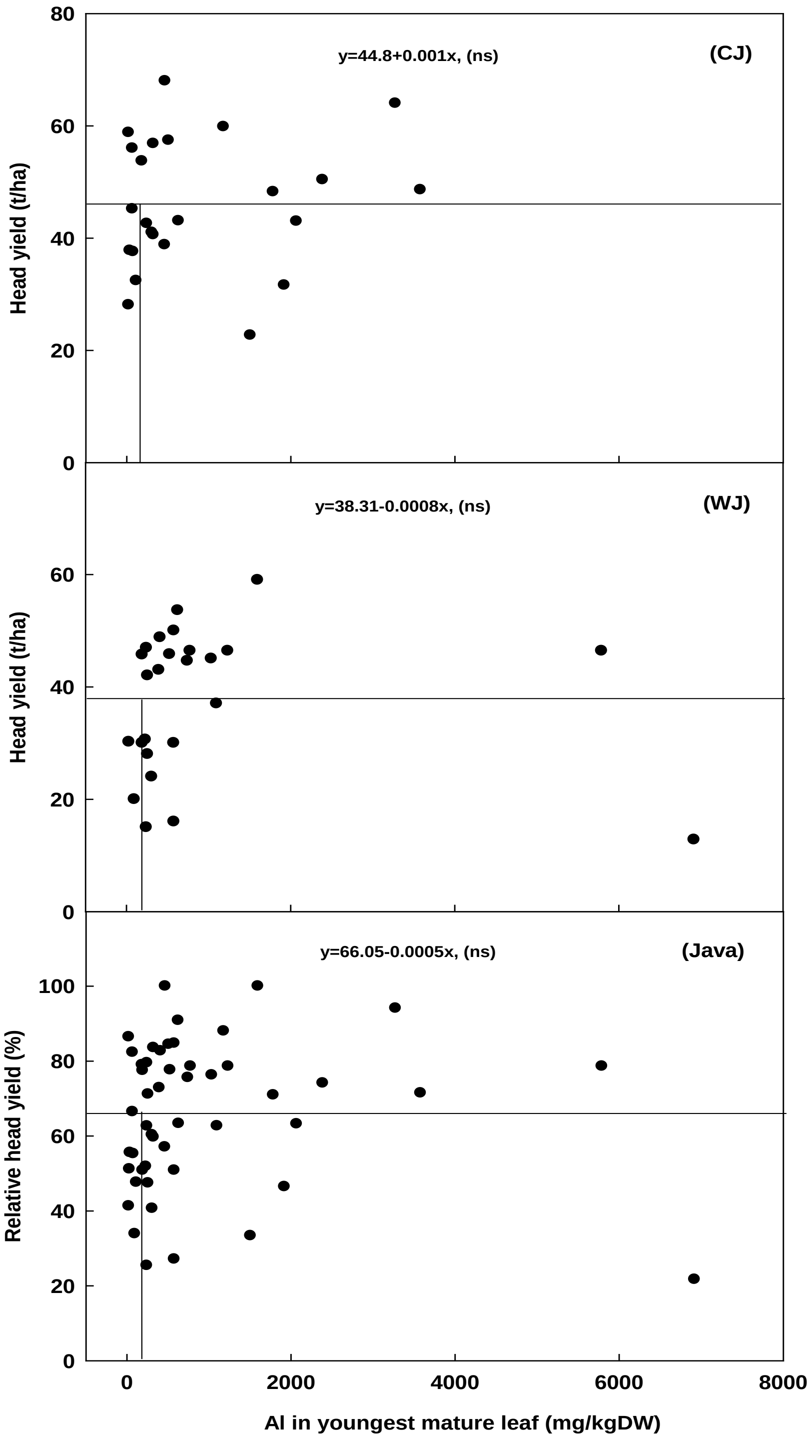

Figure 1. Linear regression between Al concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature

leaf sampled at 28 to 35 days after transplanting. Values > intercept of vertical bar represents nutrient excess or toxicity (if greater than).

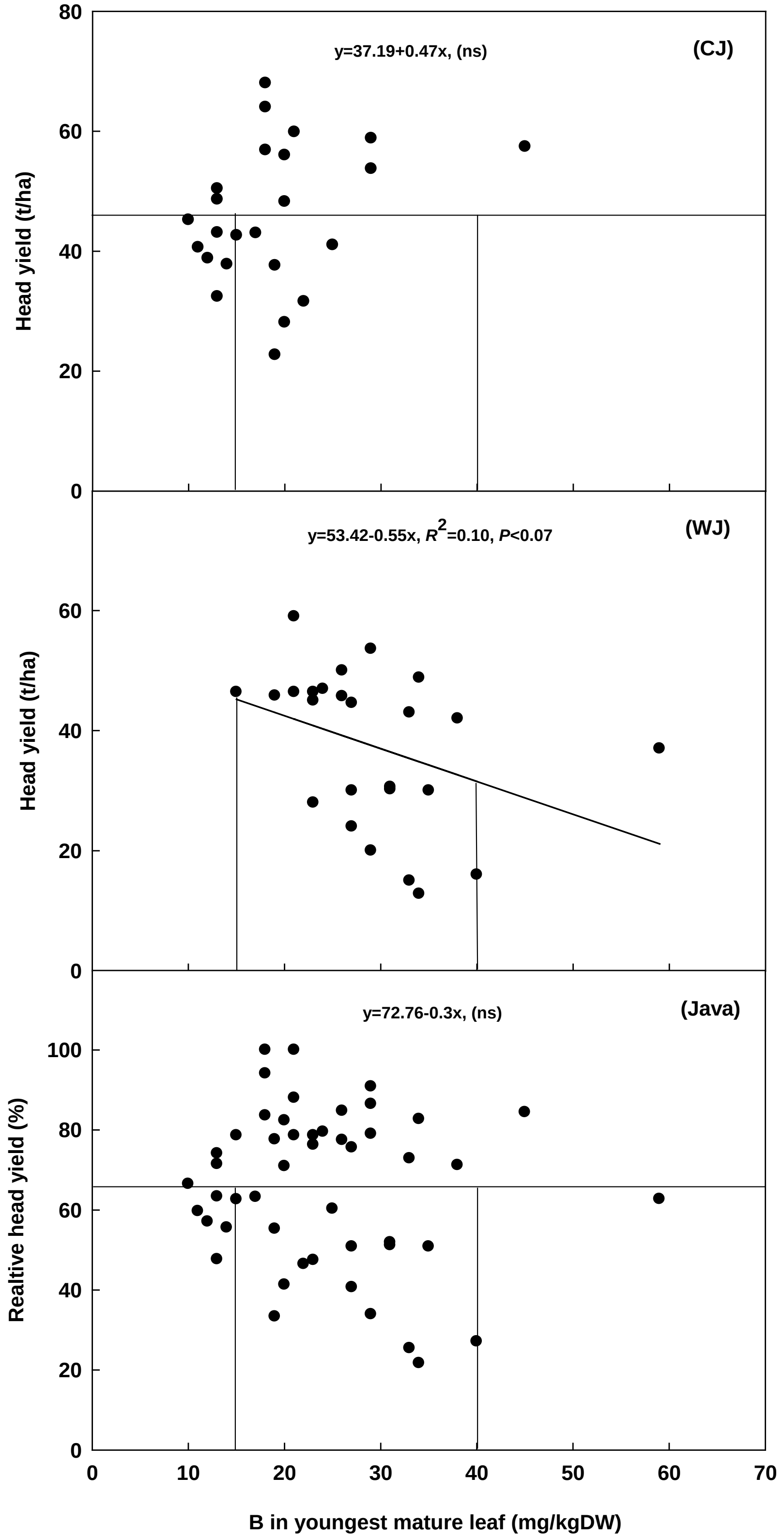

Figure 2. Linear regression between B concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature

leaf sampled at 28 to 35 days after transplanting. Vertical bars represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

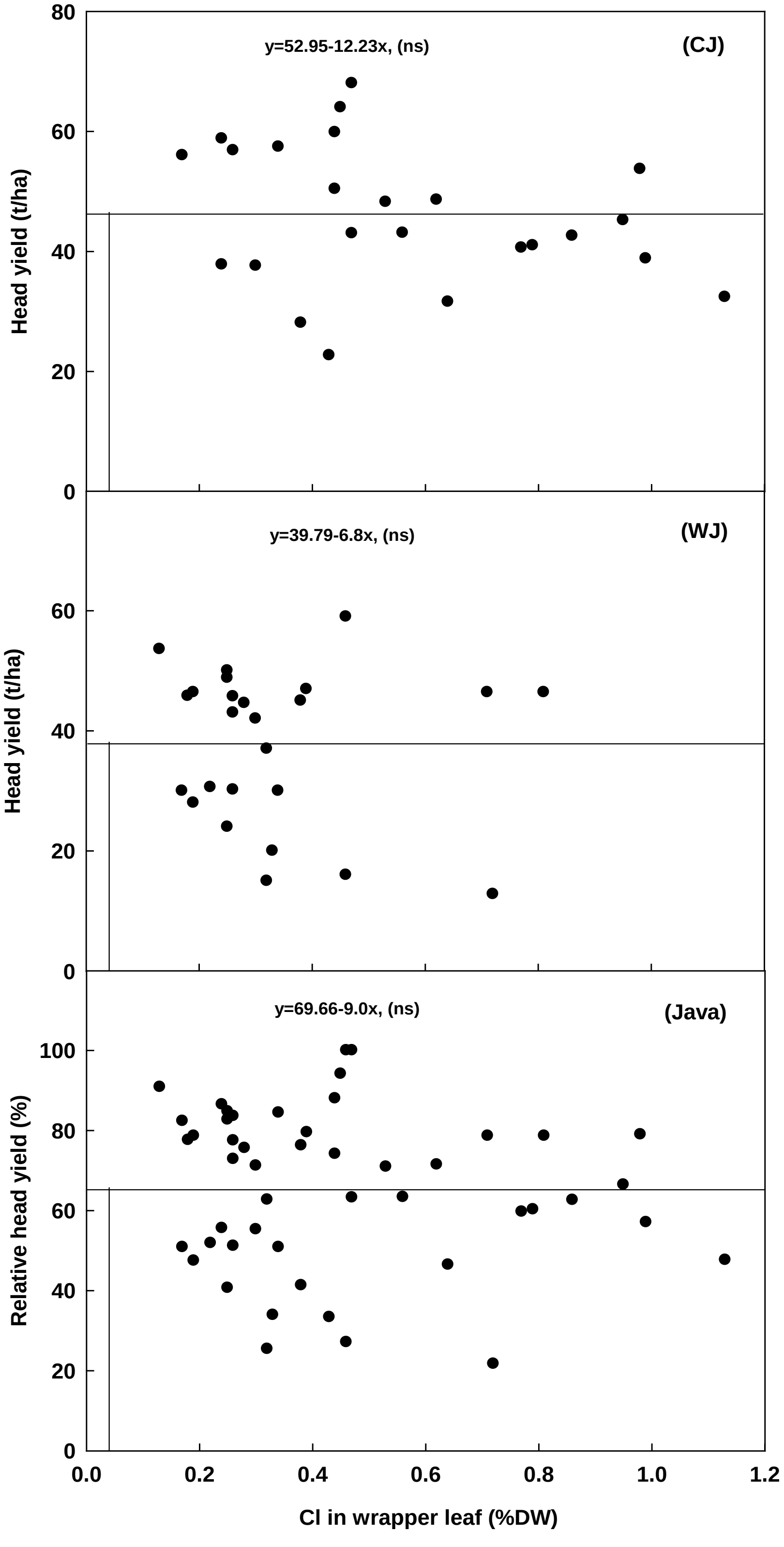

Figure 3. Linear regression between Cl concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature

leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

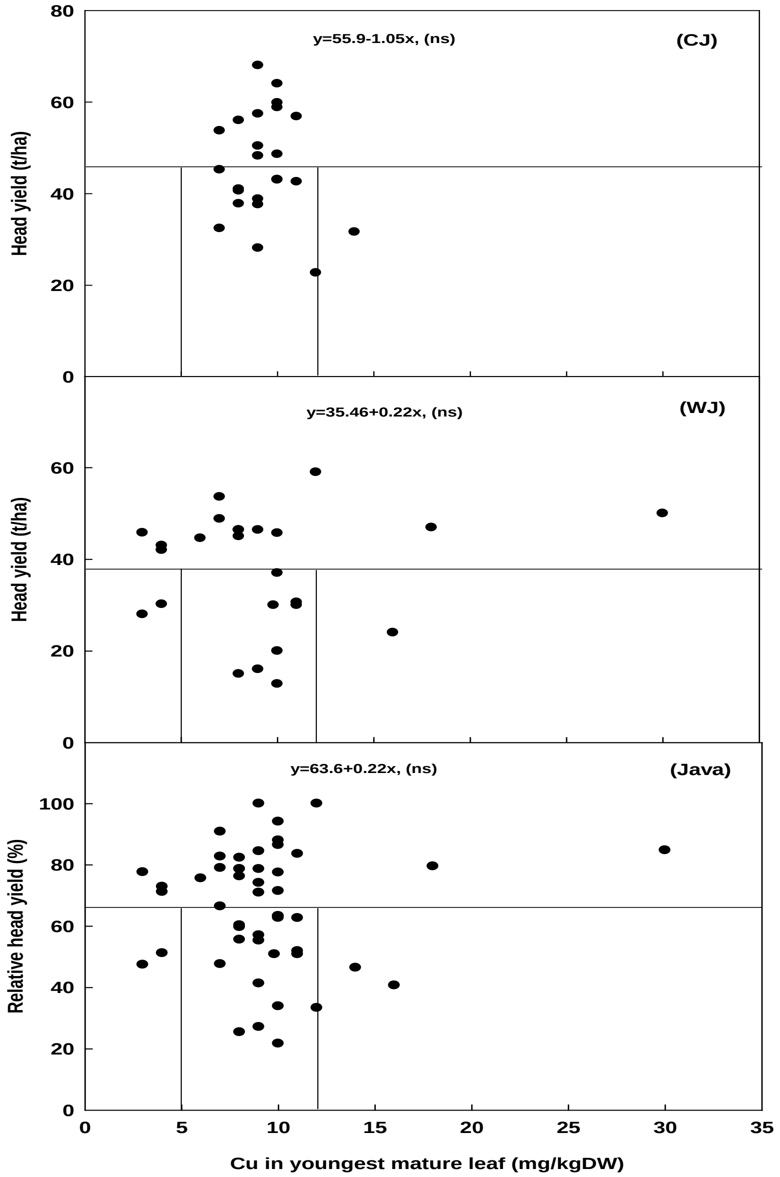

Figure 4. Linear regression between Cu concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

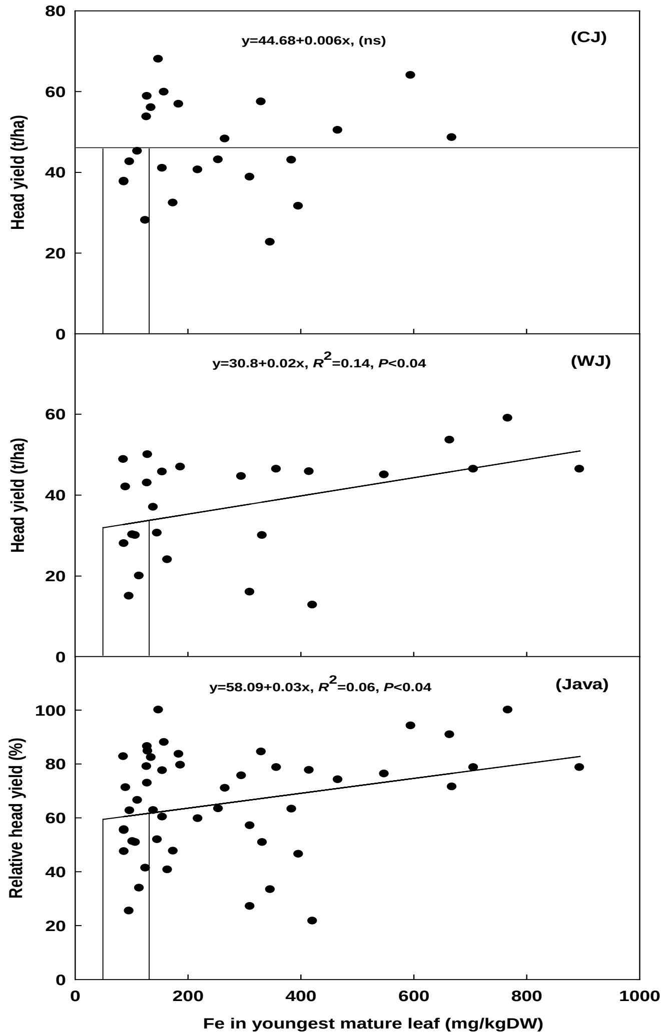

Figure 5. Linear regression between Fe concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

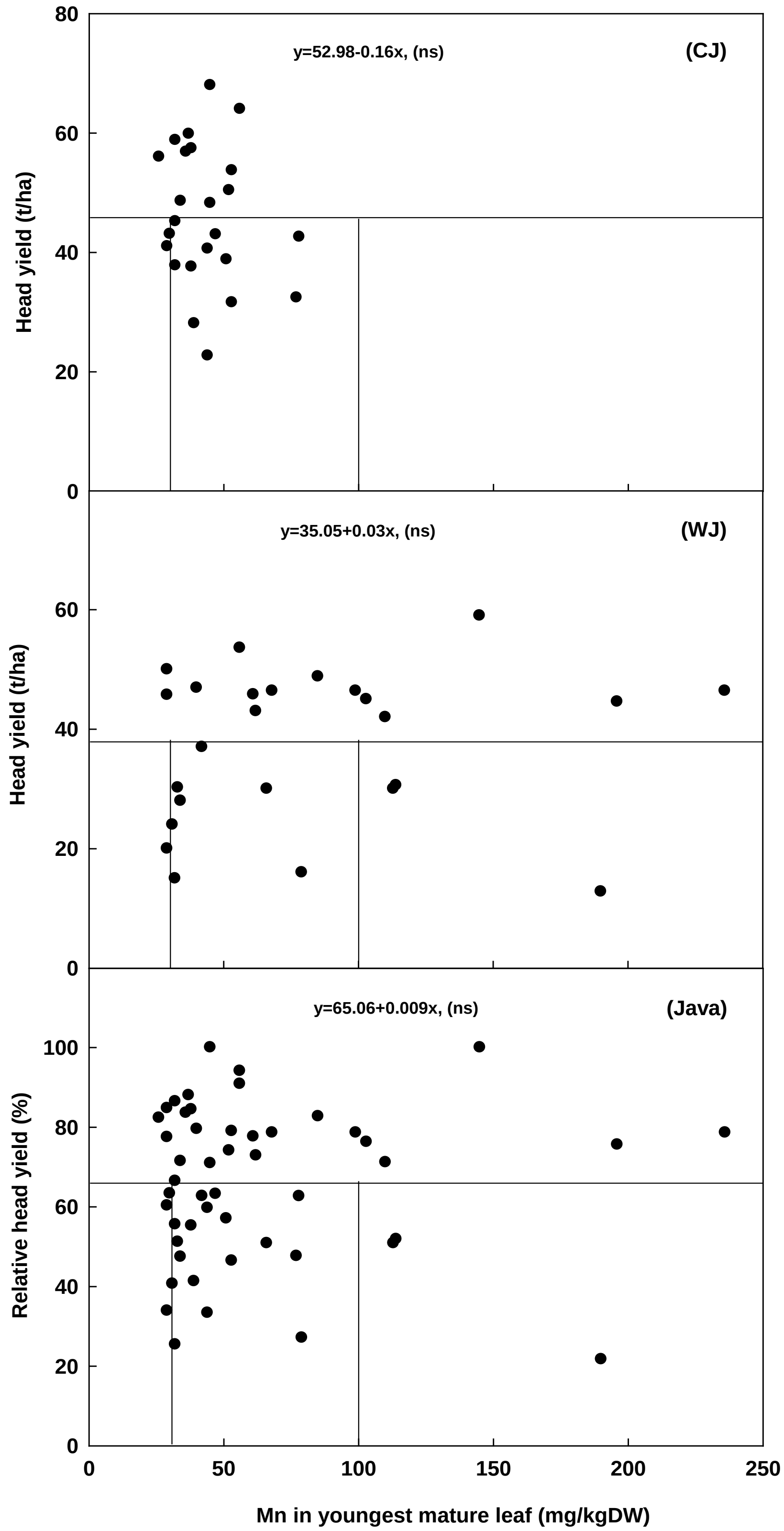

Figure 6. Linear regression between Mn concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

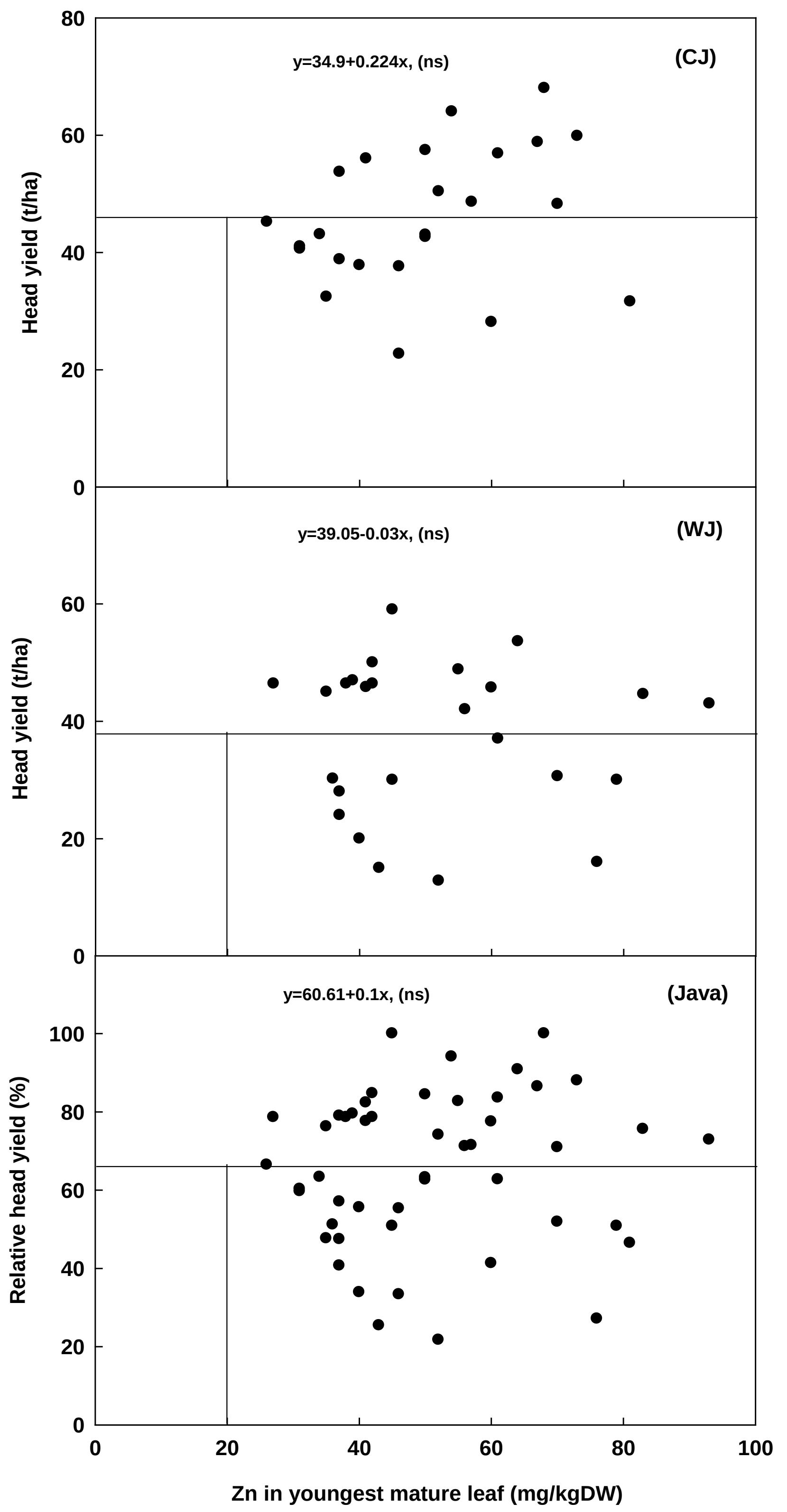

Figure 7. Linear regression between Zn concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Concentrations <vertical bar intercept represents deficiency and > adequacy.

Macro-nutrients

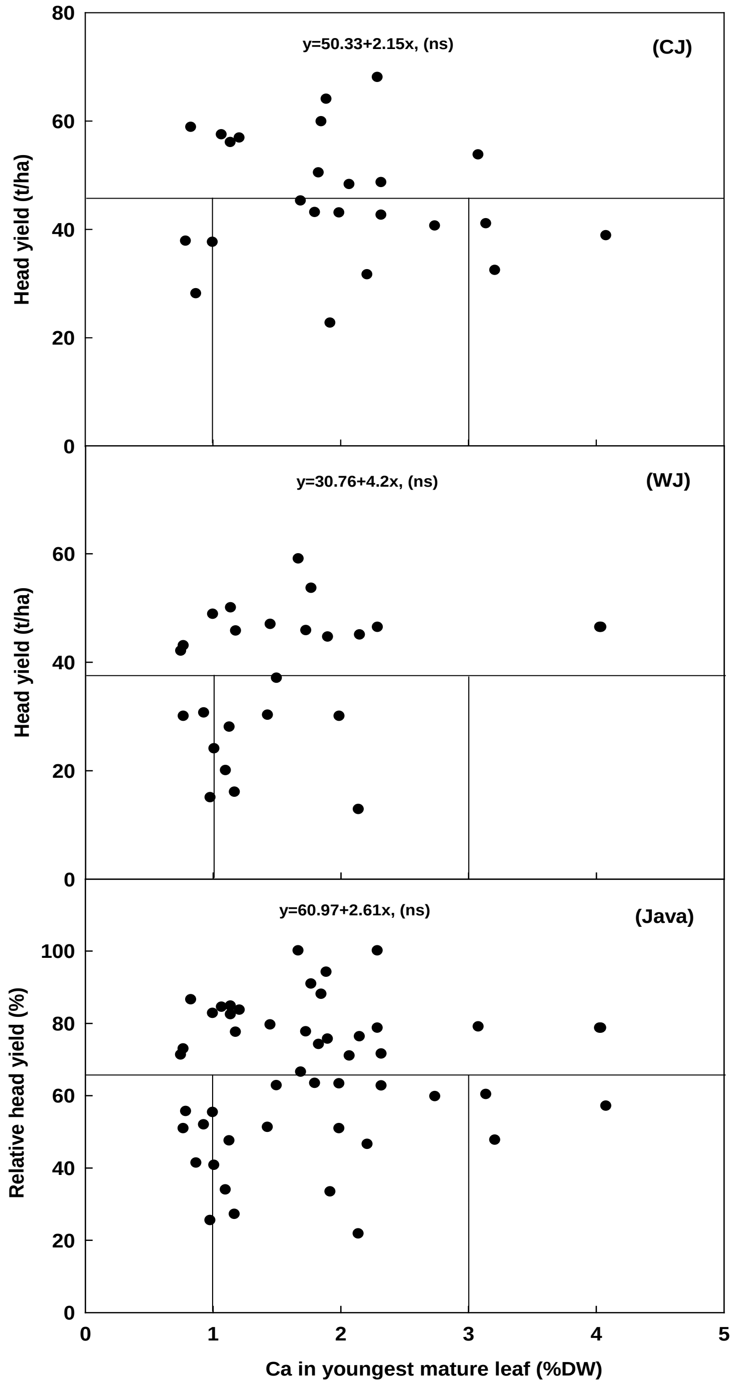

Figure 8. Linear regression between Ca concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

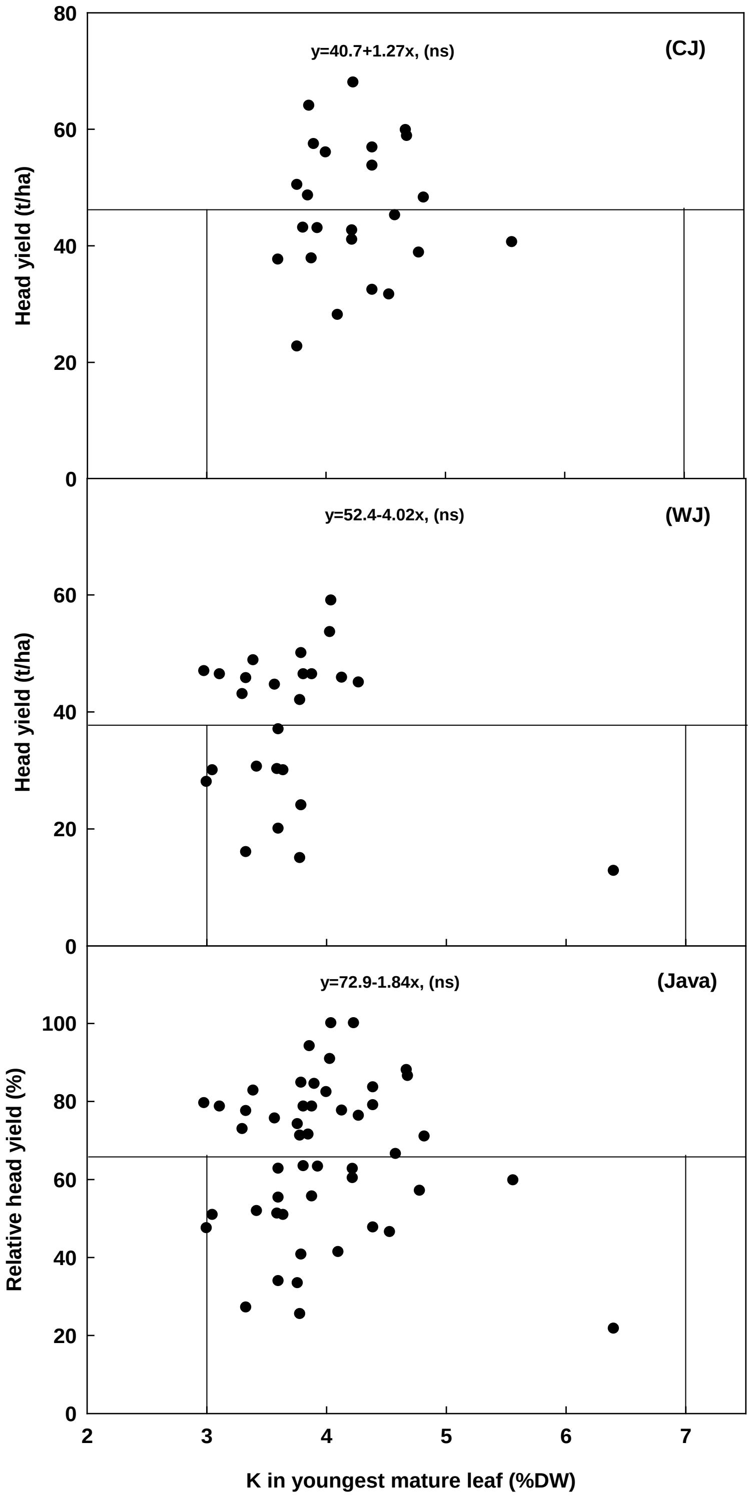

Figure 9. Linear regression between K concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield(%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

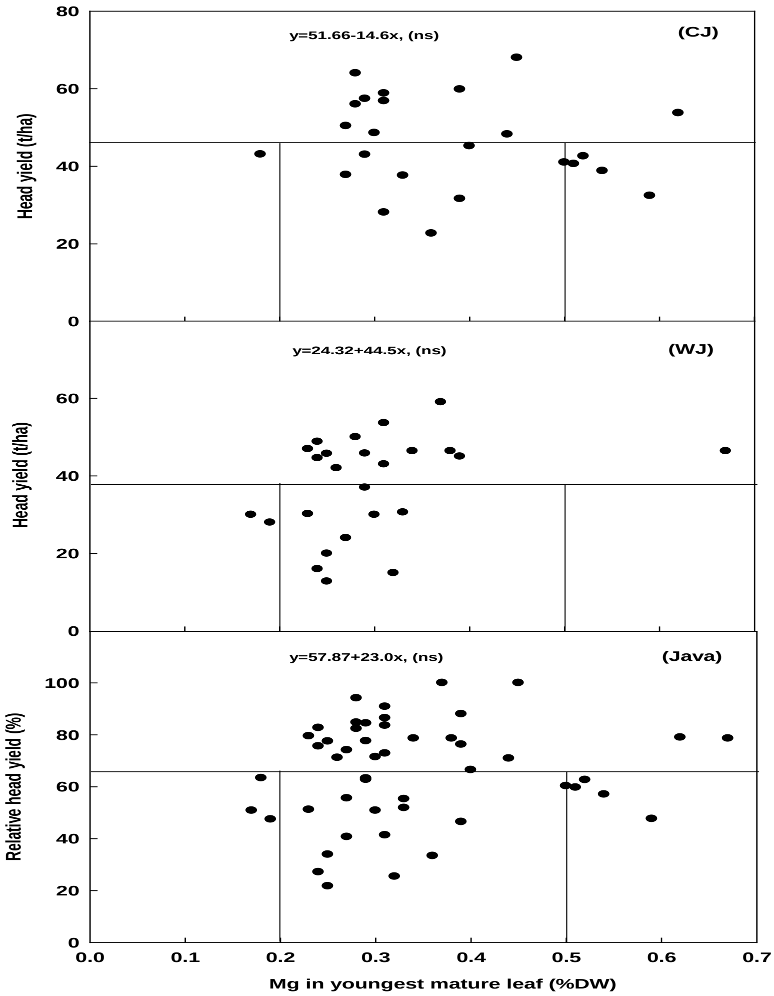

Figure 10. Linear regression between Mg concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

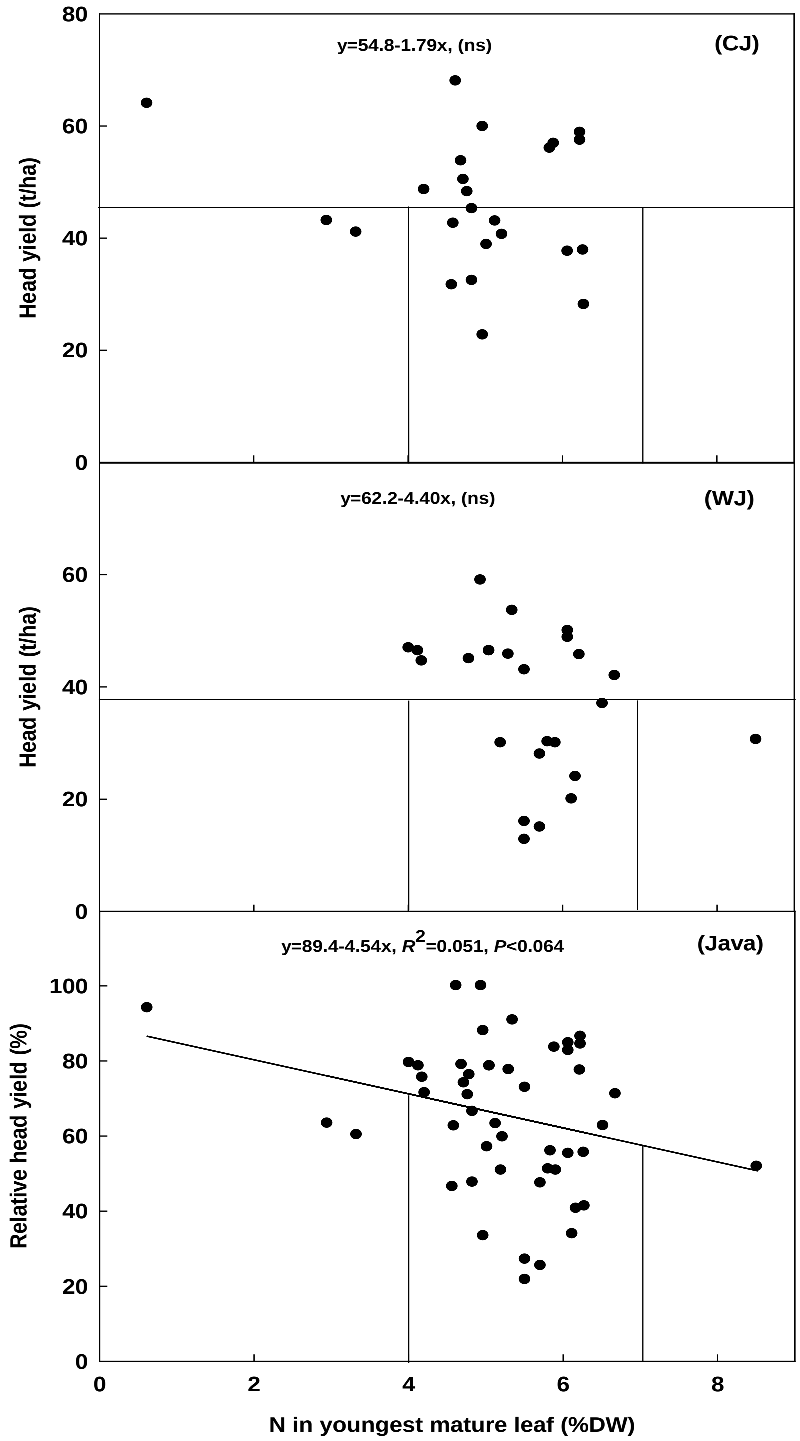

Figure 11. Linear regression between N concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

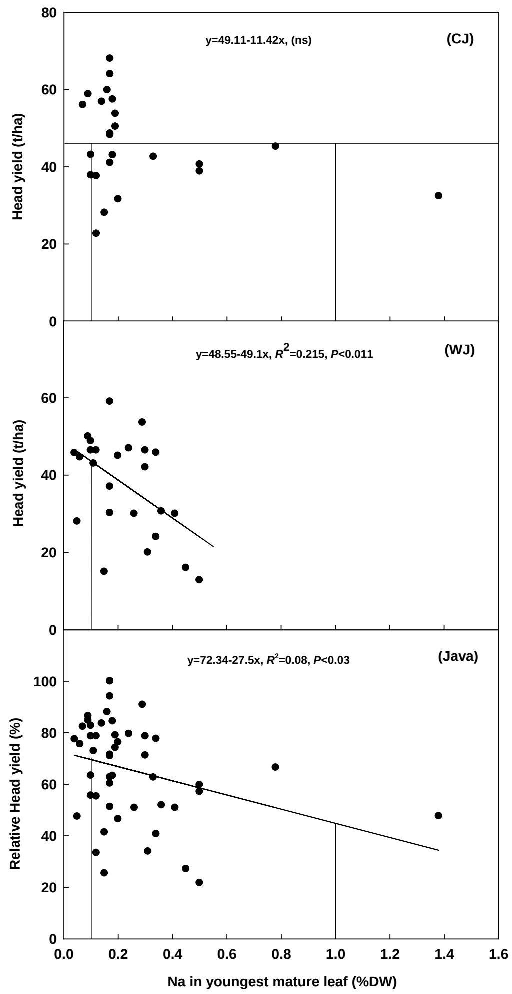

Figure 12. Linear regression between Na concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield (%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with

deficiency (< left bar) and excess (> *right bar) outside the range.*

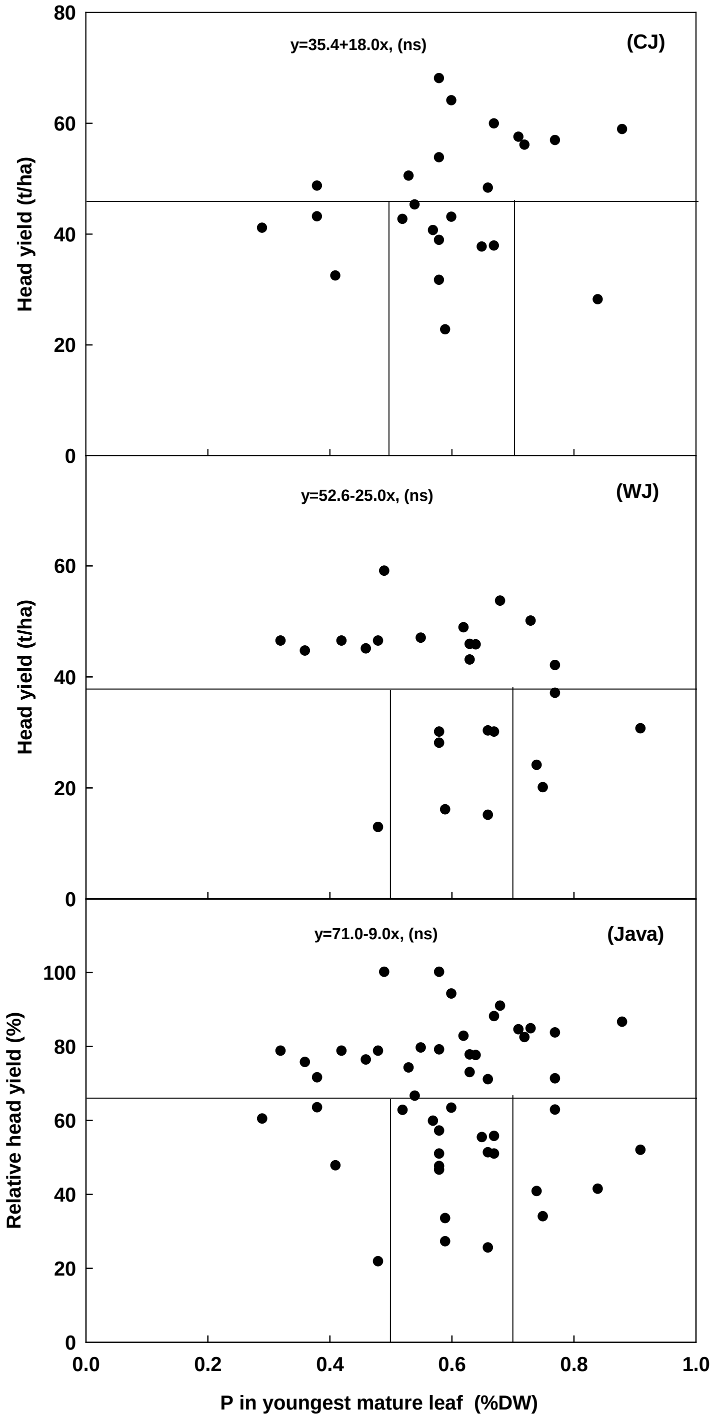

Figure 13. Linear regression between P concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield(%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

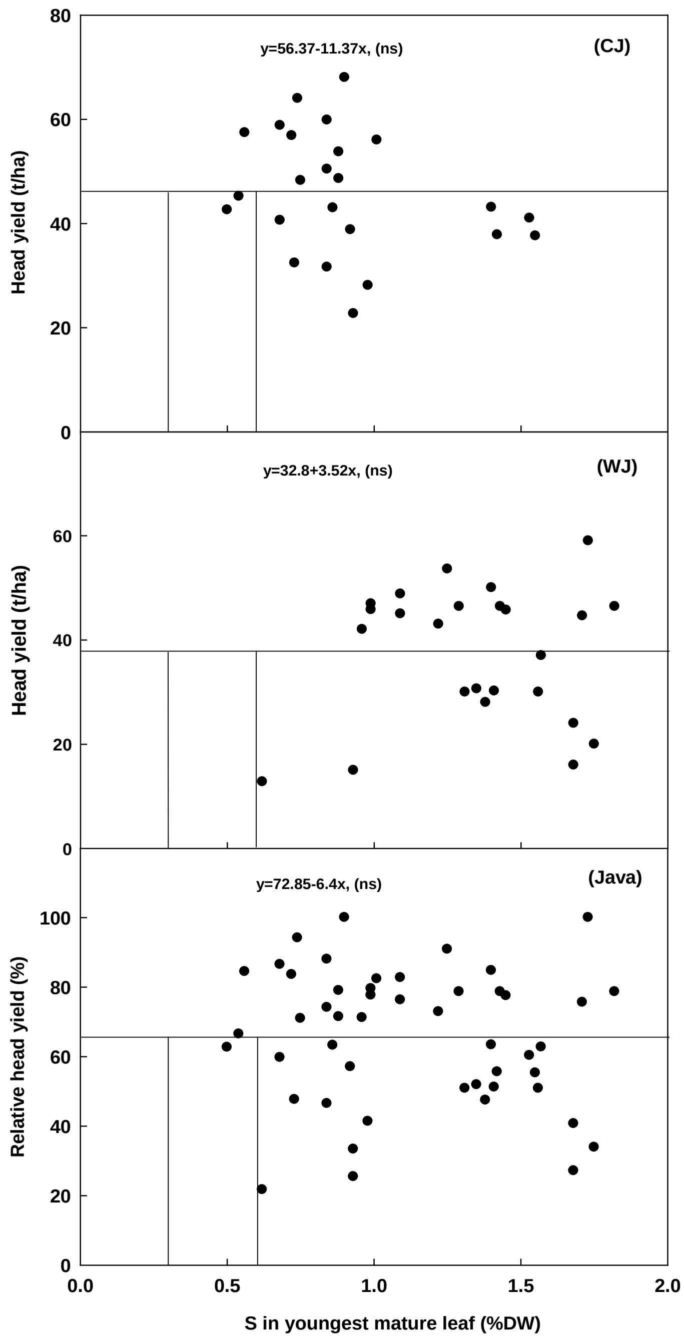

Figure 14. Linear regression between S concentration in youngest mature leaves (mg/kg DW) and head (t/ha) or relative head yield(%) of cabbage in Central (CJ), West Java (WJ) or the 2 provinces combined (Java). Nutrient concentration is from youngest mature leaf sampled at 28 to 35 days after transplanting. Vertical bar intercepts represents adequate concentration range with deficiency (< left bar) and excess (> right bar) outside the range.

Australian Government

Australian Centre for International Agricultural Research

Final report appendix 4

title

AGB/2005/167 Economic baseline survey of cabbage

prepared by

Paul Mattingley

co-authors/ contributors/ collaborators

Julie Warren

Mieke Ameriana (dec), BPTP NTB

1 Executive summary

One of the main activities at the commencement of the project was a broad baseline survey of potato and Brassica crops for the wet and dry seasons. The economics component of the survey aimed to identify relationships between key economic drivers for potato and Brassica production across the project provinces for different conditions and different varieties. The economics survey was conducted at the same time as the production survey.

The format for the economics survey was developed by DAFWA and IVEGRI Economists. In practice the surveys were not uniform across all the provinces as local data collection teams tailored the survey to enable information to be gathered in the most appropriate format.

The cabbage economics survey looked at cabbage production in West Java (WJ) and Central Java (CJ).

The survey demonstrated that there are a wide range of yields, prices and input costs.

The results of the economics baseline survey form the basis for measuring improvement to the system recommended by project researchers and investigated through Farmer Initiated Learning (FIL) groups.

The main cost of production for CJ and WJ were fertilisers which represent 47% and 44% of costs respectively. The analysis indicates that there is no correlation for either province for fertiliser expenditure with yields, average prices or gross margin returns. Fertilisers appear to be being overused and there is a need for future research work to investigate how to optimise fertiliser use.

Other significant costs include seedlings (12% for West Java and 10% for CJ) and insecticides (13% WJ and 10% CJ). Seedling expenditure and quantity had a positive correlation with yield in West Java and with gross margin returns in CJ. Insecticide expenditure had a negative impact on average price per kg in CJ and no impact on yields or gross margin returns.

CJ has a higher average yield (34.1 tonnes/ha) than West Java (30.8 tonnes/ha) which when combined with CJ's much higher average price (Rp 1,031/kg compared to 476 Rp/kg) provides a higher income and gross margin.

Despite not being widely used fungicide expenditure had a positive correlation on average price in WJ and on gross margin in CJ.

Both provinces saw a positive correlation between yield and gross margin returns however only CJ saw a positive correlation between average price received for produce and gross margin returns.

The results of the economics baseline survey form the basis for measuring improvement to the system recommended by project researchers and investigated through FIL groups learning-by-doing (LBD) demonstration plots. For example survey gross margins combined with results of FIL activities enabled the economic impact of project clubroot management recommendations for use of lime and resistant varieties to be assessed. The benefits of improved management of clubroot disease through the use of lime and resistant varieties has a present value of Rp 756 billion or $AUD 86 million using the current prices and a present value of Rp 89 billion or 10 million with a price elasticity of -2.5 (Table 8.1).

2 Background

The project aims to increase the returns to potato and Brassica growers in WJ and CJ and South Sulawesi (SS) and Nusa Tenggara Barat (NTB) through adapting proven Australian, Indonesian and CIP practices. At present there are a wide spread of agricultural practices employed by growers throughout the four provinces and the management of crops is often not optimal nor uniform. Accordingly an economic baseline survey was undertaken to document and analyse the practices employed by growers and link practices to profitability or losses. The economic analysis was then used to plan what agronomy, pathology and entomology management practices should be targeted to improve yields or reduce costs. New management practices were tested by FIL groups. The grower groups recorded their inputs and yields and these were then used to model the financial impact of revised practices. The improved returns would then act as an incentive for growers to adopt the new practices. In addition the careful testing of new management techniques enables growers and researchers to develop knowledge of how to measure financial performance and analyse changes to their production system.

The funds provided by ACIAR enabled the Indonesian and Australian researchers to undertake this comprehensive study. Indonesian cabbage growers normally do not have access to computers to record and analyse financial information. Supporting institutions such as IVEGRI and provincial Dinas Pertanian do have economists however undertaking a baseline survey of 40 – 50 growers throughout a production season required significant funds for manpower and transport.

3 Objectives

An objective of the project was to conduct an economic baseline survey of cabbage crops in CJ, WJ, NTB and SS to identify relationships between key economic drivers for cabbage production such as the effectiveness of inputs (agro-chemicals and fertilisers), impact of prices, yield and commercial relationships. Drivers that were identified to improve cabbage returns would then be tested in Farmer Initiated Learning learning-by-doing plots.

The economics survey provided a snapshot of production practices and profitability across the two provinces at the beginning of the project. This provides a future opportunity to compare changes to practices resulting from project recommendations and gauge their financial impact for growers.

The survey provided a training opportunity to develop the capacity of the counterparts in survey design, data collection, analysis and interpretation. The survey was conducted collaboratively by DAFWA and Indonesian counterpart economists.

4 Methodology

4.1 Baseline survey

Use of Gross Margin analysis

The team used a standardised model for Gross Margin Analysis which measured income minus costs (predominantly variable costs). ACIAR Final Report Project AGB/2005/167 Appendix 2 Baseline economic survey of potatoes contains the questionnaire used in the economic survey.

Development of the questionnaire

The draft questionnaire covering production costs and sales income for cabbages was developed by Australian Agricultural Economists. The draft survey was translated and then sent to each of the provinces for comment. Where necessary changes were made and clarification sought on certain issues. Survey enumerators were trained to interview growers and record their responses. The growers were visited regularly during the cropping period to ensure that data was recorded as activities were undertaken. The baseline survey focused on variable costs because production is small scale with limited use of capital equipment. The farms surveyed were of differing sizes and the results were converted to a per hectare basis to enable comparison.

Analysis

The data was sent from Indonesia to Western Australia where it was analysed in Excel. A sensitivity analysis was conducted to gauge the impact of changes in input costs on the gross margin using the Sensit Add-in in Excel. This was used to determine regressions that should be investigated. A yield and price sensitivity for the gross margin was also performed. Regression analysis was used to investigate whether there was a relationship between practices and grower yields, prices and gross margin. Where no graph is presented there is no significant correlation found between the variables. Where necessary, counterparts and enumerators from the provinces were consulted to clarify any issues with data. The analysis sought to find correlations between the following main variables shown in Table 4.1.

Table 4.1. Column headings show the main variables and the body of the columns shows the correlations that were investigated.

Gross Margin & Correlations investigated:	Yield & Correlations investigated:	Average price & Correlations investigated:
Yield		
Average price of produce sold	Average price produce sold	
Scale	Scale	Scale
Fertiliser expenditure	Fertiliser expenditure	Fertiliser expenditure
Insecticide expenditure	Insecticide expenditure	Insecticide expenditure
Herbicide expenditure	Herbicide expenditure	Herbicide expenditure
Fungicide expenditure	Fungicide expenditure	Fungicide expenditure
Quantity of seed used	Quantity of seed used	Quantity of seed used
Value of seed used	Value of seed used	Value of seed used

4.1.1 Impact evaluation

The benefits of outcomes from FIL activities were determined from projected future value due to adoption of project findings. A “with project” and “without project” scenario was developed. The annual value of each scenario was calculated from gross margins and area planted of each scenario. The annual project benefit was the additional value accrued from adoption of project findings, i.e. the “without project” value subtracted from the “with project” value. The annual project benefit was for the projected years were used to calculate the Present Value (PV) of the benefits of the work using the Net Present Value function in Excel with a discount rate of 7%, with year 1 not discounted. This PV was then adjusted for project attribution and chance of success. Additional production can lead to falls in prices. Necessities such as vegetables are usually inelastic in demand in the short term. However Indonesian population will increase by 11.9% between 2010 and 2020 to over 260 million (The World Bank 2011) and additional supplies should not cause major price falls for SS cabbage growers. Therefore the analysis used an elasticity of demand of -2.5 to gauge the impact of possible price falls due to additional supply. Here a 25% increase in production leads to a 10% fall in prices. The PV differs from the net present value of project benefits as project costs have not been subtracted from project benefits.

5 Achievements against activities and outputs/milestones

Objective 1: To Adapt and apply robust integrated crop production, pest management and postharvest handling systems for potato and Brassicas/Alliums suited to Java, NTB and Sulsel conditions.

No.	Activity	Outputs/ milestones	completion date	Comments
1.2	Training in survey design, crop monitoring, sampling, data collection and analysis	Questionnaire finalised & training completed at workshops	CJ &WJ in 2006 & NTB & SS in 2008	Training at workshops was complimented by practical demonstrations during field visits to WJ in 2006, CJ in 2007 and NTB and SS in 2008.
1.3	Conduct baseline survey for potatoes in CJ, NTB, SS & WJ	Summary reports of baseline surveys completed and results presented at workshops	CJ &WJ in 2007 & NTB & SS in 2009	Summary reports all baseline surveys from each province included in annual reports. Results of surveys presented to workshops in WJ and CJ in 2007 and in NTB and SS in

PC = partner country, A = Australia

6 Key results and discussion

The analysis looked at a number of variables to discover whether there was a relationship between practices and grower yields, prices and gross margin returns. Where there is no graph there is no correlation between the variables.

6.1 Gross margins

Central Java has a higher average yield (34.1 t/ha) than West Java (30.8 t/ha) which when combined with Central Java's much higher average price (Rp 1,011/kg compared to 476 Rp/kg) provides a higher income, gross margin and benefit:cost ratio (Table 6.1).

Table 6.1. Average gross margin returns for West and Central Java.

Item	Units	West Java	Central Java
Crop size	ha	0.45	0.39
Yield	tonnes/ha	30.8	34.1
Price	Rp per kg	476	1,031
Income	Rp per ha	14,670,284	35,163,006
Cost of Seedlings	Rp per ha	1,042,042	992,051
Fertiliser	"	4,011,419	4,493,621
Insecticide	"	1,136,950	918,077
Fungicide	"	285,483	88,564
Herbicide	"	32,381	7,231
Planting	"	161,899	235,513
Weeding	"	315,727	472,359
Labour-other	"	715,238	1,692,385
Equipment	"	260,841	368,983
Other	"	1,094,059	244,555
Total	"	9,056,039	9,513,338
Gross Margin	"	5,614,245	25,649,667
Benefit:cost ratio (Income/expense)		1.62	3.70

Average costs per ha are similar for both provinces at Rp 9.1 – 9.5 million. The largest costs for both West and Central Java was fertiliser followed by either insecticides or labour-other (primarily harvest labour) and seedlings (Table 6.2). Both provinces spend similar amounts on fertiliser. Central Java's growers spend less on insecticide, herbicide and fungicide than their West Javanese counterparts. Central Java's growers plant on average 19,000 seedlings per ha compared to 24,000 seedlings per ha, however including labour costs and nursery costs (chicken manure and fungicides) the total expenditure on seedlings is similar.

Table 6.2. Average costs by percentage for West and Central Java.

Item	West Java	Central Java
Seedlings	12%	10%
Fertiliser	44%	47%
Insecticide	13%	10%
Fungicide	3%	1%
Herbicide	0%	0%
Planting	2%	2%
Weeding	3%	5%
Labour other activities	8%	18%
Equipment	3%	4%
Other	12%	3%

6.2 Sensitivity analysis

Results of the Excel input cost sensitivity analysis that was conducted on the Central Java data is shown in the spider chart in Figure 6.1. Using the Sensit Add-in in Excel a sensitivity analysis was conducted to gauge the impact of percentage changes in input costs on the gross margin returns. This helps to identify inputs that should be investigated for correlation. On this spider chart, lines that are nearly horizontal generally indicate an input variable where small percentage changes do not have much affect on the gross margin. Lines that are more vertical indicate an input variable where small percentage changes have a greater affect on the gross margin. The slope downwards from left to right indicates a negative relationship. The inputs are listed in the legend in Figure 6.1 in decreasing order of impact on gross margin. The graph clearly shows that if fertiliser use efficiency can be increased then gross margins should increase.

Most agricultural enterprises are highly sensitive to factors affecting returns – prices received, gross yield and waste. A sensitivity analysis was conducted using price and yield to measure their impact on the gross margin for Central Java (Table 6.3). Large fluctuations in gross margins result from 10% or 20% changes in yield and price. A 10% increase in yield and 10% increase in price leads to a 28% increase in gross margin; from Rp 25 million per ha to Rp 32 million per ha. Accordingly it is worth investigating the effect of various inputs and practices on yields, average prices and gross margin.

The sensitivity analysis showed that cabbage is a low risk crop because even at low yields and prices in the sensitivity analysis the gross margin remains positive.

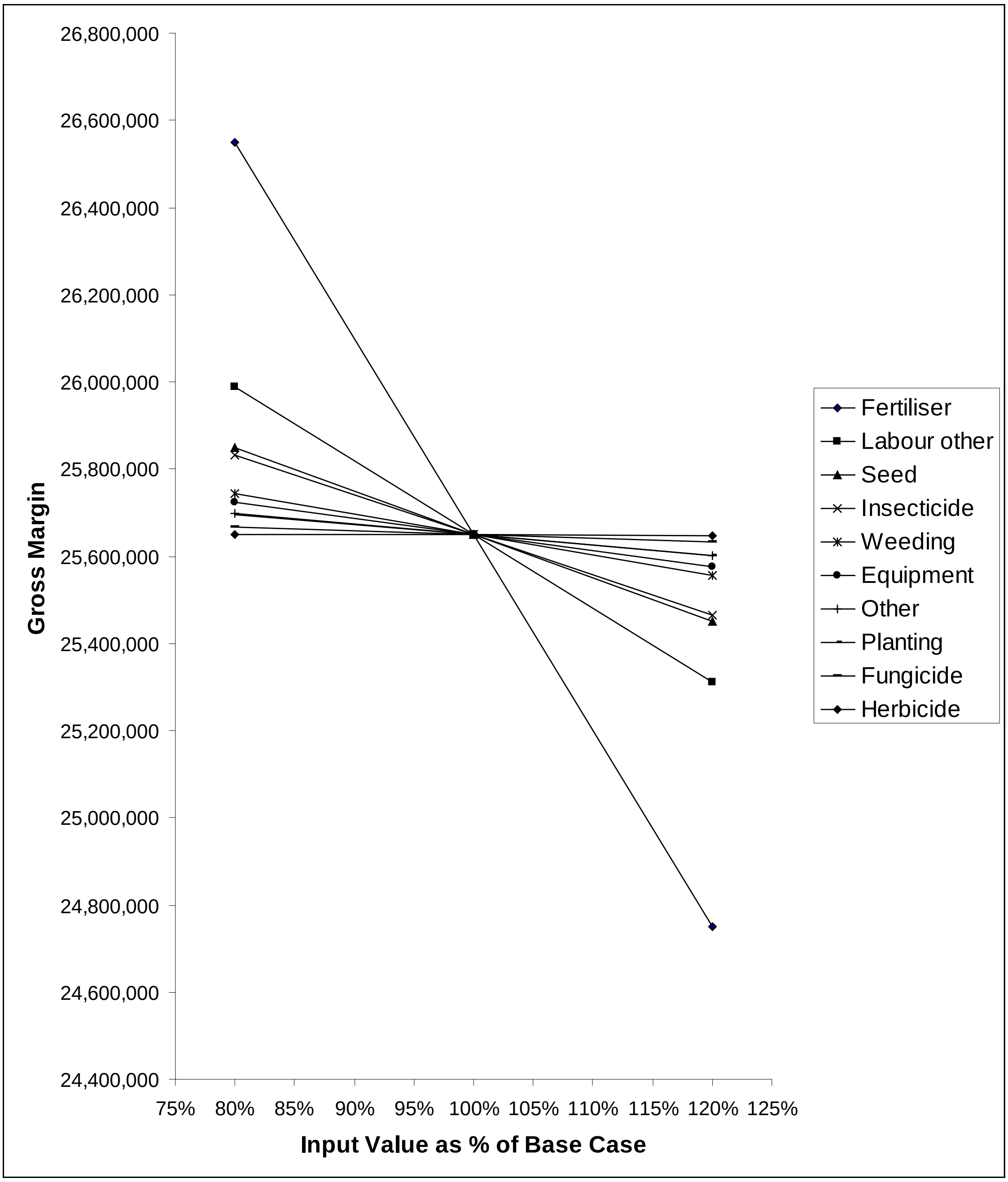

Figure 6.1. Sensitivity Analysis (spider chart) for Central Java.

Table 6.3. Sensitivity analysis for price and yield for cabbage grown in Central Java.

			Yield (tonnes/ha)				
			- 20%	- 10%	0%	+ 10%	+ 20%
			27.29	30.71	34.12	37.53	40.94
Price (Rp/kg)	- 20%	825	13,329,462	15,973,264	18,617,066	21,260,868	23,904,670
	- 10%	928	16,142,503	19,137,935	22,133,367	25,128,799	28,124,231
	0%	1,031	18,955,543	22,302,605	25,649,667	28,996,729	32,343,791
	+ 10%	1,134	21,768,583	25,467,276	29,165,968	32,864,660	36,563,352
	+ 20%	1,237	24,581,624	28,631,946	32,682,268	36,732,591	40,782,913

6.3 Regression analyses

6.3.1 Yield and gross margin

The correlation of gross margin to yield was investigated to determine:

- whether there was a correlation between yield and gross margin,
- whether Indonesian cabbage farmers can increase their gross margin by aiming to produce higher yields, i.e. that they are not at the point of diminishing returns,
- the likely break-even yield.

If there is a correlation between yield and gross margin it helps explain the use and over-use of inputs by growers aiming to maximise gross margins through high yields.

Both provinces saw a correlation at $P < 0.05$ between yield and gross margin (Figure 6.2). Correlations between gross margin and yield for West and Central Java provinces showed gross margin continued to increase directly with yield. The correlation between yield and gross margin is stronger in West Java than Central Java. Central Java has a higher indicative break-even yield at 18.4 t/ha than West Java's 13.1 t/ha according to the x-intercepts in Fig 6.2. This initially appears unusual as the averages provided in Table 6.1 indicate that both provinces have similar costs and with higher returns generated by higher prices it would be expected that growers with lower yields in Central Java would still break-even. However the average figure for Central Java masks a wide spread of input costs and returns. The two growers that returned losses growing cabbage in Central Java had an average price per kg of Rp 200, well below the Rp 1,031 kg average.

The correlations between gross margin and yield for West and Central Java provinces shows that there is scope to increase profitability of cabbage farmers through improved agronomic efficiency as gross margin continues to increase directly with yield.

Most of the growers produce a positive gross margin from their cabbage crops e.g. 10 out of 13 growers in Central Java and 5 out of 6 growers in West Java.

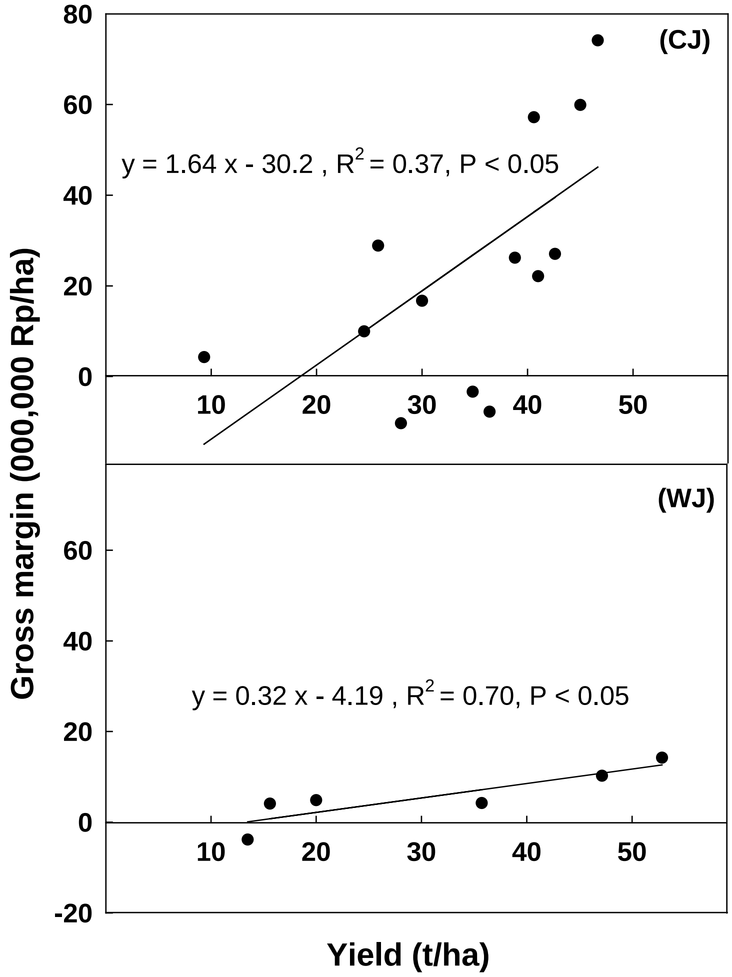

Figure 6.2. Linear regression of yield with gross margin in West Java and Central Java, ($P < 0.05$).

6.3.2 Price received for produce and gross margin

Central Java showed a correlation at $P < 0.05$ between the price received for produce and gross margin. There is a wide spread of prices received for both sets of growers reflecting differing standards of quality.

West Java did not have a significant correlation between price received for produce and gross margin. As stated the gross margin return is highly sensitive to factors affecting income – yield and average price. Accordingly it would be expected that those receiving higher prices would achieve a higher gross margin unless they were trading off yield or increasing input cost beyond the point of diminishing returns to improve quality and hence price.

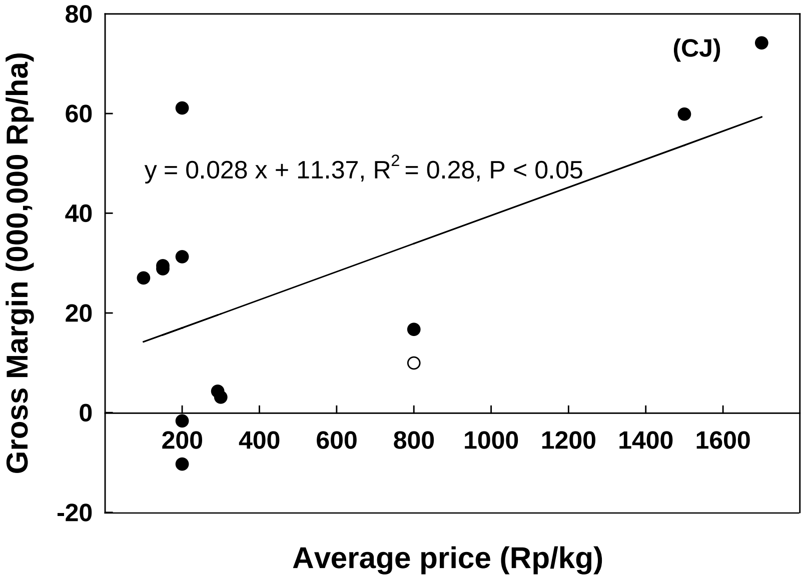

Figure 6.3. Linear regression of price received per kg for produce and gross margin per ha for Central Java.

6.3.3 Fertiliser expenditure and average price

There is a negative correlation between fertiliser expenditure and average price received in Central Java at $P < 0.05$ (Fig 6.4). However fertiliser expenditure did not have any statistically significant association with yield or gross margin. Fertiliser has the greatest effect on gross margin with increasing fertiliser costs reducing gross margin steeply (Fig 6.1). This means that factors affecting the efficiency of fertiliser use will be worth investigating. The availability of fertilisers to the crop will depend on root system health and soil pH. The prevalence of both the damaging root pathogen clubroot and low soil pH was described in the baseline agronomic survey of cabbage (ACIAR Final Report Project AGB/2005/167 Appendix 3) and these may contribute to the inefficient fertiliser use of the Javanese cabbage farmers. Farmers may be trying to overcome poor crop performance due to low soil pH and clubroot by applying high rates of fertiliser. As the cause of low price is not fertiliser *per se* this extra input cost is wasted (Fig 6.4).

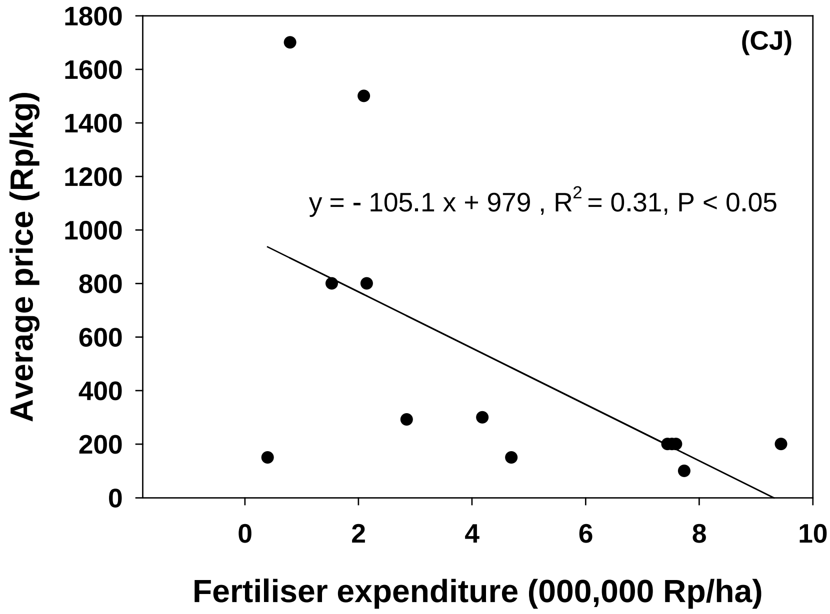

Figure 6.4. Linear regression of fertiliser expenditure (including labour to apply fertilisers) with average price per kg in Central Java.

6.3.4 Seedling expenditure and yield

Seed expenditure includes nursery labour and inputs such as chicken manure and fungicides. There is a positive correlation between the amount spent on seedlings and yields achieved in West Java (Fig 6.5). Seed expenditure could be a limiting factor in West Java and those spending more on seed and its management are seeing an improvement in yield. No significant correlation was found between seed expenditure and yield in Central Java. Seed expenditure is not a limiting factor for achieving good yields.

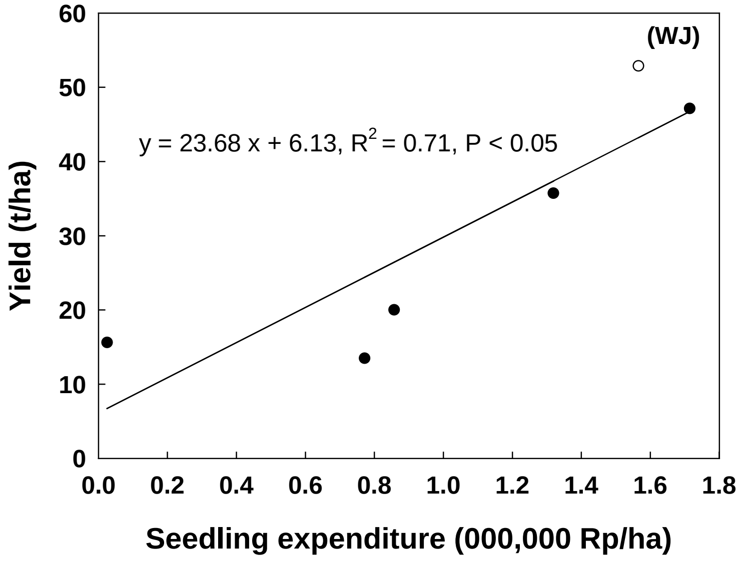

Figure 6.5. Linear regression of seedling expenditure with yield in West Java.

6.3.5 Seedling quantity and gross margin

There is a positive correlation between the amount of seedlings used and gross margin in Central Java (Fig 6.6). Those growers using more seedlings are seeing an increase in gross margin however they are not seeing a statistically significant increase in yield or average price. It may be that better farmers use more seedlings rather than increased seedling use causing higher gross margins.

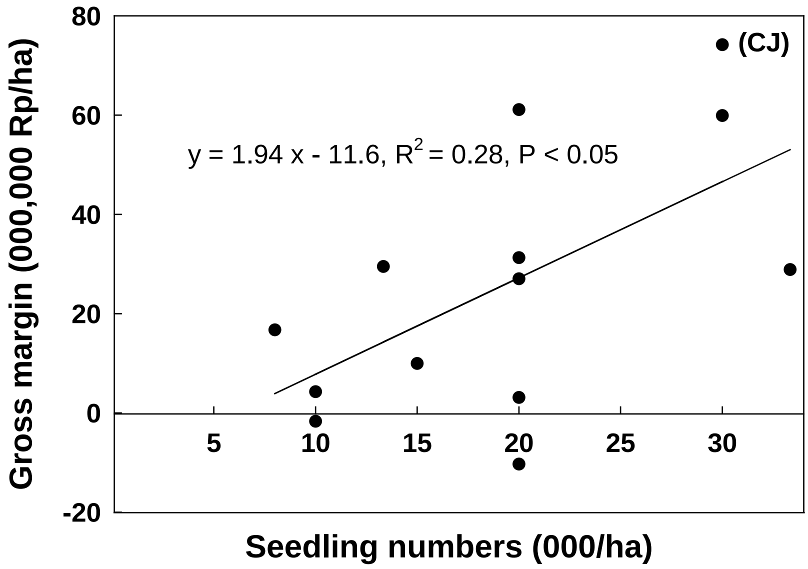

Figure 6.6. Linear regression of seedling number with gross margin in Central Java.

6.3.6 Insecticide expenditure and average price

Central Java had a negative correlation between pesticide expenditure and average price of produce at $P < 0.05$ (Fig 6.7). Possible explanations for this are:

- The use of broad spectrum insecticides may be reducing the population of beneficial insects and leading to increased pest problems which then affect produce quality,
- Pest populations are resistant to insecticides,
- Inefficient insecticide use, for example targeting adults of diamondback moth rather than its caterpillars.

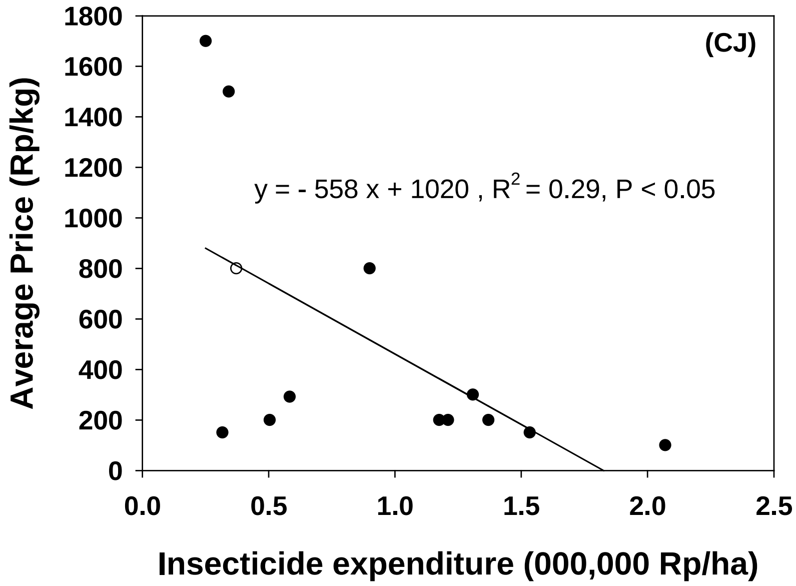

Figure 6.7. Linear regression of insecticide expenditure (including labour to apply insecticides) with average price received in Central Java.

6.3.7 Fungicide expenditure and average price

Of the 6 growers in the West Java data set 5 used fungicide and there is a correlation between fungicide use and the average price received for produce (Figure 6.8 lower). However prices are fairly uniform between Rp 400/kg and Rp 600/kg and there is no correlation between fungicide expenditure and gross margin returns in West Java.

Only 3 of the 13 growers in the Central Java data set use fungicides. The growers achieving the highest average price use fungicide and have a strong correlation with their fungicide expenditure (Fig 6.8 top).

6.3.8 Fungicide expenditure and gross margin

The use of fungicide in Central Java is associated with higher gross margins (Fig. 6.9). Some fungicides also have good activity against bacterial diseases of Brassica like black rot. This association may indicate that spraying for fungal and bacterial disease may be beneficial in Central Java. Other methods of control, like seed heat treatment for black rot should be considered.

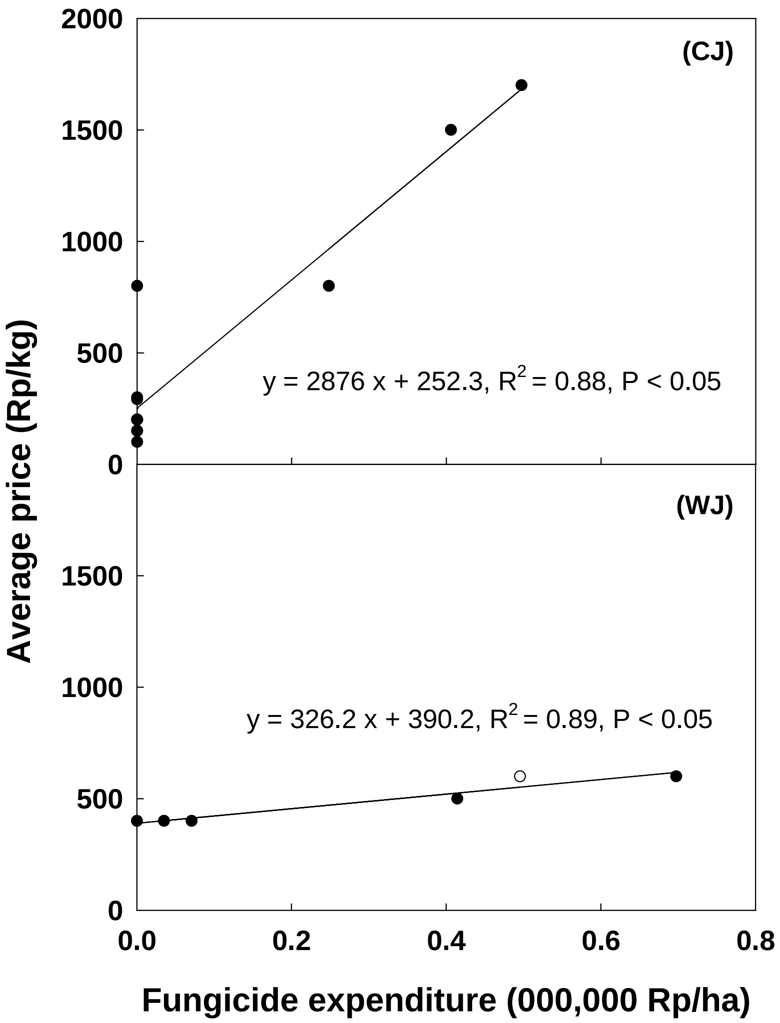

Figure 6.8. Linear regression of fungicide expenditure (including labour to apply) with average price per kg in West and Central Java.

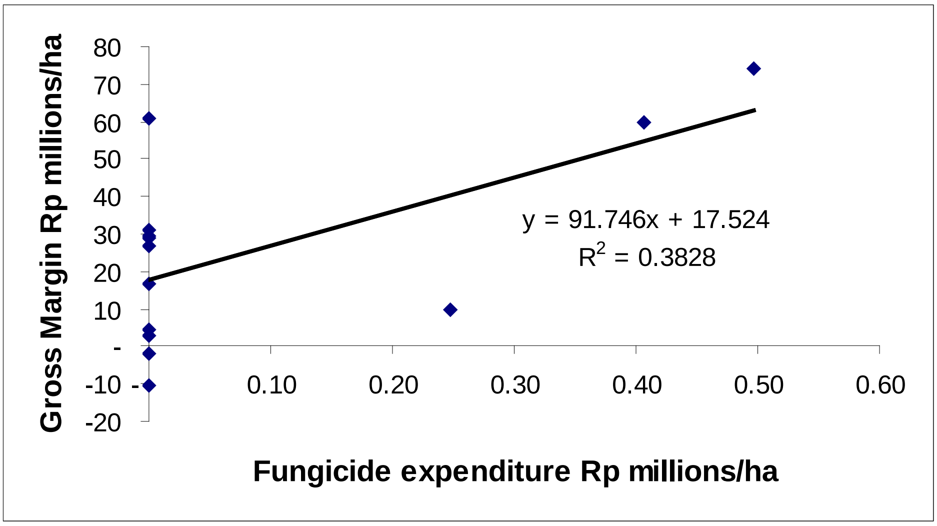

Figure 6.9. Linear regression of fungicide expenditure with gross margin in Central Java ($P < 0.05$).

6.3.9 Scale and yield regression

There is a negative correlation between crop size and yield in West Java with smaller farms producing higher yields per ha (Fig 6.10). There was no significant correlation between crop size in Central Java and gross margin.

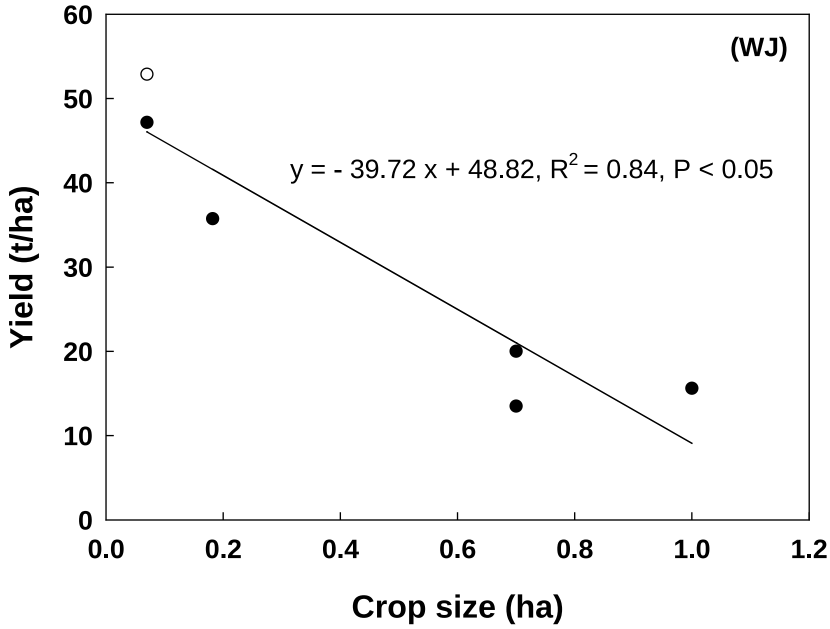

Figure 6.10. Linear regression of yield with crop size in West Java.

6.3.10 Scale and average price

There was a positive relationship between size of the area cropped and price received in Central Java (Fig 6.11). This could be due to

- larger farmers cropping larger areas having stronger relationships with marketing agents, being able to command higher prices.
- larger farmers cropping larger areas spending more of their time on management rather than labouring leading to improved quality and higher prices.
- Better farmers are able to expand their operation over time and so larger farms in Central Java may be operated by better farmers.

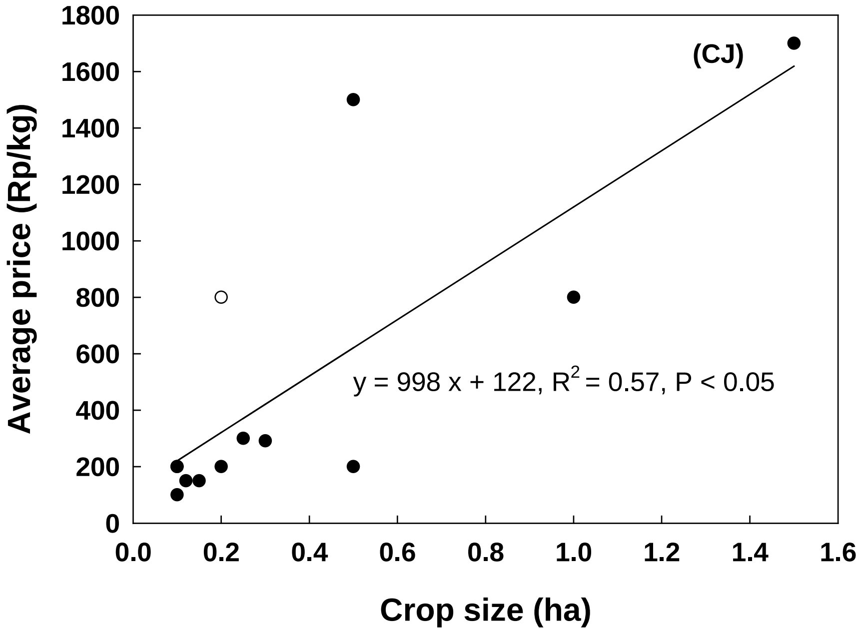

Figure 6.11. Linear regression of yield with crop size in Central Java.

7 Impacts

7.1.1 Scientific impacts – now and in 5 years

The baseline survey identified that fertilisers and insecticides were often being used ineffectively. Farmers receiving little or no scientific advice were wasting money over applying inputs. This finding and the methodology used will enable growers to optimise their inputs in the future to maximise profits.

The baseline survey indentified that fungicides are having a beneficial effect on average prices in both provinces and on gross margin returns in Central Java.

The quantity of seedlings planted and the expenditure on seedlings was found to be significant with regard to gross margin returns in Central Java and yield in West Java respectively.

Now that growers and researchers have a better understanding of the economics of cabbage production they can use the information to prioritise their research requirements and then justify these priorities to research organisations. In 5 years time growers will have a greater involvement in prioritising and then evaluating research and development work.

7.1.2 Capacity impacts – now and in 5 years

Researchers now have the capacity to design, undertake and analyse a baseline survey. The researchers have the capacity to tailor the baseline survey to the project needs and to train enumerators in how to interview growers and collect data.

The growers and trainers involved now have the capacity to analyse the profitability of their crop production and marketing systems. The impact of adjustments to those systems can be quantified through economic analysis.

In 5 years time it is envisaged that researchers will have a much better understanding of the key economic drivers in the production of cabbage and other important crops. This information can then be fed into research and development projects aimed at improving the production and marketing of crops. The baseline survey can be used to measure the impact of research, development and extension work providing before and after figures.

Researchers also have learnt how to cost the staff time and transport required to undertake a baseline survey and this can then be used in future proposal development.

7.1.3 Community impacts – now and in 5 years

Economic impacts

The baseline survey has identified problem areas for growers in Central and West Java provinces. The follow on work of the FIL groups enabled the growers to work together undertaking trials based on recommendations provided by the project team to improve yields, prices and returns and in so doing reduce risk.

Growers face three main forms of risk:

- Production risk related to crop management which affects yields, quality and costs.
- Market risk related to price fluctuations for product sold
- Financial risk related to the cost of borrowing to finance land rental and inputs.

The baseline survey and follow on Farmer Initiated learning program reduce risk for growers through:

- Improved technical knowledge reducing production risk
- A better understanding of cost structures leads to better informed decisions regarding the impact of variations in prices. Those selling their crop pre harvest have a better understanding of the "real price" they are receiving.
- A better understanding of the impact of borrowing on the financial performance of the production system identifying how much debt the enterprise can carry.

Benefit of treating clubroot with variety and lime

South Sulawesi

Two FIL activities tested clubroot management using lime and the resistant variety Maxfield. The SS activity showed there was a significant difference in yield and clubroot incidence between varieties with Maxfield producing higher yields and lower clubroot percentage. Variety and liming had a significant effect on clubroot incidence with Maxfield and liming having significantly lower clubroot incidence. Gross margins for the SS FIL activity treatments were based on cabbage gross margins developed in CJ (Table 6.1). The cost of the lime applied, its application costs and the cost of Maxfield seed were included in the appropriate modified gross margin. Yield used was the experimental yield from the Pemuda Tani Vetran FIL activity (ACIAR Final Report Project AGB/2005/167 Appendix 11 Table 6.2.2i). The gross margins for the Maxfield variety and lime treatments were Rp 9.5 million per ha, more than twice the gross margin of Rp 4.5 million for the local variety without lime treatments (ACIAR Final Report Project AGB/2005/167 Appendix 11 Table 6.2.2j) and gross margins and yields are also given in Table 7.1. These gross margins were used to calculate the PV of the benefits of the work. The use of a local variety without lime is called the "without project" scenario while the use of the clubroot resistant variety Maxfield with lime is called the "with project" scenario. Adoption rates for the use of lime and Maxfield within each scenario" were estimated for 10 years in the future and are shown in Table 7.1. The 1,864 ha of cabbage harvested in SS (Badan Pusat Statistik 2011) was multiplied by the adoption rate and the yield of each treatment to calculate production in tonnes. This production was valued using the value per tonne calculated from the gross margins. The annual value for the "without project" scenario was subtracted from the annual "with project" scenario to calculate an annual benefit. The project PV was calculated using the Excel NPV function with a discount rate of 7%, and the annual values for years 2 to 10 fed into the formula, year 1 was not discounted. The analysis used an elasticity of demand of -2.5. The PV of project benefits for SS was Rp 19 billion or $AUD 2.3 million (Table 7.1). When price elasticity was considered these values fell to Rp 4 billion or $AUD 0.5 million (Table 7.1).

Table 7.1. Value of project clubroot management recommendations of use of lime with the resistant variety Maxfield in South Sulawesi. With the project adoption of these innovations commences in year 1 and adoptive growers enjoy a gross margin of 9.5 million Rp/ha. Without the project adoption is delayed until year 5 and adoption is at a lower rate. The annual benefits due to the project are shown in the last column. These are applied to the NPV function in Excel with the discount rate shown to determine the discounted benefits. These are adjusted for project attribution and chance of success in the lower section of the table.

Year	Without project			With project			Project benefits
	"Without project" scenario (local variety, no lime)						
	Area (ha)		1,864	GM (Rp/ha)		4,629,051	
	Yield (t/ha)		14.8	GM (Rp/t)		312,774	
	Adopt rate (%)	Production (tonnes)	Value A	Adopt rate (%)	Production (tonnes)	Value B	=(B-A)+(D-C) for each year
1	1.00	27,587	8,628,551,347	1.00	27,587	8,628,551,347	0
2	1.00	27,587	8,628,551,347	0.85	23,449	7,334,268,645	1,363,951,540
3	1.00	27,587	8,628,551,347	0.70	19,311	6,039,985,943	2,727,903,080
4	1.00	27,587	8,628,551,347	0.53	14,621	4,573,132,214	4,273,714,825
5	0.90	24,828	7,765,696,213	0.35	9,656	3,019,992,972	5,001,155,647
6	0.80	22,070	6,902,841,078	0.15	4,138	1,294,282,702	5,910,456,673
7	0.70	19,311	6,039,985,943	0.00	0	0	6,365,107,187
8	0.50	13,794	4,314,275,674	0.00	0	0	4,546,505,133
9	0.50	13,794	4,314,275,674	0.00	0	0	4,546,505,133
10	0.50	13,794	4,314,275,674	0.00	0	0	4,546,505,133
	"With project" scenario (adoption of Maxfield variety and lime)						
	Area (ha)		1,864	GM (Rp/ha)		9,507,276	
	Yield (t/ha)		22.2	GM (Rp/t)		428,256	
	Adopt rate (%)	Production (tonnes)	Value C	Adopt rate (%)	Production (tonnes)	Value D	
1	0.00	0	0	0.00	0	0	
2	0.00	0	0	0.15	6,207	2,658,234,242	
3	0.00	0	0	0.30	12,414	5,316,468,484	
4	0.00	0	0	0.47	19,449	8,329,133,959	
5	0.10	4,138	1,772,156,161	0.65	26,898	11,519,015,049	
6	0.20	8,276	3,544,312,323	0.85	35,174	15,063,327,372	
7	0.30	12,414	5,316,468,484	1.00	41,381	17,721,561,614	
8	0.50	20,690	8,860,780,807	1.00	41,381	17,721,561,614	
9	0.50	20,690	8,860,780,807	1.00	41,381	17,721,561,614	
10	0.50	20,690	8,860,780,807	1.00	41,381	17,721,561,614	
	Discount rate						7%
	Discounted benefits						Rp 27,367,212,731
	Attribution				80%		Rp 21,893,770,185
	Likelihood of success				90%		Rp 19,704,393,166
	Ex rate Rp/AUD				8750		$ 2,251,931
	Price elasticity -2.5 Rp						Rp 4,041,768,851
	Price elasticity -2.6 AUD						$ 461,916

Central Java

The CJ clubroot FIL activity also showed there was a significant difference in yield between Maxfield with lime and the local variety without lime (producing higher yields and lower clubroot percentage. Gross margins were prepared using the yields obtained in the FIL clubroot activity of the Bukit Madu Farmer Group (ACIAR Final Report Project AGB/2005/167 Appendix 11 Section 6.2.4, Table 6.2.2hj) with the CJ gross margin details shown in Table 6.1. The additional treatment costs were once again added to the appropriate gross margin. The “without project” scenario had a gross margin of Rp 6.9 million per ha while the “with project” scenario had a gross margin of Rp 23 million per ha (Table 7.2). CJ has 18,843 ha of cabbage harvested per annum (Badan Pusat Statistik 2011) which is more than 10 times that of SS. The adoption rates with and without the project are the same as used for SS and are shown in Table 7.2. The method of calculation and assumptions regarding likelihood of success, attribution and discount rate are as detailed above for SS. The PV of project benefits for CJ was Rp 647 billion or $AUD 74 million (Table 7.2). When price elasticity was considered these values fell to Rp 70 billion or $AUD 8 million (Table 7.2).

West Java

No FIL cabbage clubroot activities were conducted in WJ so the analysis is conservative in its assumptions. The baseline survey indicates that the average yield in WJ is 30.8 tonnes per hectare however 73% of respondents had clubroot in their fields (ACIAR Final Report Project AGB/2005/167 Appendix 3 Table 6.5) and so a higher yield could be expected with improved clubroot management using lime and resistant varieties. The figure of 30.8 tonnes per hectare marketable yield is a conservative indication of the impact of growing cabbage in areas free from clubroot. The local variety with no lime scenario is assumed to have a marketable yield of 21.6 tonne per hectare (70% of the with project yield) and the Maxwell seed plus lime scenario has a marketable yield of 30.8 tonnes per hectare. The respective gross margins were Rp 1.4 million per ha and Rp 4.4 million per ha (Table 7.3). A PV calculation was made using the WJ gross margin shown in Table 6.1 with an area of cabbage harvested of 13,604 ha (Badan Pusat Statistik 2011) with the same adoption rates, assumptions regarding likelihood of success, attribution and discount rate as for SS. Badan Pusat Statistik 2011). The PV of project benefits for WJ was Rp 89 billion or $AUD 10 million (Table 7.3). When price elasticity was considered these values fell to Rp 16 billion or $AUD 1.8 million (Table 7.3).

Table 7.2. Value of project clubroot management recommendations of use of lime with the resistant variety Maxfield in Central Java. With the project adoption of these innovations commences in year 1 and adoptive growers enjoy a gross margin of 9.5 million Rp/ha. Without the project adoption is delayed until year 5 and adoption is at a lower rate. The annual benefits due to the project are shown in the last column. These are applied to the NPV function in Excel with the discount rate shown to determine the discounted benefits. These are adjusted for project attribution and chance of success in the lower section of the table.

Year	Without project			With project			Project benefits
	"Without project" scenario (local variety, no lime)						
	Area (ha)		18,843	GM (Rp/ha)		6,926,461	
	Yield (t/ha)		15.8	GM (Rp/t)		438,384	
	Adopt rate (%)	Production (tonnes)	Value A	Adopt rate (%)	Production (tonnes)	Value B	=(B-A)+(D-C) for each year
1	1.00	297,719	130,515,304,623	1.00	297,719	130,515,304,623	0
2	1.00	297,719	130,515,304,623	0.85	253,061	110,938,008,930	44,792,731,665
3	1.00	297,719	130,515,304,623	0.70	208,404	91,360,713,236	89,585,463,330
4	1.00	297,719	130,515,304,623	0.53	157,791	69,173,111,450	140,350,559,217
5	0.90	267,947	117,463,774,161	0.35	104,202	45,680,356,618	164,240,016,105
6	0.80	238,176	104,412,243,698	0.15	44,658	19,577,295,693	194,101,837,215
7	0.70	208,404	91,360,713,236	0.00	0	0	209,032,747,770
8	0.50	148,860	65,257,652,312	0.00	0	0	149,309,105,550
9	0.50	148,860	65,257,652,312	0.00	0	0	149,309,105,550
10	0.50	148,860	65,257,652,312	0.00	0	0	149,309,105,550
	"With project" scenario (adoption of Maxfield variety and lime)						
	Area (ha)		18,843	GM (Rp/ha)		22,774,161	
	Yield (t/ha)		32.5	GM (Rp/t)		700,743	
	Adopt rate (%)	Production (tonnes)	Value C	Adopt rate (%)	Production (tonnes)	Value D	
1	0.00	0	0	0.00	0	0	
2	0.00	0	0	0.15	91,860	64,370,027,358	
3	0.00	0	0	0.30	183,719	128,740,054,717	
4	0.00	0	0	0.47	287,827	201,692,752,390	
5	0.10	61,240	42,913,351,572	0.65	398,058	278,936,785,220	
6	0.20	122,480	85,826,703,145	0.85	520,538	364,763,488,365	
7	0.30	183,719	128,740,054,717	1.00	612,398	429,133,515,723	
8	0.50	306,199	214,566,757,862	1.00	612,398	429,133,515,723	
9	0.50	306,199	214,566,757,862	1.00	612,398	429,133,515,723	
10	0.50	306,199	214,566,757,862	1.00	612,398	429,133,515,723	

Discount rate		7%
Discounted benefits		Rp 898,750,564,324
Attribution	80%	Rp 719,000,451,459
Likelihood of success	90%	Rp 647,100,406,313
Ex rate Rp/AUD	8750	$ 73,954,332
Price elasticity -2.5 Rp		Rp 69,690,166,699
Price elasticity -2.6 AUD		$ 7,964,590

Table 7.3. Value of project clubroot management recommendations of use of lime with the resistant variety Maxfield in West Java. With the project adoption of these innovations commences in year 1 and adoptive growers enjoy a gross margin of 9.5 million Rp/ha. Without the project adoption is delayed until year 5 and adoption is at a lower rate. The annual benefits due to the project are shown in the last column. These are applied to the NPV function in Excel with the discount rate shown to determine the discounted benefits. These are adjusted for project attribution and chance of success in the lower section of the table.

Year	Without project			With project			Project benefits
	"Without project" scenario (local variety, no lime)						
	Area (ha)		13,604	GM (Rp/ha)		1,356,521	
	Yield (t/ha)		21.6	GM (Rp/t)		62,918	
	Adopt rate (%)	Production (tonnes)	Value A	Adopt rate (%)	Production (tonnes)	Value B	=(B-A)+(D-C) for each year
1	1.00	293,302	18,454,111,684	1.00	293,302	18,454,111,684	0
2	1.00	293,302	18,454,111,684	0.85	249,307	15,685,994,931	6,179,426,544
3	1.00	293,302	18,454,111,684	0.70	205,312	12,917,878,179	12,358,853,088
4	1.00	293,302	18,454,111,684	0.53	155,450	9,780,679,193	19,362,203,171
5	0.90	263,972	16,608,700,516	0.35	102,656	6,458,939,089	22,657,897,328
6	0.80	234,642	14,763,289,347	0.15	43,995	2,768,116,753	26,777,515,024
7	0.70	205,312	12,917,878,179	0.00	0	0	28,837,323,872
8	0.50	146,651	9,227,055,842	0.00	0	0	20,598,088,480
9	0.50	146,651	9,227,055,842	0.00	0	0	20,598,088,480
10	0.50	146,651	9,227,055,842	0.00	0	0	20,598,088,480
	"With project" scenario (adoption of Maxfield variety and lime)						
	Area (ha)		13,604	GM (Rp/ha)		4,384,76	
	Yield (t/ha)		30.8	GM (Rp/t)		142,362	
	Adopt rate (%)	Production (tonnes)	Value C	Adopt rate (%)	Production (tonnes)	Value D	
1	0.00	0	0	0.00	0	0	
2	0.00	0	0	0.15	62,850	8,947,543,297	
3	0.00	0	0	0.30	125,701	17,895,086,593	
4	0.00	0	0	0.47	196,932	28,035,635,663	
5	0.10	41,900	5,965,028,864	0.65	272,352	38,772,687,619	
6	0.20	83,801	11,930,057,729	0.85	356,153	50,702,745,347	
7	0.30	125,701	17,895,086,593	1.00	419,003	59,650,288,644	
8	0.50	209,502	29,825,144,322	1.00	419,003	59,650,288,644	
9	0.50	209,502	29,825,144,322	1.00	419,003	59,650,288,644	
10	0.50	209,502	29,825,144,322	1.00	419,003	59,650,288,644	
	Discount rate						7%
	Discounted benefits					Rp	123,988,041,970
	Attribution				80%	Rp	99,190,433,576
	Likelihood of success				90%	Rp	89,271,390,218
	Ex rate Rp/AUD				8750	$	10,202,445
	Price elasticity -2.5 Rp					Rp	15,715,216,519
	Price elasticity -2.6 AUD					$	1,796,025

Social impacts

Increasing the profitability of growing cabbage will provide growers with higher incomes and reduce risk. Improved cabbage production systems and increased profits lead to improved nutrition for growers' families, the generation of employment opportunities and investment on farm and off farm.

Environmental impacts

The baseline survey indicates that with some exceptions the growers are over using insecticides and fertilisers. The optimisation of chemical inputs will not only lead to reduced costs but also reduce harmful environmental impacts from agro chemicals. Of particular importance will be the reduced use of insecticides which will see larger populations of beneficial predatory insects.

7.2 Communication and dissemination activities

As for ACIAR Final Report Project AGB/2005/167 Appendix 1.

8 Conclusions and recommendations

This economics baseline survey was effective in identifying links between production inputs and yields, prices received for products and hence gross margin returns. The survey identified that cabbage growers in Central Java were achieving much better returns than their counterparts in West Java primarily through higher prices. The higher prices may be due to supply or demand factors or better quality. Correlations between gross margin and yield for West and Central Java provinces showed gross margin continued to increase directly with yield. There is scope to increase profitability of cabbage farmers through improved agronomic efficiency as gross margin continues to increase directly with yield.

8.1 Fertiliser

Fertilisers represent the largest input cost in both West Java (44% of inputs) and Central Java (47% of inputs). However there was no significant correlation in either province between fertiliser expenditure and yields, average prices or gross margin returns. This indicates the fertiliser expenditure is inefficient. The agronomic baseline survey found that the root disease clubroot (*Plasmodiophora brassicae*) was an important constraint to production as was low soil pH. Clubroot could be expected to impair nutrient uptake by impairing root function while low soil pH impairs nutrient uptake by reducing the availability to plants of nutrients. At pH below 5 the major nutrients nitrogen phosphorus, potassium calcium and magnesium become markedly less available to plants (Lorenz and Maynard 1980).

Recommendation

Growers in Central and West Java should investigate management of clubroot and soil pH with the aim of capturing the significant potential to reduce fertiliser costs to improve profitability.

8.2 Insecticide

Insecticide costs were the fourth steepest line in the Excel Sensit analysis (Fig 6.1). Insecticide expenditure is a large input cost in West Java (13% of inputs) and Central Java (10% of inputs) yet there was a negative correlation between insecticide costs and price.

Recommendation

Growers in Central and West Java should investigate optimising insecticide use by testing the efficacy of IPM. If insect control is improved it will reduce input costs and improve product price and so increase gross margin.

8.3 Fungicide

Despite not being widely used fungicide expenditure had a positive correlation on average price in West Java and on Gross Margin returns in Central Java.

Recommendation

Growers in Central and West Java should investigate optimising fungicide use. If fungicide is found to be effective it will offer growers a relatively inexpensive method of improving returns. It is expected that cost would be less than Rp 0.7 million per ha.

8.4 Impacts

This economics baseline survey gross margins combined with results of FIL activities enabled the economic impact of these activities to be assessed. The benefits of improved management of clubroot disease through the use of lime and resistant varieties has a present value of Rp 756 billion or $AUD 86 million using the current prices and a present value of Rp 89 billion or 10 million with a price elasticity of -2.5 (Table 8.1).

Table 8.1. Present value of project clubroot management recommendations of use of lime with the resistant variety Maxfield in South Sulawesi, Central Java and West Java. Present values with the current price and with a price elasticity of demand of -2.5 are shown.

Province	Measurement and currency	Present value of benefits	
		Current price	Price elasticity of demand of -2.5.
SS	Present value of benefits Rp	19,704,393,166	4,041,768,851
	Present value of benefits $AUD	2,251,931	461,916
CJ	Present value of benefits Rp	647,100,406,313	69,690,166,699
	Present value of benefits $AUD	73,954,332	7,964,590
WJ	Present value of benefits Rp	89,271,390,218	15,715,216,519
	Present value of benefits $AUD	10,202,445	1,796,025
Total	Present value of benefits Rp	756,076,189,698	89,447,152,069
	Present value of benefits $AUD	86,408,707	10,222,532

9 References

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Lorenz, OA & DN Maynard (1980) *Knott's Handbook For Vegetable Growers*. Second edition. (Wiley-Interscience, New York).

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10 Annex

10.1 Economic survey questionnaire

South Sulawesi and West Nusa Tenggara – 2008 version

10.1.1 Pertanyaan umum

Identitas Responden

- Nama :
- Dusun:
- Kel :

No	PERTANYAAN	JAWABAN
1.	Berapa luas usaha tani kubis yang bapak jalankan sekarang ?	Kubis = ……… are……
2.	Bagaimana status kepemilikan lahannya ?	a) Tanah milik sendiri b) Sewa c) Gadai d) lainnya
3.	Tenaga kerja siapa yang dipakai ?	a) Tenaga kerja keluarga b) Tenaga kerja sewa /buruh c) Tenaga borongan d) Lainnya ....
4.	Berapa upah tenaga kerja	a) T. kerja sewa pria Rp ..../hari b) T. kerja sewa wanita Rp ..../hari c) Tenaga borongan Rp................. d) Lainnya Rp .... Keterangan ....
5.	Tanaman apa saja yang biasa bapak tanam dan pola tanamnya bagaimana?	
6.	Tanaman yang sekarang sedang ditanam ?	
7.	Tanaman sebelumnya dan sumber benihnya berasal dari mana?	
8.	Musim tanam yang akan datang rencananya menanam apa dan sumber benihnya berasal dari mana?	
9.	Sumber modalnya dari mana?	a) Modal sendiri b) Pinjaman c) Lainnya ....

No	PERTANYAAN	JAWABAN
10.	Jika ada pinjaman bentuk, pinjamannya apa dan bentuk, besar(nilai) serta lama pengembaliannya bagaimana?	a) Uang tunai, sebesar Rp .... b) Sarana produksi, yaitu .... c) Lainnya, ...
11.	Sumber pinjaman tersebut dari mana ?	....
12.	Berapa bunga yang harus dibayar ?	Rp ....

10.1.2 Biaya input

No	PERTANYAAN	JAWABAN
2.1. BENIH		
1.	a. Jumlah semaian yang dipergunakan b. Varietas yang digunakan	.... semaian/ha ....
2.	Harga benih	Rp ..../semaian
3.	Perlakuan benih	a) Tidak ada b) Ada, yaitu ....
4.	Biaya untuk zat kimia (pestisida) untuk perlakuan benih	Jenis zat kimia .... Jumlah zat kimia yang digunakan .... Harga zat kimia Rp ....
5.	Tenaga kerja yang dipakai untuk pengobatan (selama pembibitan)	Jumlah tenaga kerja .... Upah tenaga kerja Rp ....
6.	Bagaimana anda menyimpan benih ?	a) Gudang biasa b) Gudang gelap/Difuse light storage c) Ruang pendingin d) Lainnya .... Keterangan ....
7.	Biaya sewa untuk gudang penyimpanan dalam ruang pendingin.	Rp ...... /kg
8.	Jumlah benih yang disimpan	.... kg
9.	Apakah umbi untuk benih dibelah ?	a) Ya b) tidak

<table>
<tr><th>No</th><th>PERTANYAAN</th><th colspan="3">JAWABAN</th></tr>
<tr><td rowspan="2">10.</td><td rowspan="2">Jika ya (benih dibelah), berapa tenaga kerja yang digunakan ?</td><td>T.k sewa pria
.... org, ... hari
.... jam/org/hari</td><td colspan="2">T. k klg pria
.... org, ... hari
.... jam/org/hari</td></tr>
<tr><td>T.k sewa wanita
.... org, ... hari
.... jam/org/hari</td><td colspan="2">T.k klg wanita
...............org, ... hari
.... jam/org/hari</td></tr>
<tr><td colspan="5">2.2. PUPUK</td></tr>
<tr><td>1.</td><td>Pupuk kandang yang digunakan pada lahan kubis bapak</td><td colspan="3">Jenis : ....
Jumlah : .... kg
Sumber/Asal :</td></tr>
<tr><td>2.</td><td>Harga pupuk kandang</td><td colspan="3">Rp ..../ kg/ton/...........</td></tr>
<tr><td rowspan="2">3.</td><td rowspan="2">Tenaga kerja untuk pemberian pupuk kandang</td><td>T.k sewa pria
.... org .... hari
.... jam/org/hari</td><td colspan="2">T. k klg pria
.... org .... hari
.... jam/org/hari</td></tr>
<tr><td>T.k sewa wanita
.... org
.........hari
.... jam/org/hari</td><td colspan="2">T.k klg wanita
.... org ...... hari
.... jam/org/hari</td></tr>
<tr><td rowspan="10">4.</td><td rowspan="10">Berapa jumlah pupuk buatan yang digunakan ?</td><td>Jenis</td><td>Jumlah</td><td>Harga (Rp/kg)</td></tr>
<tr><td>Urea</td><td>................. kg</td><td>Rp ....</td></tr>
<tr><td>ZA</td><td>................. kg</td><td>Rp ....</td></tr>
<tr><td>TSP</td><td>................. kg</td><td>Rp ....</td></tr>
<tr><td>KCl</td><td>................. kg</td><td>Rp ....</td></tr>
<tr><td>NPK</td><td>................. kg</td><td>Rp ....</td></tr>
<tr><td>....................</td><td>................. kg</td><td>Rp ....</td></tr>
<tr><td>....................</td><td>................. kg</td><td>Rp ....</td></tr>
<tr><td>....................</td><td>................. kg</td><td>Rp ....</td></tr>
<tr><td>....................</td><td>................. kg</td><td>Rp ....</td></tr>
<tr><td>5.</td><td>Berapa kali pupuk buatan yang diberikan ?</td><td colspan="3">........... kali</td></tr>
<tr><td rowspan="2">6.</td><td rowspan="2">Tenaga kerja setiap kali pemberian pupuk buatan ?
Pupuk dasar...
Pupuk susulan I
Pupuk susulan II</td><td>T.k sewa pria
.... org .... hari
.... jam/org/hari</td><td colspan="2">T. k klg pria
.... org .... hari
.... jam/org/hari</td></tr>
<tr><td>T.k sewa wanita
.... org
.........hari
.... jam/org/hari</td><td colspan="2">T.k klg wanita
.... org ...... hari
.... jam/org/hari</td></tr>
</table>

No	PERTANYAAN	JAWABAN		
2.3. PESTISIDA				
1.	Jenis pestisida (insektisida dan fungisida) yang digunakan serta harga masing2 jenis, selama satu musim tanam kubis.	Jenis	Jumlah (botol/cc/ bungkus/gram)	Harga (Rp/botol)
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
		....	....	Rp ....
2.	Jenis perekat yang digunakan selama satu musim tanam kubis ?	Jenis : .... Jumlah : .... Harga :		
3.	Jumlah penyemprotan pestisida yang dilakukan pada satu musim tanam ?	.... kali		
4.	Tenaga kerja penyemprotan pestisida dalam satu kali penyemprotan	T.k sewa pria .... org .... hari .... jam/org/hari	T. k klg pria .... org .... hari .... jam/org/hari	
		T.k sewa wanita .... org ....hari .... jam/org/hari	T.k klg wanita .... org ...... hari .... jam/org/hari	
2.4. HERBISIDA				
1.	Jenis herbisida yang digunakan selama satu musim tanam kubis ?	Jenis : .... Jumlah: .... Harga :		
2.	Jumlah penyemprotan herbisida yang dilakukan pada satu musim tanam ?	.... kali		
3.	Tenaga kerja penyemprotan herbisida dalam satu kali penyemprotan	T.k sewa pria .... org .... hari .... jam/org/hari	T. k klg pria .... org .... hari .... jam/org/hari	
		T.k sewa wanita .... org ....hari .... jam/org/hari	T.k klg wanita .... org ...... hari .... jam/org/hari	

No	PERTANYAAN	JAWABAN	
2.5. Penyiangan dan Pengguludan (manual)			
1.	Jumlah penyiangan (sasak = ngeder) dalam satu musim tanam?	.... kali	
2.	Tenaga kerja yang digunakan dalam satu kali penyiangan	T.k sewa pria .... org .... hari .... jam/org/hari	T. k klg pria .... org .... hari .... jam/org/hari
		T.k sewa wanita .... org ....hari .... jam/org/hari	T.k klg wanita .... org ...... hari .... jam/org/hari
3.	Jumlah pengguludan (sasak = mbumbun) dalam satu musim tanam?	.... kali	
4.	Tenaga kerja yang digunakan dalam satu kali pengguludan	T.k sewa pria .... org .... hari .... jam/org/hari	T. k klg pria .... org .... hari .... jam/org/hari
		T.k sewa wanita .... org ....hari .... jam/org/hari	T.k klg wanita .... org ...... hari .... jam/org/hari
2.6. Pengairan			
1.	Sumber pengairan.	a. Tadah hujan b. Sungai/air tanah c. Irigasi teknis d. Lainnya	
2.	Jumlah pengairan dalam satu kali musim tanam.	.... kali	
6.	Tenaga kerja yang digunakan untuk satu kali pengairan. Upah pekasih = ...orang./musim	T.k sewa pria .... org .... hari .... jam/org/hari	T. k klg pria .... org .... hari .... jam/org/hari
		T.k sewa wanita .... org ....hari .... jam/org/hari	T.k klg wanita .... org ...... hari .... jam/org/hari

<table>
<tr><th>No</th><th>PERTANYAAN</th><th colspan="4">JAWABAN</th></tr>
<tr><td colspan="6">2.7. Pengolahan tanah</td></tr>
<tr><td>1.</td><td>Bagaimana cara anda mengolah tanah ?</td><td colspan="4">a) Menggunakan traktor
b) Menggunakan tenaga manusia
Menggunakan tenaga hewan, yaitu :</td></tr>
<tr><td>2.</td><td>Berapa biaya untuk traktor ?
berapa hari ......</td><td colspan="4">Rp ....
.... hari</td></tr>
<tr><td rowspan="2">3.</td><td rowspan="2">Tenaga kerja (manusia) untuk pengolahan tanah.</td><td colspan="2">T.k sewa pria
.... org .... hari
.... jam/org</td><td colspan="2">T. k klg pria
.... org .... hari
.... jam/org</td></tr>
<tr><td colspan="2">T.k sewa wanita
.... org
.........hari
.... jam/org/hari</td><td colspan="2">T.k klg wanita
.... org ...... hari
.... jam/org/hari</td></tr>
<tr><td>5.</td><td>Jika pengolahan tanah diborongkan, berapa ?</td><td colspan="4">Rp ....(dengan apa, tenaga kerja manusia, traktor, atau hewan)</td></tr>
<tr><td>6.</td><td>Jika menggunakan tenaga kerja hewan , berapa?</td><td colspan="4">Rp.........
.... ekor, ...hari</td></tr>
<tr><td colspan="6">2.8. Penanaman</td></tr>
<tr><td rowspan="2">1.</td><td rowspan="2">Tenaga kerja penanaman</td><td colspan="2">T.k sewa pria
.... org .... hari
.... jam/org</td><td colspan="2">T. k klg pria
.... org .... hari
.... jam/org</td></tr>
<tr><td colspan="2">T.k sewa wanita
.... org ....hari
.... jam/org/hari</td><td colspan="2">T.k klg wanita
.... org ...... hari
.... jam/org/hari</td></tr>
<tr><td colspan="6">2.9. MESIN/PERALATAN</td></tr>
<tr><td rowspan="4">1.</td><td rowspan="4">Mesin/alat yang digunakan selama pertanaman kubis.</td><td>Jenis mesin/alat</td><td>Tahun pembelian</td><td>Harga (Rp)</td><td>Biaya perbaikan (Rp)</td></tr>
<tr><td>Pompa air</td><td></td><td></td><td></td></tr>
<tr><td>Handsprayer</td><td></td><td></td><td></td></tr>
<tr><td>………………
……………...
………………</td><td></td><td></td><td></td></tr>
</table>

<table>
<tr><th>No</th><th>PERTANYAAN</th><th colspan="2">JAWABAN</th></tr>
<tr><td colspan="4">2.10. LAIN-LAIN</td></tr>
<tr><td>1.</td><td>Berapa harga sewa lahan per musim tanam ?</td><td colspan="2">Rp ..../ha/are</td></tr>
<tr><td>2.</td><td>Berapa biaya untuk sewa gudang ?</td><td colspan="2">Rp ....</td></tr>
<tr><td>3.</td><td>Berapa biaya untuk panen dan pemeliharaan umbi (pasca panen) ?
Sistem panen ? (Panen sendiri atau beregu ?)</td><td colspan="2">Rp ....</td></tr>
<tr><td>5.</td><td>Biaya Transport, handling, pengemasan hasil panen (sewa kendaraan, karung,dll)</td><td colspan="2">Rp ....</td></tr>
<tr><td rowspan="2">6.</td><td rowspan="2">Berapa biaya untuk membeli/menyewa peralatan (handsprayer,cangkul,dll) ?</td><td>Jenis</td><td>Harga beli (Rp),
Harga sewa (Rp),</td></tr>
<tr><td>Cangkul
Tali ravia
Ajir
Selang
....
....
......................</td><td>...........................
....
....
....
....
....
....
............................</td></tr>
</table>

10.1.3 Pendapatan

No	PERTANYAAN	JAWABAN		
1.	Produksi total (hasil panen) dari luasan yang ditanam	.... kg/ton		
2.	Hasil panen yang dijual sebagai kubis konsumsi	Kelas umbi untuk Psr Lokal	Jumlah (kg)	Harga (Rp/kg)
3.	Kubis yang disimpan untuk dimakan sendiri.	.... kg/ton		
4.	Kubis untuk makanan ternak	.... kg/ton		
5.	Kubis yang terbuang	.... kg/ton		

10.1.4 Pemasaran

1. Dijual kemana....(pasar lokal, antar pulau, mitra pemasaran)
2. Kalau ada kemitraan, bagaimana pola/sistemnya
3. Sistem pembayaran …….(Tunai, Panjar, Tunda… berapa hari)
4. Sistem penjualan (natura, Tebasan(Ijon), Borongan).

Australian Government
Australian Centre for International Agricultural Research

Final report appendix 5

title

AGB/2005/167 Potato seed system development - potato cyst nematode

prepared by

Peter Dawson

co-authors/ contributors/ collaborators

Dr John Marshall,
Dr Eri Sofiari,
Prof Mulyadi,
Bambang Rahayu, T.P
B. Triman,
Siwi Indarti
Baiq Nurul Hidayah,
Kelompok Horsela (Sembalun Lawang Horticulturists Farmer Group)

1 Executive summary

One of the aims of the project was to develop and implement a scheme to improve the availability of affordable, high quality potato seed to Indonesian farmers.

The project found that potato cyst nematode (PCN) was the most serious challenge currently facing Indonesian potato farmers.

Seed potatoes must be free from this introduced pest. To produce PCN free seed potatoes commercial quantities of PCN free seed is needed and this must be bulked up in an area known to be free of the pest.

The highland area of Sembalun on the Island of Lombok in NTB has been identified as a potential site for the production of PCN free seed. This is a relatively new potato area which has a good chance of being free from PCN. The area is characterised by the production of dry season potatoes which follow a wet season highland rice crop.

The small size of the Sembalun area means that it is feasible for a high quality seed potato production area to be established here where all seed can be replenished annually from a clean source. This area could then form the basis of a new seed supply chain that could augment the existing Indonesian seed supply schemes.

To ensure that such a plan is feasible the following investigations into PCN in Indonesia were needed:

- A survey to accurately assess the PCN status of Sembalun,
- Identification of species of PCN in the major potato production areas,
- Identification of the pathotypes of the species found, and
- PCN population decline studies in highland potato soils had to be determined so that appropriate rotation periods for these soils could be determined.

Training was also needed to build capacity in government officials and empower farmers who would capitalise on this opportunity to develop a new seed supply chain within their existing vegetable production capabilities.

Results of investigations carried out in this project found:

- That the species of all 14 populations of PCN collected from Java was *Globodera rostochiensis* (Ro) according to morphological characteristics.
- The pathotype of three of these populations which were submitted for pathotype determination was Ro2. The pathotype of the fourth population submitted was not able to be assessed due to low viability of the cysts.
- A 3 x 3 m soil survey was undertaken in the Sembalun area of East Lombok and no PCN was found as at November 2008.
- Field experiments showed that PCN cysts and egg populations declined rapidly in paddy soils. The paddy sites in PCN infested areas of Central Java were used for this test and closely resemble those found in Sembalun.

- No live cysts or eggs found after 60 days flooding.
- This result indicates that there is potential to use the annual flooding of paddy fields to prevent PCN build up.
- rapid decline shows that the paddy fields at Sembalun which are inundated for three months of the year will prevent PCN establishing.

During these investigations capacity building training has resulted in:

- NTB Province having the capacity to monitor potato production areas for PCN.
- Kelompok Horsela has the skills and capacity to undertake routine PCN surveys using the 3 x 3 m soil sampling methods as well as the 10 row by 10 plant fork testing to examine roots of plants at the yellow leaf stage.
- NTB Province having the capacity to introduce seed scheme regulations to ensure the Sembalun area exceeds the seed specifications of the Indonesian public certified seed potato system.
- NTB Province drafting Governor Regulations to prevent the uncontrolled movement of potatoes into the Sembalun area to minimise the chance of introducing PCN.
- The Nematology Team under Professor Mulyadi at Gadjah Mada University becoming experienced in identifying PCN species using PCR.
- The Nematology Team at Gadjah Mada University becoming experienced at PCN population experiments.

These activities have provided information that should enable the area of Sembalun to develop into a leading seed supply area that has established integrated PCN monitoring and control systems and can produce supplies of high quality, affordable seed potatoes for the Indonesian potato industry.

2 Background

One of the project aims was to develop Good Agricultural Practice (GAP), often called SOP (Standard Operational Procedure) in Indonesia, for potatoes. A major component of GAP/SOP is the development and implementation of a scheme to improve the availability of affordable, high quality potato seed to Indonesian farmers. The seed must be free from the recently introduced pest potato cyst nematode (PCN). This pest is the most serious challenge currently facing Indonesian potato farmers because it is well adapted to potatoes, it can reduce yields substantially and the common management tools used in developed countries which include; PCN free seed, resistant varieties, long rotations with non-host crops, fumigants and nematicides plus quarantine and biosecurity barriers, are not available for Indonesian farmers.

In Indonesian PCN was first reported from Bumiaji, Kota Batu, East Java in 2003 by PT Syngenta and the species identified as *Globodera rostochiensis* (Indarti *et al.* 2004, Mulyadi *et al*. 2003a). PCN was then found in Central Java at Batur, Banjarnegara and at Kejajar, Wonosobo (Mulyadi *et al*., 2003b). Pangalengan in West Java is also reported to be infected with PCN (Mulyadi *et al.* 2010). The other species of PCN, *G. pallida*, has also found in Batur, Banjarnegara (Lisnawita, 2005). The spread and population build up of PCN has been most rapid in Central Java near Banjarnegara and Wonosobo where continuous, year round cropping of potato takes place.

In addition to the reasons already outlined at the end of the first paragraph management of PCN in East, Central Java, and West Java will be difficult because:

1) PCN appears to be already well established,
2) potato planting areas are mostly hilly which facilitates spread of the pest with soil erosion
3) labour intensive, small scale manual production means that the use of fumigant nematicides will be very dangerous to the farmers, and
4) the pathotype/s have not yet been identified meaning resistant varieties cannot be identified,

A vital tool in the management of PCN is to have a supply of PCN free seed for areas in Indonesia which currently remain free of the pest. The Indonesian public certified seed scheme and imported seed only supplies about 4% of the country's seed demand (Fuglie *et al.* 2005, Rasmikayati and Nurasiyah 2004). The remaining seed demand is fulfilled by the informal system which has no controls or checks for PCN and so has a risk of spreading the pest. So there is an urgent need to expand the availability of PCN free seed in Indonesia.

The highland area of Sembalun on the Island of Lombok in NTB has been identified as a potential source of PCN free seed (Dawson *et al.* 2007). This relatively new potato area only produced small amounts of potatoes up to 2006; for example just 131 ha was grown in 2001 and production ranged from 28 to 44 ha in the four years to 2005. Since then farmers have started growing the potato variety Atlantic on a larger scale for PT Indofood. The Atlantic crops have been planted with imported seed from PCN free areas supplied by PT Indofood. The small size of the Sembalun area means that it is feasible for all seed to be replenished annually from a clean source. The production of processing potatoes in a new, specialized, relatively small, isolated area may also be a good model for new seed areas in Indonesia.

These new areas could replenish all seed annually form a clean source which could then be bulked once before distribution as PCN free seed to uninfested production areas. This method is a way to improve quality seed supply at a lower cost to freshly imported seed which has already been shown to work in Indonesia (Dawson *et al.* 2004). Therefore if the Sembalun area can be shown to be free from PCN it could become an important seed supplier to other areas of Indonesia.

The development of a potato seed supply from NTB would also fulfil a subsidiary aim of the Smallholder Agribusiness Development Initiative (SADI) to help develop viable agribusiness alternative for smallholders in Eastern Indonesia.

Several PCN research activities have already been completed in Indonesia i.e. bio-ecology of PCN (life cycle, host plants, soil pH and soil temperature), resistant response of several potato cultivars/varieties, “crop rotations”, biological control, and nematicides screening (Mulyadi *et al*., 2005). A monograph on PCN has also been published (Hadisoeganda 2006). However to meet the challenge of this pest the following additional investigations and activities were needed;

- A comprehensive soil survey similar to that undertaken in Sembalun to confirm the distribution of the PCN species in Indonesian potato planting areas.
- The pathotypes within the species identified to enable the identification of resistant varieties which should be tested in Indonesia
- Population increase and decline studies in highland potato soils to determine appropriate rotation periods for these soils.
- A survey of the potential seed production area of Sembalun to accurately determine its PCN status.
- Training to build capacity of farmers and government officials so that this opportunity can be developed effectively and efficiently.

This paper reports on the outcomes of these new activities.

3 Objectives

Two objectives of the project were to;

- develop and implement low-cost schemes that significantly improve the access of smallholder vegetable producers in NTB and Sulsel to quality potato seed, and
- Assess the potential to develop a potato seed producing area in eastern Indonesia, creating viable agribusiness alternatives for smallholders.

With respect to PCN, these objectives were to be achieved through two activities:

1. Activity 2.4: Training Indonesian project collaborators in pest and disease diagnostics and seed potato care and certification systems in Australia.
2. Activity 2.6: Development, training and implementation of improved practices for producing clean low-generation seed with and by lead farmers and/or commercial seed producing companies.

Activity 2.6 could be achieved through the development of the Sembalun area of East Lombok as a high quality seed production area with freedom from PCN. A series of investigations was undertaken to support this development of this area. This included:

- A survey to determine PCN status of Sembalun which would allow the drafting of a management plan for this area,
- The identification PCN species in Indonesia to help determine future variety and seed needs,
- The identification of PCN pathotypes in Indonesia to determine future variety and seed needs,
- PCN population increase and decline studies to help determine appropriate rotations required to recommend safe rotation periods for seed and consumption potatoes.

Activity 2.4 was achieved through training which occurred as part of the above tasks as well as through three study tours to WA.

3.1 PCN Status of Lombok

3.1.1 Potato cyst nematode survey at Sembalun, East Lombok

The objectives of the research were:

1) To determine the PCN status of the Sembalun potato producing area in East Lombok in order to determine whether the region could be suitable for PCN free seed potato production.

3.1.2 Development of Sembalun as seed production area

2) To develop a plan to enable diversification of this area into seed potato production.

3.2 PCN species identification using PCR

Growing of resistant varieties is a good way to manage PCN infestations but resistant varieties can only be identified once the species and pathotype of the pest is known. The two main potato varieties grown in Indonesian have resistance to PCN. Both Atlantic and Granola have high to very high resistance to pathotype Ro1 of *G. rostochiensis* (Science and Advice for Scottish Agriculture 2010a &b). Therefore PCN in Indonesia is either *G rostochiensis* pathotypes Ro2, Ro3 or Ro5 or it could be second species *G. pallida.*

The objectives of the research were:

1) To identify the species of PCN using morphological methods,

2) To confirm species identification using a PCR method,
3) To confirm the pathotype status of Indonesian PCN populations, and
4) To study the distribution of PCN species Java.

3.3 Pathotype identification using indicator plants

The objective of the research was to identify the pathotypes of PCN found in Indonesia. This information is needed before resistant varieties of potatoes can be identified as explained in Section 3.2 above.

3.4 PCN population increase and decline studies

The objective was to gather information to determine the length of rotations which ensure PCN decline for highland paddy fields as well as for highland terraced land. This information could then be used to recommend safe rotation periods for seed and consumption potatoes.

The objectives of the research were:

1) To study the effect of five different population levels i.e. : 40,000; 80,000; 120,000; 160,000; and 200,000 eggs of PCN per 8 litres of soil on the population increase of PCN in Banjarnegara, and the effect of 5 different population levels of PCN to the growth and yield of potato.
2) To study the population decrease of PCN in potato planting area/terrace soil in Banjarnegara and in paddy planting area in Wonosobo, Central Java, Indonesia.

3.5 Training

The objective was to develop suitable training material on quality seed propagation for capacity building of seed producers, and on benefits and use of quality potato seed for potato growers. With respect to PCN there was a need to train stakeholders in appropriate biosecurity measures that can prevent the uncontrolled movement of potatoes which may be infested with PCN.

Training was incorporated into the previously mentioned activities and the results and impacts of training will be discussed within the results of these other activities.

4 Methodology

4.1 PCN status of Lombok

4.1.1 Potato cyst nematode survey at Sembalun, East Lombok.

A field soil survey was undertaken under the direction of consultant nematologist Dr John Marshall of JM Marshall Advisory NZ Ltd. Dr Marshall visited Sembalun three times and established an intensive 3 x 3 pace soil sampling method with the *telu-telu* slogan forming the identity of the Sembalun PCN team (telu-telu = Sasak language for 3 x 3). Labour for soil sampling was provided free of charge by Kelompok (Tani) Horsela (**Hor**ticulture **Se**mbalun **La**wang).

A list of all fields with a history of potato production was made through discussion with the executive of the farmers' group Kelompok Horsela led by Mr. Minardi.

All fields that had a history of repeated potato production and therefore the highest risk of having acquired PCN were surveyed. The survey then moved to lower risk fields that had only produced potatoes using a long rotation over a number of years and finished by examining fields that had a single crop of potatoes. Both terrace and paddy fields were sampled.

After Dr Marshall's visits the soil sampling programme was completed and soil consigned to his trainee, Plant Pathologist Baiq Nurul Hidayah, at the BPTP-NTB laboratory.

A large scale cadastral map showing all sampled fields was produced of the Sembalun area showing all sampled fields. The map was produced bv Dr Marshall from digital data kindly supplied by Dr Heryadi Rachmat of the Government of NTB Mining and Energy Office. A formal diary was also made by the field staff of the Sembalun Dinas Pertanian office and a copy was sent to Baiq Nurul Hidayah at BPTP-NTB.

The soil samples were processed in Sembalun village using a soil washing system based on the modified Fenwick Can elutriator provided by Dr Marshall. Once the soil samples had been processed onto filter paper these papers were examined with a new stereoscopic microscope provided by the project. Filter paper, funnels, Endecott sieves and a Fenwick can were provided by the project.

The nematology equipment and microscope were transferred to BPTP-NTB laboratories and established as a central facility. The remaining soil samples were processed at this facility.

4.1.2 Development of Sembalun as seed production area

Should the survey described above find that the Sembalun area is free from PCN then this status must be maintained. The following activities will helpful in maintaining PCN free status:

1) Regulations. Dinas Pertanian NTB and BPTB NTB should prepare a proposal for Provincial regulations to be introduced to control the movement of potatoes into East Lombok. The procedure for introducing regulations to protect PCN freedom of Lombok would be as follows;

1 Mandate of DPRD I – NTB (DPRD 1 = Provincial Level Parliament)

- Propose issue of Sembalun as free zone of PCN

- Propose issue of Sembalun as potato seed centre for East Indonesia

2 Action by Kepala Dinas Pertanian NTB

- Draft of seed regulations submitted to Governor & Dinas (supported by BPTP). Reference (e.g. Citrus regulations for NTT)
- Support data/references by BPTP

Draft by Governor & Dinas (supported by BPTP) submitted to DPRD 1

2) Support Dinas Pertanian NTB and Kelompok Horsela to develop seed production regulations for Sembalun. These must include appropriate rotation times and continued PCN testing to ensure claim of PCN freedom can be justified.

3) Support BPTP NTB to help Kelompok Horsela ensure demand for seed potatoes can be met from local certified seed potato production. Supply of seed from Sembalun needs to be carefully planned to ensure local demand is met and threat of uncertified seed from outside is reduced. This will require improved storage so that seed ready for planting will be available from February until October. BPTP NTB will support Kelompok Horsela to achieve this goal.

The method used to achieve these 3 activities was for five key players from Lombok to visit Western Australia to undertake a rapid appraisal of the systems in place in Western Australia to protect the potato industry from PCN and other exotic pests and to supply high quality seed. This would enable the participants to understand what practical measures should be adapted to protect potato production at Sembalun. Before the study tour began the participants were asked to send draft regulations to the Australian partners so that these could be discussed during the study tour. The curriculum developed is shown in Table 4.1.

To make sure each learning component of the study was properly understood the participants were asked to prepare a short video scene explaining the study topic and how this was relevant to improving the protection of the potato industry at Sembalun. A storyboard was used to plan the video scenes before filming commenced. An example is shown in Figure 4.1.

Table 4.1. Curriculum Timetable 6 – 13 February 2010

	Sat 6 Feb 10	Sun 7 Feb 10	Mon 8 Feb	Tue 9 Feb
0800 – 1000		Introduction to the training program. **Travel to Albany**	**Dawson:** WA seed scheme rules which protect the seed crops from exotic disease	**Travel to Manjimup** Early start
			Morning tea	
1015 – 1230		Travel to Albany	**Farmers Terry Ackley, Chris Westcott:** Seed potato swamp producing registered seed	**Farmer Moltoni Certified Seed Potatoes** at Pemberton
		Lunch		
1330 – 1500		Keep travelling to Albany	**Farmers GP Ayres & Sons:** Assessment of late planted swamp potato seed crop & cool storage.	WA seed potato scheme. Inspector's role. **Dale Spencer**:
			Afternoon tea	
1530 – 1700	**1625 arrive Perth** Flight GA 726. Experience Australian quarantine procedures for international travellers	Recovery walk from long drive at Middletown Beach	**Discussion & review:** Groups present their assessment of potato crop pests and disease levels in seed crop.	**Ian McPharlin** Potato nutrition
			Prayers & dinner	
1930 - 2100	Taken to Hotel by **Ian McPharlin …**	Accommodation at Albany	Accommodation at Albany	**Kathleen Larsen** BBQ & horse cart ride

Table 4.1 continued**.** Curriculum Timetable 6 – 13 February 2010

<table>
<tr><th></th><th>Wed 10 Feb</th><th>Thur 11 Feb</th><th>Friday 12 Feb 10</th><th>Saturday 13 Feb 10</th></tr>
<tr><td>0800
–
1000</td><td>Entomologist Stewart Learmonth:
Insect monitoring & assessment of pest & disease levels in commercial ware or processing potato crop.</td><td>Nematologist Dr Sarah Collins:
Inspect old PCN sites.
Biosecurity discussion & PCN monitoring; different tests (fork, soil) & accuracy comparison</td><td>WA Quarantine Graeme Lukeis:
Visit to interstate quarantine depot to seed inspection of freight
Mr Jim Turley:
Executive Officer Potato Growers Association</td><td rowspan="3">Dawson:
TBA / Free time

Midday check out</td></tr>
<tr><td></td><td colspan="3">Morning tea</td></tr>
<tr><td>1015
–
1230</td><td>Inspector Dave Tooke:
PCN test practical session
• fork test
• soil test
Location: TBA, Manjimup</td><td>To Perth</td><td>Terry Hill:
Review & evaluation of study tour

Planning for the needs of Lombok seed potatoes</td></tr>
<tr><td></td><td colspan="4">Lunch</td></tr>
<tr><td>1330
–
1500</td><td>Pathologist Andrew Taylor:
Hot Box seed treatments [4°C, ambient]
Inspection of Sth Packers cool stores in Manjimup.</td><td>Nematologist Dr Sarah Collins
South Perth laboratory tests for PCN</td><td>Sholat at Perth Mosque</td><td rowspan="2">Dawson:
1300 Perth Airport for 1515 departure from Perth, Flight GA 725.</td></tr>
<tr><td></td><td colspan="3">Afternoon tea</td></tr>
<tr><td>1530
–
1700</td><td>Travel to Perth</td><td>Holland/Collins:
Tour of laboratories to see PCN testing, and virus testing for potato seed scheme</td><td>Dawson:
Caversham Wildlife Park.
Film introduction and conclusion of DVD</td><td></td></tr>
<tr><td></td><td colspan="3">Prayers & dinner</td><td></td></tr>
<tr><td>1930
-
2100</td><td>Accommodation at Perth</td><td>Late night shopping

Accommodation in Perth</td><td>Perth late night shopping

Accommodation in Perth</td><td></td></tr>
</table>

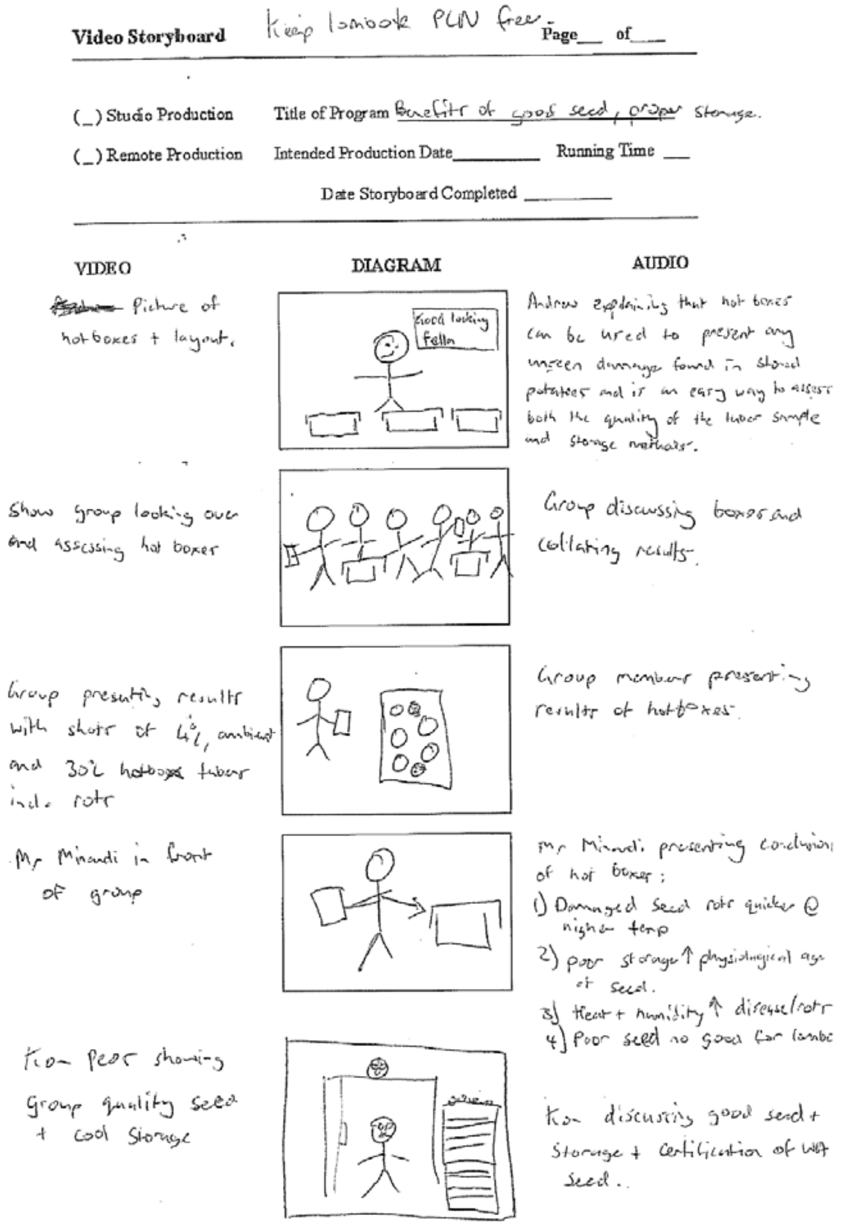

Figure 4.1. Storyboard plan of scene about the hot-box test for assessing seed potato lots resistance to rots under hot, humid conditions.

4.2 PCN species identification using PCR

4.2.1 Collecting Soil Samples

Soil samples were collected from potato planting areas shown in Table 6.2. In effort to get numerous numbers and fresh of cysts of PCN, the soil samples were collected over more than one potato planting season in some areas.

Collecting Cysts of PCN

PCN cysts were collected (extracted) from each of the soil sample by using the method of Shurtleff and Averre III (2000).

Morphological Identification of PCN

Morphological identification to distinguish between *Globodera rostochiensis* and *G. pallida* were also done based on the morphological differences of the stylet knob of the larvae/juvenile and on the perineal pattern of the cyst. The number of PCN cysts in each of the soil samples were also counted.

Molecular analyses of PCN

DNA preparation
Eighty nematode cysts were collected (from each soil sample) and put in a tissue grinder containing DNA extraction buffer (CTAB 2%; NaCl 1.4 M; EDTA 100mM, Tris-Cl 50 mM pH 8, and mercaptoethanol 1%), then the cysts were ground and added with 250-400 µl CTAB and mixed thoroughly in an Eppendorf tube. The DNA containing solution in the Eppendorf was incubated at 65 ºC for 30 minutes with shaking every 10 minutes. An equal volume of chloroform isoamyl alcohol 24:1 (CIAA) was added and mixed thoroughly by shaking the tube (or vortex) for one minute. DNA containing solution in Eppendorf was centrifuged at 12,000 rpm for 10 minutes. The supernatant then was transferred into sterilized Eppendorf and the interface debris was discarded. The supernatant in the tube was mixed with 2 times the volume of cold absolute ethanol. The DNA containing solution was incubated overnight at -20 ºC. The DNA containing solution was then centrifuged at 12,000 rpm for 15 minutes and the supernatant was discarded, then the DNA pellet was collected. The pellet was rinsed by adding 500-1,000 µl of 70% cold ethanol and re-centrifuged at 12,000 rpm for 10 minutes. The supernatant was discarded and DNA pellet air dried (or vacuum). The DNA pellet was dissolved in 20-30 µl aquabidest and then cleaned by using microclean. Finally the DNA quality and quantity was identified by electrophoresis.

Polymerase chain reaction
The PCR reactions were carried out using primers PITSr3 and PITSp4 in combination with primer ITS5. Cycling conditions included an initial denaturation step of 94 ºC for 2 minutes, followed by 35 cycles of 94 ºC (30 s), 60 ºC (30 s), 72 ºC (30 s), and finished with one cycle at 72 ºC (5 minutes) (Skantar *et al*. 2007).

4.3 PCN pathotype tests

Four populations of PCN which had been collected in Indonesia by Prof Mulyadi's Team (see Section 4.2) were sent to the Agri-Food & Biosciences Institute (AFBI) in Belfast, Northern Ireland for a differential screening test to identify their pathotype. The tests were undertaken by Mr Trevor Martin.

Four differential potato clones were inoculated with the unknown *Globodera* cyst population; *Solanum andigena* CPC 1673; *S. kurtzianum* 60.21.19; *S. vernei* 58.1642/4 and Desiree, a fully susceptible potato cultivar.

High reproduction rates of the cysts should take place when on the fully susceptible host which indicates the cyst's potential capacity for reproduction. The cysts placed on *S. andigena* CPC 1673 will not reproduce if they are of the pathotype Ro1 but will multiply if they are of other pathotypes Ro2; Ro3; Ro5; Pa1 or Pa2/3. When the cysts are inoculated into *S. kurtzianum*, neither Ro1 or Ro2 will reproduce in high numbers. *S. vernei* will not allow Ro1; Ro2 or Ro3 to multiply in high numbers.

4.4 PCN population increase and decline studies

4.4.1 Propagation of PCN cysts

The design of the following study plus the bags and sachets used were supplied by Dr Marshall. The bags were developed in New Zealand (Marshall 1997) and are twin skinned Terylene voile bags. The mesh size of the bag is small enough to stop major root escape and the resultant nematode population is contained within the bag. The developing potato plant and roots suffer little container effect. Sachets are made of the same material and the inoculum cysts are held within the sachet and the sachet buried in the soil in the Terylene bags. As the plant grows the larvae hatch, move out of the sachet and infect the developing roots contained within the Terylene bag. This approach allows for the separation of the inoculum from subsequent progeny and the resultant cysts are of a single generation. The main advantage of this approach is reduced variability of inoculum that results from using old, partially hatched and empty cysts collected from the field.

1. A large volume of PCN infested soil in Batur, Banjarnegara, Central Java were collected and brought to the Nematology Laboratory, Agriculture Faculty, Gadjah Mada University, Yogyakarta.
2. All of the soil from Batur was washed and roughly screen washed through 1,000 and 250 µm sieves.
3. Fresh and healthy cysts were collected from washed materials.
4. The average number of eggs in each of PCN cyst was calculated from a sample of 25 cysts.
5. The number of eggs/ml of soil in 10 ml of washed materials was calculated.
6. Thirty Terylene bags and 150 sachets were prepared for this PCN propagation.
7. Each Terylene bag was filled with 2.5 L sterilized soil from Batur.
8. One certified Granola potato seed was planted in each Terylene bag.
9. Five sachets filled with 5 PCN eggs/ml were placed in each Terylene bag around the potato tuber, and then 2.5 L of sterilized soil were added into the Terylene bag. Thirty Terylene bags were prepared in this PCN propagation.
10. All of the thirty Terylene bags were placed in Pejawaran, Banjarnegara. A fence made from plastic nets was put around the Terylene bags to protect the potato plants.
11. PCN propagation bags were harvested at 100 days after planting.
12. Potato plants were cut off and the Terylene bags filled with soil were brought back to Nematology Laboratory.
13. Soil was washed through 1,000 and 250 µm sieves.
14. The number of the PCN eggs in 10 ml of washed materials was calculated.
15. The fresh PCN eggs/cysts collected from the propagation were used for the next experiments.

4.4.2 PCN population increase experiment

1. The experiment was carried out in clean terrace soil in Banjarnegara.
2. Five different population levels were used i.e.;
   1) 5 eggs/ml of sterilized soil in a Terylene bag
   2) 10 eggs/ml of sterilized soil in a Terylene bag
   3) 15 eggs/ml of sterilized soil in a Terylene bag

   4) 20 eggs/ml of sterilized soil in a Terylene bag
   5) 25 eggs/ml of sterilized soil in a Terylene bag
3. Five replications were used for each inoculum level (25 Terylene bags were prepared)
4. Certified potato seed (Granola variety) was planted in each Terylene bag and placed in potato production field in Pejawaran, Banjarnegara. A fence was put around the Terylene bags to protect the potato plants.
5. The potato plants were harvested at 90 days after planting.
6. The data collected included:
   1) Potato plant height
   2) Number of stems
   3) Plant dried weight
   4) Root weight
   5) Number of tubers
   6) Weight of tubers
   7) Number of cysts in 20 ml of soil in each bag at 90 days after planting. The soil in the bag was well mixed before taking the soil sample.
   8) Number of eggs/cyst with 25 replications of cyst
   9) Number of eggs/g of soil.

7. The Pf/Pi ratios were calculated and Pi value against total yield and plant values were plotted.

4.4.3 PCN population decrease experiment

1. The experiment was done in terrace soil in Pejawaran, Banjarnegara and paddy soil in Wonosobo.
2. Fifty litres each of non-infected PCN soil from terrace in Banjarnegara and from paddy soil were collected and were brought back to Nematology Laboratory.
3. Each terrace and paddy soil was mixed well, stones and weeds were removed and the soil was checked for freedom from PCN.
4. Twenty five litres of terrace and paddy soil were taken and each soil-type was mixed well with 25% of new PCN infested soil (from the PCN propagation).
5. Five replications were used in this experiment.
6. Over time 100 ml of terrace and paddy soils from each replication were taken to determine the number of the cysts or eggs present.
7. The bag in each replication was tied and 5 replications (5 bags) of terrace soils were buried (below the soil surface) in Banjarnegara (potato planting area) and the other 5 bags of paddy soils were buried in Wonosobo (paddy planting area).
8. Data were collected at 30; 60; and 90 days after Terylene bags were put in terrace or paddy soil. This experiment was done for a period of two planting seasons (6 months).
9. The data collected were: number of cysts in 300 ml soil from each replication and the number of the viable eggs in the cysts.

5 Achievements against activities and outputs/milestones

Objective 2: To develop and implement low-cost schemes that significantly improve the access of Indonesian farmers to quality potato seed

no.	activity	outputs/ milestones	completion date	comments
2.4	Training Indonesian project collaborators in pest and disease diagnostics and seed potato care and certification systems in Australia.	Identification of trainees Training materials finalised Training visits to Australia Training completed & reported		Training visit to WA in February 2010 with 5 participants from NTB. Sessions of the last training course were filmed for an Indonesian farmer audience for the DVD "Keeping Lombok Free From PCN".
2.6	Development, training and implementation of improved practices for producing clean low-generation seed with and by lead farmers and/or commercial seed producing companies	Training conducted [Best seed supply production system for on-farm trials] Trial report [Seed comparison tests] GAP manual revised [develop GAP (rotations, resistant varieties)]		PCN soil survey of Sembalun conducted and survey team from Kelompok Horsela trained in collection, mapping and soil processing. Baiq Nurul Hidayah of BPTP-NTB trained in soil sample analysis using binocular and compound microscopes. The soil survey found no PCN at Sembalun. Mulyadi team PCR and population experiments

PC = partner country, A = Australia

6 Key results and discussion

6.1 PCN Status of Lombok

6.1.1 Potato cyst nematode survey at Sembalun, East Lombok

The PCN survey in the Sembalun areas was undertaken from July to November 2008 by taking soil samples from potato fields at Sembalun. The soil samples from Sembalun were examined at Sembalun, Mataram and at the Nematology Laboratory of Gadjah Mada University, Yogyakarta.

The survey results can be seen in Table 6.1. From a total of 454 samples examined, **no cysts of potato cyst nematode were found in the potato cropping area of Sembalun**. Based on the survey results it can be concluded that the Sembalun was free from PCN at that time, November 2008. This situation means that the Sembalun region has good potential to become a centre of potato seed production to fill the potato seed needs of other areas of Indonesia.

Figure 6.1. *Telu-telu* team ready for field sampling at Sembalun.

Figure 6.2. Soil samples collected to tests for presence of cysts using a Fenwick can and binocular microscope.

Post wash debris of soil from paddy fields and those from terraces was very different as the terrace samples had greater organic material and diversity of PCN-like bodies while the paddy samples had very little organic material and no PCN like spherical bodies. Therefore future surveying for PCN from paddy sites should be very easy.

Table 6.1. Results of the Potato Cyst Nematode Survey at Sembalun July – November 2008.

Site No.	Farmer's name	No. soil tests	Results	Site No	Farmer's name	No. soil tests	Results
1	Musnaeli	16	No PCN	23	Amaq Lepi	3	No PCN
2	Haji Sayuti	12	No PCN	24	Haji Sayuti	8	No PCN
3	Sukirno	6	No PCN	25	Amaq Fika	8	No PCN
4	Sukirno	32	No PCN	26	Fery	3	No PCN
5	Haji Hairil	6	No PCN	27	Haji Jun	8	No PCN
6	Haji Dia	12	No PCN	28	Haji Wir	4	No PCN
7	Haji Muhlisin	4	No PCN	29	Haji Ros	6	No PCN
8	HM Kartif	37	No PCN	30	Haji Upin	4	No PCN
9	Sayuti	19	No PCN	31	Samirih	4	No PCN
10	Musnaeli	4	No PCN	32	H. Suhilwadi	14	No PCN
11	Suandi	11	No PCN	33	Amaq Deri	6	No PCN
12	Haji Nidia	5	No PCN	34	Amaq Dia	7	No PCN
13	Musnaeli (Mentagi)	8	No PCN	35	Amaq Leli	8	No PCN
14	H. Anwar (D. Blek)	14	No PCN	36	H. Atahar	7	No PCN
15	H. Wildan	6	No PCN	37	Amaq Joi	4	No PCN
16	Am. Peni (Dorit)	6	No PCN	38	Amaq Exl	12	No PCN
17	Bp. Izah (D. Blek)	16	No PCN	39	Musnaeli	13	No PCN
18	H. Amir (Dorit)	26	No PCN	40	H M Idris	14	No PCN
19	H. Muspaidi	22	No PCN	41	H. Ayup	9	No PCN
20	Amaq Filad	21	No PCN	42	Amaq Susi	4	No PCN
21	Amaq Pino	7	No PCN	43	Amaq Dwi	5	No PCN
22	Minardi	13	No PCN				
Total samples examined						454	

6.1.2 Development of Sembalun as seed production area

Regulations for potato movement

A draft Governor's Regulation was prepared entitled *Draft of Governor Regulation of West Nusa Tenggara Province, No............ of 2010 Regarding Circulation of Potato Seeds in West Nusa Tenggara Province.*

Study Tour to Western Australia

Participants in the study tour to Western Australia represented the Sembalun Horticulturists' Group, The NTB Quarantine service, The NTB Department of Agriculture Seed Service and BPTP NTB. They were;

- Mr Minardi, Leader of 'Horsela' Farmers' Group, Sembalun, Lombok Timur NTB
- Mr Risdun, Treasurer 'Horsela' Farmers' Group, Sembalun, Lombok Timur
- Ir. M. Samsul Hedar, Head Quarantine Office, Class 1 Agriculture I Mataram, NTB
- Ir. Usman Fauzi, M.Si., Head Production Sector, Horticulture, Dinas Pertanian Food Crops and Horticulture NTB
- Mr Sudjudi, BSc.SP., Laboratory Head, BPTP NTB

Mr Kus Kuswardiyanto of DAFWA acted as interpreter but when he wasn't available Mr Minardi and Mr Sudjudi took on this role.

The topics studied are shown in Table 6.2. This Table summarises the scenes that were filmed for the DVD by the participants. At the end of the study tour all participants received a copy of the scenes that were filmed. The scenes were edited by Mr Cahyo Mursito of LPTP and the final DVD was released at the Farmers Review Conference at Pangandaran in June 2010. The most important aspects of the training with regard to protecting Sembalun from PCN and other exotic threats were:

Table 6.2. Content of scenes filmed during WA Study Tour about protecting potatoes form exotic pests & diseases.

Viewing order	Title	Description & aim of scene	Time (min; secs)
1	Introduction	Explanation by Pak Minardi of the aim of the video and the scenes it contains. Also the Australian wildlife will ensure viewers know the information is from Australia	10:20
2	Introduction laughing bird	Vision of the bird which makes a long, loud laughing noise during the introduction. It could be edited into the introduction to synchronise with the laughing noise. Also has close up of kangaroo.	0:32
3	Quarantine inter province scene 1 explanation	Explanation by Pak Samsul explains inter province quarantine inspection procedures. Regulation controlling the movement of potatoes into Western Australia protects WA from exotic pests and diseases. Similar regulations developed for Lombok made help to reduce the risk of PCN coming to the island.	4:33
4	------------“---------- scene 2 procedure	Vision of inter province quarantine inspection procedures for editing into explanation if appropriate.	1:39
5	------------“---------- scene 3 procedure	Vision of inter province quarantine inspection procedures for editing into explanation if appropriate.	5:24
6	Biosecurity at farm level scene 1.	Explanation by Pak Samsul about how localised quarantine, called farm biosecurity, can give protection against new pests and diseases. If potato farmers at Sembalun adopt farm biosecurity then they will have improved protection against new pests and diseases.	1:27
7	-----------------“------------- scene 2.	Improved ending of previous scene [Biosecurity at farm level scene 1]. Vision showing how people can enter the field once biosecurity precautions have been taken.	0:14
8	Seed production Albany	Pak Minardi explains order of work (order of entering field) when managing different generations of potatoes.	1:26
9	Seed production Albany G0 Albany	Pak Minardi explains G0 (minitubers) rotation at Albany.	1:09
10	Seed production Albany isolation between generations	Pak Minardi explains isolation between generation in seed production in Western Australia.	1:55
11	Seed production Albany avoiding mixed varieties by skin colour	Pak Sudjudi explains how seed growers can prevent mixing varieties by planting varieties with different coloured skin next to each other.	0:46
12	Seed production Albany low aphids	Mr Colin Ayres explains why there re low numbers of aphids and viruses in the seed potato production areas of Western Australia. Pak Samsul is the translator. The lack of other solanaceous crops e.g. (tomatoes, chilli) is a benefit. Kelompok Horsela must consider how chilli and tomato production may affect high quality seed production.	2:05
13	Seed certification Simon Moltoni scene 1	Pak Usmam explains seed certification system in front of Simon Moltoni’s seed potato crop. Lombok will need to introduce a seed certification system if farmers there want to sell seed potatoes. This scene explains what the inspector looks for at the first inspection while the plants area still small enough for the base of plants 4 rows away can still be seen..	3:32
14	Seed certification Simon Moltoni scene 2	Seed certification continued. This scene explains what occurs at the second inspection when the crop is flowering.	0:58

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Table 6.2 continued. Content of scenes filmed during WA Study Tour about protecting potatoes form exotic pests & diseases.

Viewing order	Title	Description & aim of scene	Time (min; secs)
15	Cool storage benefits improved storage quality	Pak Minardi explaining how cool storage improves the storage life of seed potatoes. This is important for Lombask as the best protection against the introduction of bad quality seed that may carry exotic pests and diseases is to have a local supply of seed available for all planting times. Cool storage will make it easier to achieve a year round local supply of seed for Lombok.	2:43
16	Hotbox test	Shows the results from the hotbox demonstration. The 4ºC storage treatment had 7% rots, the ambient (variable) temperature storage had 40% rots while the 30ºC storage treatment had 29% rots.	1:01
17	Hotbox test results	Pak Samsul explains this demonstration of hotbox treatments. The demonstration was designed to show how cool storage of potato seed reduces rots and allows seed to be stored for longer periods.	2:42
18	Cool storage benefits rapid emergence	Pak Sudjudi explains how cool stored seed has rapid and even emergence which is a benefit to areas which demand rapid crop establishment like Indonesia.	0:40
19	Eradication of PCN at Perth	Pak Sudjudi explains how PCN was found, contained and eradicated from a small area south of Perth in Western Australia. This shows what actions may have to be taken if PCN is found in Lombok.	2:48
20	PCN fork test scene 1	Pak Sudjudi explains the fork test for PCN while Pak Usmam carries out the test in a seed crop at Manjimup. This test could be used in Lombok to back-up Lombok's claim of PCN freedom. It can also be used for early detection as it is 100 times more accurate than a soil test.	3:20
21	PCN fork test scene 2	Pak Sudjudi explains the biosecurity measures that are undertaken when doing the PCN fork tests. These are demonstrated by Pak Usmam.	0:50
22	Seed cutting Simon Moltoni scene 1	Pak Sudjudi explains the seed cutting procedure used in Western Australia. Shows the size of tubers that have been removed from cool store for cutting.	0:58
23	Seed cutting Simon Moltoni scene 2	Pak Sudjudi explains the seed cutting procedure used in Western Australia. Shows the conveyor belt from bunker to cutting machine.	0:42
24	Seed cutting Simon Moltoni scene 3	Pak Sudjudi explains the seed cutting procedure used in Western Australia. Another view of the conveyor belt from bunker to cutting machine. Shows shoot development of the tubers before cutting.	1:24
25	Seed cutting Simon Moltoni scene 4	Pak Sudjudi explains the seed cutting procedure used in Western Australia. Shows the results of cutting and the application of mancozeb dust (20% a.i.).	0:39
26	Seed cutting Simon Moltoni scene 5	As above. Sudjudi also explains the curing process the seed undergoes after cutting.	1:25
27	Specific gravity take 3	Pak Minardi explains how and why specific gravity is measured.	4:16
28	Ending	Acknowledgements by Pak Sudjudi, Pak Samsul, Pak Risdun, Pak Minardi and Pak Usmam.	2:52

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- A visit to an airfreight company at Perth airport allowed the participants to see the interstate quarantine inspection procedures that take place before horticultural products are allowed to be distributed in WA. Pak Samsul indicated that the same regulations may not work in NTB as the transport industry does not have the experience of following such regulations. Alternative mans of regulating potato movements were discussed. For example Sembalun can only be reached by two roads which have gates on them. These may be better sites for regulating potato movements rather than at the main port at Lembar, south of Mataram.

- A visit to a seed potato farm allowed the participants to discuss the measures that individual farmers or visitors to farms can take to reduce the risk of introducing pests, diseases and weeds.

- The Registered seed production scheme which operates at Albany where annual flooding is used in lieu of rotation was examined. The use of and the reasons for a minimum distance to isolate generations was discussed. The lack of closely related solanaceous crops like tomatoes and capsicums was seen.

- Certified seed scheme regulations were also studied at another seed grower's crop at Pemberton.

- The benefits that cool storage gives to seed potato growers were studied on a seed potato farm at Albany.

- The world's first, successful eradication of PCN from an area near in Perth was investigated and the trainees were shown how fork testing of growing potato plants can be used to monitor quickly and accurately the PCN status of a crop (Wood *et al*. 1983).

Alternatives to regulations for potato movement

At Sembalun in 2009 about 10 – 15 farmers planted around 7 ha with uncertified seed from East Java because there was not enough local seed available. To prevent this risk of introducing PCN an alternative solution to regulations may be to ensure that Sembalun grown seed is available to fulfil local needs. Table 6.3 shows once-grown seed supply from existing Sembalun crops should be available for 9 months of the year without the need for cool storage. This will cover the period from March to May when the seed from East Java was used.

The fields that were planted with this seed from Java should be tested for PCN either by soil testing or by fork testing as part of the seed scheme regulations that must be developed for Sembalun.

When suitable seed regulations are introduced for Sembalun, PCN free sources of seed for the local (non PT Indofood) crops must be stipulated.

Table 6.3. Potato cropping times for Sembalun and the period when local seed is not available for planting. Seed supply times assumed to begin 3 months after harvest when shooting begins until 6 months after harvest.

	J	F	M	A	M	J	J	A	S	O	N	D
Seasonal conditions												
Rain too much	■	■										■
Rest of wet season			■	■							■	
Dry season					■	■	■	■	■	■		
Cropping times												
Indofood earliest crops grown					growing crop	growing crop	growing crop	growing crop				
provide seed for planting:	seed	seed										seed
Indofood last crops grown							growing crop	growing crop	growing crop	growing crop		
provide seed for planting:		seed	seed	seed								
Local seed earliest grown			growing crop	growing crop	growing crop	growing crop						
provide seed for planting:										seed	seed	seed
Local seed crops latest grown									growing crop	growing crop	growing crop	growing crop
provide seed for planting:				seed	seed	seed						
Threat of uncertified seed												
Local seed not available							■	■	■			

6.2 PCN species identification using PCR

6.2.1 Collecting Soil Samples and Cysts of PCN

The number of cysts in the soil samples which have taken from the potato planting areas in East Java, Central Java, and West Java were shown in Table 6.4. In East Java the highest population of PCN was found in Brakseng, because here potatoes are planted continuously, whereas elsewhere they are rotated with carrot. The distribution of PCN in East Java in 2008 was almost the same with the data collected by Mulyadi *et al*. (2003a and 2003b). However in Central Java in 2008 PCN was found in many areas in Wonosobo and Banjarnegara whereas in 2003 it was only found in Karang Tengah and Kejajar. This distribution may have started in 2007 in East Java where there is a potato carrot (non host of PCN) rotation but spread more rapidly in Central Java as potatoes are planted continuously throughout the whole year, and many farmers in Central Java may have bought potato seeds from PCN infected areas.

6.2.2 PCN identifications based on morphological characters

Based on morphological characters especially stylet of the larvae/juveniles of PCN and perenial pattern of PCN cysts, we found only *G. rostochiensis* in all of the soil samples from East, Central Java, and West Java (Table 6.4).

6.2.3 Molecular identification of PCN

Initially difficulties in using PCR to identify PCN were encountered but after modifications method as suggested by Dr John Marshall and Prof Siti Subandiyah (Head of Agriculture Biotechnology Laboratory, Gadjah Mada University), consistent results from PCR as seen on electrophoresis gels (Mulyadi *et al.* 2008) and these are summarised in Table 6.4.

Table 6.4. Number of cysts of PCN in East, Central and West Java and the species of PCN found based on morphological characteristics and molecular identification.

Province & site	Altitude	Number of cysts/20 g soil				PCN
	(m asl)	1*	2*	3*	4*	sp†
East Java, Bumiaji						
Brakseng	± 1,700-1,800	14.30	10.30			Ro
Tunggangan	± 1,600	13.15	6.00			Ro
Kembangan	± 1,500-1,600	2.25				Ro
Watu Tumpuk	± 1,500	0				
Bon XV	± 1,200	0				
Central Java, Wonosobo						
Patak Banteng	± 800	2.0	22.60	19.30	4.60	Ro
Kejajar	± 1,500	5.00	3.30	0.30		Ro
Central Java, Banjarnegara						
Dieng Wetan	± 1,800	46.30				Ro
Dieng Kulon	± 1,800	1.30				Ro
Karang Tengah	± 1,900	44.40	44.00			Ro
Karang Bakal	± 1,900	6.00				Ro
Batur	1,900	10.00				Ro
Dieng Gapura	± 1,500	18.30				Ro
Pasurenan	± 1,900	14.00	4.30	0.30		Ro
Sumberejo	± 1,900	0.30	16.30			Ro
West Java, Pangalengan	± 1,400				13.67	Ro

1*; 2*; 3* and 4 *: at first, second, third, and fourth soil sampling
†: Ro = *Globodera rostochiensis*

6.3 PCN pathotype tests

Three collections of PCN from Indonesia were able to be challenged with the differential screening tests using indicator species. The Banjarnegara population did not hatch and therefore was unable to be tests.

The Pangalengan collection did not have the same number of replicates. This was because a large number of cysts per inoculum were needed in order to meet the required number of eggs per gram. Mr Trevor Martin of AFBI considers that the results for this population will still be valid (personal communication, 2009).

Results from the Indonesian cysts tested showed good reproduction took place when grown with *S. andigena* and the susceptible potato variety, Desiree. This combination indicates the pathotype was Ro2, Ro3 or Ro5.

S. kurtzianum and *S. vernei* restricted cyst multiplication (Table 6.5) which indicates that the pathotypes were not Ro3 or Ro5.

Therefore it is concluded that the pathotype is Ro2.

Had there been *G. pallida* then high multiplication would have been observed on all of the potato clones.

In addition the original populations and those multiplied on the susceptible hosts were tested by AFBI using PCR and all of the results indicated pure populations of *G. rostochiensis* which confirmed the results reported in Section 6.1.5.

It is likely that the pathotype of the Banjarnegara population is one of Ro2, Ro3 or Ro5 because this collection was identified as *G. rostochiensis* (Section 6.1.5) and the cysts were collected from the variety Granola which has resistance to Ro1.

Table 6.5. Results of differential indicator test to determine pathotypes of four Indonesian populations of potato cyst nematode.

Indicator species or variety	Allows reproduction of pathotype*: Ro1	Ro2	Ro3	Ro5	Sample	Wonosobo Indo 1	Banjarnegara† Indo 2	Kota Batu Indo 3	Pangalengan Indo 4	Interpretation
						(Number of cysts produced on indicator plant)				
Desiree					1/5	232	-	1288	657	High numbers of cysts here indicate pathotype
					2/5	1260	-	2492	980	is one of Ro1, Ro2, Ro3 or Ro5.
	✓	✓	✓	✓	3/5	612	-	1256	406	It is not *Globodera pallida* as there would be high
					4/5	860	-	2000		numbers of cysts produced on all the indicators.
					5/5	1660	-	988		
S.vernei					1/5	16	-	20		High numbers of cysts here indicate pathotype
58.1642/4					2/5	21	-	41		Ro5. No sample was considered to be Ro5
	×	×	×	✓	3/5	3	-	22		due to the low numbers of cysts produced
					4/5	6	-	62		on this indicator.
					5/5	2	-	18		
S.kurzianum					1/5	10	-	24	8	High numbers of cysts here indicate either
60.21.19					2/5	9	-	44	7	pathotype Ro3 or Ro5. No sample was
	×	×	✓	✓	3/5	4	-	35		considered to be Ro3 due to the low numbers
					4/5	15	-	47		of cysts produced here.
					5/5	5	-	24		
S.andigena					1/3	409	-	42	1358	The high numbers of cysts here indicate pathotype
(MP)	×	✓	✓	✓	2/3	1021	-	3200	621	Ro2, Ro3 or Ro5. As Ro3 & Ro5 have already
CPC 1673					3/3	493	-	512		been eliminated the high number of cysts
										show the pathotype of all samples is Ro2.

* According to the International Pathotype Scheme
* Not tested as not enough cysts could be produced.

The finding that the pathotype of three collections of PCN from Batu, (West Java), Wonosobo (Central Java) and Pangalengan (West Java) is important information for managing PCN as it now allows resistant potato varieties that may be appropriate for testing in Indonesia to be identified. There is a potato breeding program in New York State of USA that has been breeding potatoes for resistance to this pathotype. These include crisp processing varieties that could be suitable for Indofood. One hurdle is that many of these Ro2 resistant potato varieties will have plant breeders' right and Indonesia as at 22/10/2009 was not a member of the International Union for the Protection of New Varieties of Plants (UPOV).

6.4 PCN population increase and decline studies

6.4.1 Propagation of PCN cysts

PCN reproduced well in potato plant grown in Terylene bags at Banjarnegara. The cysts or the eggs of the PCN collected were used as the inoculum for doing the two subsequent experiments on the population increase and decrease of PCN.

6.4.2 PCN population increase experiment

Potato plant growth 90 days after planting

Based on the observations and statistical analyses (using the Duncan's Multiple Range Test), there were no significantly different of the potato plant height, number of stems and root weight treated with 5 different population levels of PCN. However there were significant differences in plant dry weight between potato plants challenged with 5 different population levels. The data showed a trend of declining potato plants growth with the increasing of PCN population levels treated (Table 6.6).

Table 6.6. Average potato plant height, number of stems, plant dried weight, and root weight at 90 days after planting.

Treatments (number eggs/ml soil)	Plant height (cm)	Number of stems	Plant dried weight (g)	Root weight (g)
5	53.90 a	4.2 a	42.30 a	25.64 a
10	59.10 a	4.6 a	37.00 ab	27.60 a
15	54.20 a	2.8 a	35.68 ab	28.06 a
20	49.80 a	3.4 a	21.64 b	23.64 a
25	51.20 a	3.4 a	21.20 b	19.72 a

Different letters after the numbers in each column show significant differences between the treatments based on the Duncan's Multiple Range Test at the 5% level.

The average number and weight of potato tubers at 90 days after planting.

There was no significant difference between the treatments on the number of potato tubers and although here appeared to be a trend of decreasing tuber number per plant with the increasing PCN population levels this trend was not significant.

There were significant differences in the yield of potato tubers challenged with 5 different population levels of PCN (Table 6.7).

Table 6.7. Potato tuber number and yield 90 days after planting.

Treatment (number eggs/ml soil)	Tuber number/plant		Tuber yield (g/plant)	
5	11.4	a	998	ab
10	11.8	a	834	ab
15	12.2	a	1,052	a
20	8.4	a	620	b
25	9.4	a	778	ab

Different letters after the numbers in each column show significant differences between the treatments based on the Duncan's Multiple Range Test at the 5% level.

Number of eggs in each cyst, number of eggs per ml of soil, and the ratio of Pf/Pi

The $P_{final}/P_{initial}$ ratio (number of PCN eggs after potato plants harvested as compared to the number of PCN eggs at planting time), showed a trend of decreasing of the $P_{final}/P_{initial}$ ratio with the increasing PCN population levels treated (Table 6.8, Figure 6.3.1). Based on the experiment done by Ehwaeti *et al*. (2000), the similar trend was also found on root-knot nematode and PCN. Specific examples for PCN dynamics are seen in Marshall (1997).

Table 6.8. The average number of eggs in each cyst, number of eggs/ml of soil, and Pf/Pi ratio

Treatments (Pi) number eggs/ml soil)	Number of eggs in each cyst	Number of eggs/ml soil (Pf)	Ratio Pf/Pi on the number of eggs/ml soil
5	382	143	28.7
10	323	174	17.4
15	334	269	17.9
20	317	177	8.8
25	311	155	6.2

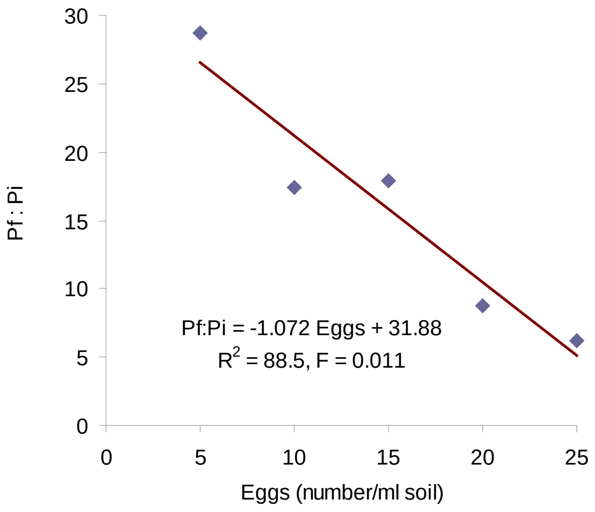

Fig 6.3.1. Pf:Pi (the number of PCN eggs after harvest compared to the number of PCN eggs at planting) with increasing PCN egg populations.

PCN population decrease experiment

The number of the cysts drastically decreased (more or less 99% at 30 days) and reached zero at 60 days after burying the bags containing the cysts in paddy soil. Whereas the number of the cysts in terrace soil had drastically decreased by approximately 87% within the first 30 days then the rate of decline decreased after this time. The cysts and eggs seem to be very susceptible to breakdown and death in flooded condition (Table 6.9).

The number of PCN viable eggs in paddy soil were also drastically decreased (more or less 16% remaining after 30 days) and with none detectable after 60 days after burying the bags containing the cysts. Whereas eggs in the terrace soil were still detectable at the end of the experiment (Table 6.9).

The trend of decreasing number of cysts and viable eggs of PCN in paddy and terrace soils (in Banjarnegara) are shown in Figures 6.3.2 to 6.3.5.

Table 6.9. The average number of cysts and viable eggs at 30; 60; 90; 120; 150; 180 days after burying(DAB) the bags in paddy and terrace soil.

Treatments	Initial Population	30 DAB	60 DAB	90 DAB	120 DAB	150 DAB	180 DAB
Cysts							
In paddy soil	140	0.8	0	0	0	0	0
In terrace soil	160	20	44	27	12	15	21
Eggs							
In paddy soil	464	72	0	0	0	0	0
In terrace soil	426	204	237	187	190	163	176

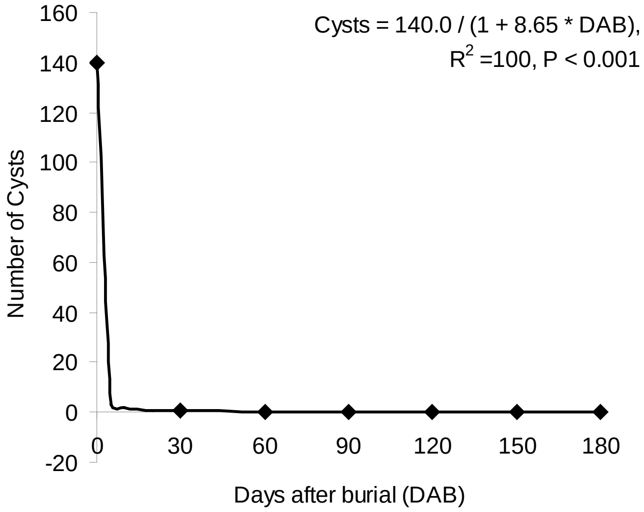

Figure 6.3.2. Decline equation for PCN cysts buried in highland paddy soils on the Dieng Plateau, Central Java, in the absence of a host. The relationship is a rectangular hyperbola, i.e. an initial rapid linear decline followed by a more gradual decline.

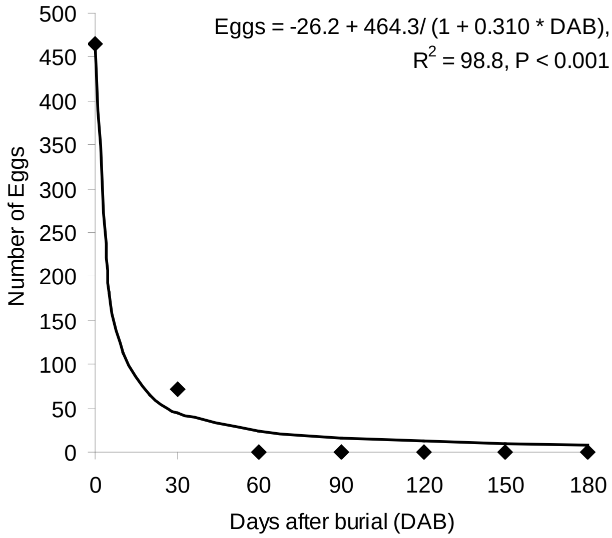

Figure 6.3.3. Decline equation for PCN eggs buried in highland paddy soils on the Dieng Plateau, Central Java, in the absence of a host. The relationship is a rectangular hyperbola, i.e. an initial rapid linear decline followed by a more gradual decline.

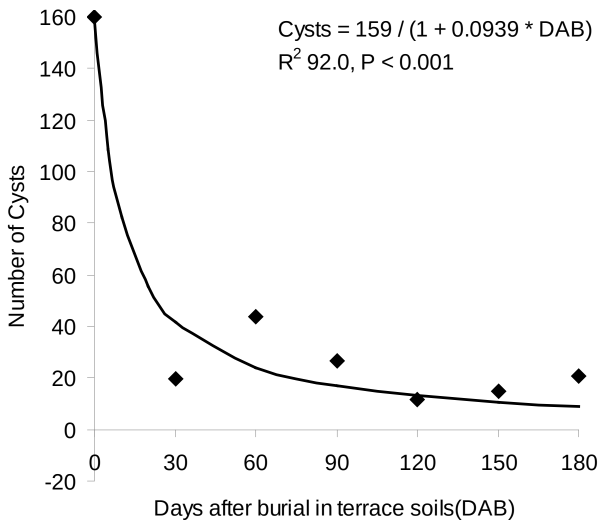

Figure 6.3.4. Decline equations for PCN cysts buried in highland terrace soils on the Dieng Plateau, Central Java, in the absence of a host. The relationship appears to be a rectangular hyperbola, i.e. an initial rapid linear decline followed by a more gradual decline.

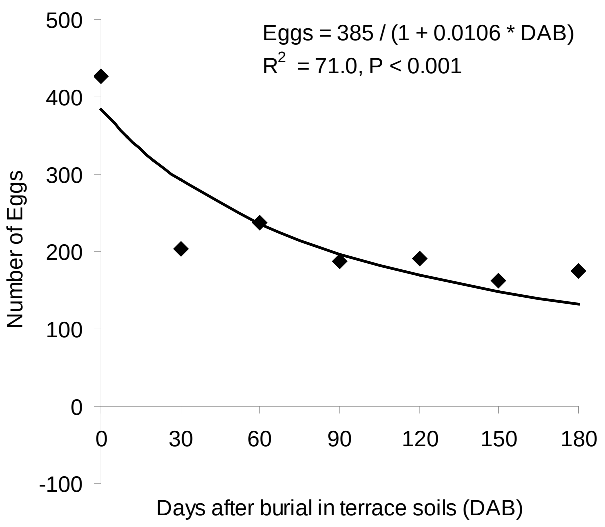

Figure 6.3.5. Decline equations for PCN cysts buried in highland terrace soils on the Dieng Plateau, Central Java, in the absence of a host.

7 Impacts

7.1 Sembalun soil survey

7.1.1 Scientific impacts – now and in 5 years

The soil survey to determine PCN status has identified an area free from PCN suitable for seed potato production at Sembalun. This finding can be used to base a potato seed supply system that has the lowest risk of spreading PCN while increasing the availability of affordable high quality seed to the Indonesian potato industry.

7.1.2 Capacity impacts – now and in 5 years

There is now an opportunity for the Sembalun area of east Lombok to become a potato seed production area. If this opportunity is realised it means that Indonesia will have an additional high quality seed production free from PCN to complement the existing public certified seed production.

The potato industry of NTB now has the capacity to:

- Conduct soil and fork test surveys of potato production areas to monitor PCN status of the area. Baiq Nurul Hidayah, Plant Pathologist at BPTP-NTB, was trained in the observation the extraction process using the Fenwick can and the examination of the washed organic material under stereo microscope. She was instructed in the examination of the material and how to differentiate non PCN-like spherical bodies from PCN cysts. Baiq Nurul's prior training and qualifications meant she was familiar with microscopic methods and also recognized mychorrizal fruiting bodies that can on first glance look like PCN. BPTP NTB now has all equipment and microscopes needed for further PCN survey work. In addition the five trainees who visited Western Australia in February 2010 received training in the use of the fork test to check a growing crop for the presence of PCN. This is a good way to continue to monitor the PCN status of Sembalun.
- Capacity to introduce an appropriate seed potato scheme for Sembalun. Production of seed potatoes from the paddy field area may be able to be done annually if 3 month flooding occurs during the rice production phase. The length of rotations to protect seed crops grown on terraced land still needs to be determined. In the meantime annual production at these sites may be unwise.
- BPTP, Dinas, Kelompok Horsela have capacity to train farmers in specialised seed potato techniques
- Quarantine regulations. NTB Quarantine service has the knowledge to develop appropriate regulation to reduce the risk of introducing PCN to Sembalun. Appropriate regulation may involve local movement of potatoes into Sembalun rather than restricting potatoes coming into NTB.

7.1.3 Community impacts – now and in 5 years

If seed potato production develops at Sembalun then the wealth of Sembalun area will increase. There will be more employment opportunities as potato production can increase and additional seed production work of sourcing PCN free source material, roguing, inspection, grading and marketing will need to be done. There will be community benefits outside the area and a supply of PCN free seed to other areas not yet infected with PCN will allow these areas to enjoy the benefits of potato production untroubled by the scourge of PCN.

Bapak Zukiardi (Head Horticulture, Dinas Pertanian, Sembalun Kecamatan) reported that now the Dinas Pertanian Road Map was for Sembalun to become the centre for Horticultural Development (personal communication 2009).

Economic impacts

Production of seed potatoes will produce greater income than the farmers at Sembalun currently receive from processing potatoes. A survey of 27 potato farmers at Sembalun showed that profit from Atlantic grown for processing and sold for 2,700 Rp/kg was 17 million Rp/ha (BPTP NTB 2009). If a hypothetical Granola crop is grown and half of these Granola tubers are of seed size and sold at a seed price of 5,400 Rp/kg then the profit increases to 44 million Rp/ha (Table 7.1). This includes an allowance for cool storage of one third of the seed produced for 6 months. This cost is Rp 40 /kg/day (Scott Martin, personal communication) or Rp 7,200/kg.

Table 7.1. Gross margins for Granola once-grown imported seed production at Sembalun based on Table 7.5). It is assumed that half the Granola production will be seed size. The yield and costs of Granola are assumed to be similar to Atlantic. However cool storage costs for holding seed before planting and for storing 1/3 of seed produced after harvest are included for the Granola enterprise. Seed price is set at twice the Indofood price of Rp 2,700/kg.

Budget item	Atlantic for Indofood	Granola 50:50 ware & seed & 1/3 seed cool stored
	(Sale prices shown in bold)	
Yield (t/ha) – processing or ware	21.02	10.5
Price (Rp/kg)	**2,700**	**2,700**
Income (Rp/ha)	56,757,817	28,378,909
Yield (t/ha) – seed shed stored	0	7.0
Price (Rp/kg) (2 x 2,700)		**5,400**
Income (Rp/ha)		37,838,545
Yield (t/ha) – seed cool stored	0	3.5
Price (Rp/kg) (2 x 2700 + 7,300 cool store cost)		**12,700**
Income (Rp/ha)		44,495,326
Total income (Rp/ha)	56,754,000	110,712,779
Costs (Rp/ha unless shown otherwise)		
Seed (cost/kg)*	10,500	9,450
Seed	21,564,471	19,408,024
Seed cool storage (imported seed before planting)	0	2,464,511
Fertiliser	3,716,338	3,716,338
Pesticide	7,940,392	7,940,392
Labour	6,258,650	6,258,650
Other	1,203,761	1,203,761
Cool storage 1/3 seed produced (Rp 7,300 kg for 6 months)	0	25,576,053
Total costs	40,683,612	66,567,729
Gross Margin (Rp/ha)	16,074,205	44,145,050
(AUD $/ha) (Rp 8990 = AUD $1.00, 2 Mar 2011)	1,788	4,910

* Cool stored seed price is reduced as there will be less waste.

Environmental impacts

An increased supply of PCN free seed will help maintain potato productivity without the need for nematicides or fumigants.

7.2 PCN species identification using PCR

7.2.1 Scientific impacts – now and in 5 years

The identification of the *G rostochiensis* as the species of PCN shows that biosecurity measures between potato growing areas are still useful to prevent the spread of *G. pallida* which has been previously found at Banjarnegara (Lisnawita, 2005). However only four collections have been identified in this project and more collections must be identified to get an accurate understanding of the distribution of these species.

7.2.2 Capacity impacts – now and in 5 years

The nematology team at Gadjah Mada University now have the capacity to identify PCN species using PCR.

7.3 PCN pathotype identification using indicator plants

7.3.1 Scientific impacts – now and in 5 years

The identification of the pathotype of three populations of PCN at Pangalengan, Wonosobo and Batu means that resistant varieties can be selected for testing in Indonesia. There is a potato breeding program in New York State of USA that has been breeding potatoes for resistance to *G. rostochiensis* Ro2 pathotype. These include crisp processing varieties that could be suitable for Indofood. One hurdle is that many of these Ro2 resistant potato varieties will have Plant Breeders' Rights and Indonesia as at 22/10/2009 was not a member of the International Union for the Protection of New Varieties of Plants (UPOV).

7.3.2 Capacity impacts – now and in 5 years

The pathotype tests were done in the United Kingdom. It will be important for the capacity to identify pathotypes using differential host tests to be done in Indonesia. This is because new pathotypes can emerge due to new selection pressures that may be imposed when resistant varieties are grown or when new introductions of the pest occur.

The identification of the pathotype means that the Indonesia potato variety evaluation program can now select resistant varieties from breeders worldwide for introduction to Indonesia.

7.3.3 Community impacts – now and in 5 years

Economic impacts

If commercially acceptable resistant varieties can be identified then this may prolong the potato productivity in areas that are currently affected by PCN

Environmental impacts

The introduction of potato varieties resistant to *G rostochiensis* Ro2 may provide a pesticide free way of producing potatoes in areas currently infested with PCN.

7.4 PCN population increase and decline studies

7.4.1 Scientific impacts – now and in 5 years

The population decline experiments showed that in flooded paddy soils PCN cysts and eggs are completely killed at around 30 days. This shows that seed potato grown in rotation with paddy rice that is inundated for 3 months is a rotation that protects against PCN and will eradicate the pest if it is introduced to this rotation.

The rapid death of the cysts and eggs may indicate that a factor other than flooding is contributing to the decline of the pest. There may be organisms in the paddy fields that have the ability to feed on PCN cysts and eggs. This may provide a useful research area for the biological control of PCN.

The slower decline of PCN in terrace soils indicates that rotations of longer than 180 days (6 months) are needed in these soils. At this time still around 25% of the PCN eggs were still viable. 180 days was the length of the experiment so further work is required to determine how long it take for the PCN cyst and eggs populations to decline below initial levels This information is important for improving the protecting the seed potato production areas in Indonesia. These areas have short rotations which may expose them to the risk of PCN establishment and build up. At the government seed production facility at Pangalengan the rotation is one crop of potatoes every 18 months (Fuglie *et al.* 2005) while at the similar facility at Kledung it is one crop of potatoes every nine months (Bapak Aris Munandar Head of Potato Seed Production, personal communication).

The slower decline in terrace soils means that when potato seed production regulations are introduced the terraced areas at Sembalun will require a longer rotation than the paddy fields. Initially it would be safest to restrict seed production to the paddy areas until the decline of PCN cysts and eggs in terraced sols is completely understood.

7.4.2 Capacity impacts – now and in 5 years

The nematology group at Gadjah Mada University led by Prof Mulyadi now has the capacity to investigate appropriate rotations for other potato rotations.

7.4.3 Community impacts – now and in 5 years

Enables a new, higher value seed potato industry to take place on the paddy fields at Sembalun.

Economic impacts

Enable potato farmers at Sembalun to become seed potato growers.

Social impacts

As for 7.1.3

Environmental impacts

May provide a pesticide free way of producing potatoes safe from PCN.

7.5 Communication and dissemination activities

DVD

These activities are shown in Table 7.2.

Table 7.2. Potato cyst nematode communication and dissemination activities.

Date	Personnel	Organisation & Position	Location	Activities
Mar 08	Terry Hill Julie Warren	Project Leader, DAFWA	NTB	Planning meeting NTB
Mar 08	Peter Dawson John Marshall	Seed specialist DAFWA Consultant nematologist	NTB/Central Java	Planning meeting NTB partners, Prof Mulyadi Gadjah Mada University, commence soil survey Sembalun with Kelompok Horsela
May 08	Peter Dawson	Seed specialist	NTB/Sembalun	ToT & baseline survey training
May 08	John Marshall	Consultant nematologist	NTB/Central Java	PCN survey Sembalun and training Baiq Nurul Hidayah & Prof Mulyadi Gadjah Mada University for PCR PCN species identification
Oct 08	John Marshall	Consultant nematologist	NTB/Central Java	PCN survey Sembalun and training Baiq Nurul Hidayah & Prof Mulyadi Gadjah Mada University for PCR PCN species identification
Nov 08	Kunto Kumoro Nurul Hidayah	BPTP NTB Coordinator & Plant Pathologist	Western Australia	Study Tour on seed potato production
Feb 09	Ian McPharlin	Potato agronomist	Sembalun	Farmer Initiated Learning planning
Feb 09	Prof Mulyadi Ir Nana Ranu Laksana Aris Munandar	Nematologist, Gadjah Mada Uni Director of Hort Seed Prod, Dinas Head Potato Seed Production, Kledung	Western Australia	Study Tour on seed potato production and PCN management
Apr 09	Peter Dawson	Seed specialist DAFWA	Sembalun	Review of Farmer Initiated Learning and planning for new cycle
July 09	Stewart Learmonth	Entomologist DAFWA	Sembalun	Farmer Initiated Learning planning
Nov 09	Terry Hill/Julie Warren		NTB	Project review
Feb 10	Minardi Risdun, Ir M Samsul Hedar Ir Usman Fauzi MSi Sudjudi BSc.SP	Head, Sembalun Farmers' group Treasurer, Sembalun Farmers' group Head Quarantine Office NTB Head Production Sector Laboratory Head, BPTP NTB	Western Australia	Study Tour on seed potato production and PCN management. Production of DVD about seed production techniques appropriate for Indonesia and how Sembalun aras of NTB can be kept free from PCN.
Jun 10	Peter Dawson Asep Abdie	Seed specialist DAFWA Project Reviewer	Pangandaran & Sembalun	Farmer Conference. Technical presentation by Peter Dawson included PCN findings. Project review at Sembalun
Sep 10	Terry Hill Julie Warren	Project Leader, DAFWA	NTB	Project review

8 Conclusions and recommendations

8.1 Conclusions

8.1.1 Potato cyst nematode survey at Sembalun, East Lombok

As of November 2008 PCN could not be found in the Sembalun area of East Lombok.

8.1.2 PCN species identification using PCR

The potato cyst nematode species found in three populations from East, central and West Java in Indonesia was identified as *Globodera rostochiensis* based on the morphological characters and PCR tests.

8.1.3 Pathotype identification using indicator plants

The pathotype was determined to be Ro2 using differential indicator plants.

8.1.4 Potato yield decline studies with increasing inoculum

When challenged with increasing PCN population levels Granola potato plants had decreasing plant growth especially plant dried weight and potato tuber yield. Plant dry weight declined from 42 g to 21 g as PCN population levels increased from 5 eggs/ml to 25 eggs/ml of soil. Similarly potato tubers yield had a declining trend from 998 g/plant to 778 g/plant. The decline in yield was not significant and may indicate that the damage threshold for PCN under Indonesian conditions is greater than 25 eggs/ml

The Pf/Pi ratio on the potato plants infected with PCN decreased with increasing initial population levels. The Pf/Pi ratio on the potato plants treated with PCN population levels from 5 to 25 eggs/ml of soil declined from 28.7 to 6.2.

8.1.5 PCN population decline studies

The number of viable eggs in PCN cysts in flooded paddy soil was drastically reduced by 84% within 30 days. The initial number of eggs/cyst was 464 viable eggs, but only 72 viable eggs were present at 30 days after burying the bags containing PCN cysts. The cysts and eggs of PCN seem to be susceptible to breakdown and death in flooded conditions.

Similarly the PCN populations in flooded paddy soils decreased rapidly. The number of cysts 30 days after burial decreased by more than 99% and at 60 days cysts had disappeared. The PCN population in terrace soil decreased within 30 days by 87% but then decreased only gradually. At 180 days the number of cysts decreased by about 80%

8.2 Recommendations

The lack of high quality, affordable seed potatoes may be overcome by augmenting existing seed systems with a new supply chain that based on PCN free imported seed which is bulked up once-only in isolated and PCN free areas. The once-grown seed would then be distributed to PCN free potato production regions in order to help these areas maintain freedom from this pest.

The Sembalun area in East Lombok is one suitable area for this idea to be tested. For this area to become a commercial seed potato production it is recommended that the following actions be completed:

- Regulations to control potato movement into Sembalun are enacted.
- Seed potato scheme introduced to Sembalun
- Establish internationally acceptable Plant Breeders' Rights or equivalent system to allow testing of new PCN resistant cultivars.
- Enablement of commercial scale importation of Granola from PCN free areas to be used as the basis of a once-only bulking seed system.
- A commercial scale test of a seed supply chain based on imported seed from areas known to be free from PCN that is once-bulked in Sembalun before distribution to commercial potato growers in PCN free areas outside NTB.
- Survey other potential seed supply areas like South Sulawesi and North Sulawesi (Manado) to determine their PCN status and whether these areas will also appropriate for PCN free seed potato production.
- Test more PCN populations for species and pathotypes
- Develop capacity to test pathotypes in Indonesia.
- Establish relationship of damage threshold and PCN multiplication rates in differing locations and Pi levels.
- Conduct further, longer duration population decline experiments in common potato soils to determine appropriate length of rotations on soils types on which potatoes are commonly grown.
- Investigate rapid decline of PCN cysts & eggs in highland paddy soils to elucidate the mechanism causing the rapid decline with the view of identifying whether a biological control agent or method exists.

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Final report appendix 6

title	AGB/2005/167 Potato seed system development - WA seed supply chain analysis
prepared by	Andrew Taylor and Ian McPharlin
co-authors/ contributors/ collaborators	Rachelle Crawford David Tooke

1 Executive summary

The Western Australian seed potato industry aims to become a world renowned producer of high quality seed free of pests and diseases. The quality of seed potatoes can be reduced through mechanical damage at harvesting as they are more susceptible to disease as there are more entry points for the disease through the cut surfaces on the tuber. Key areas of the harvesting process that lead to mechanical damage and bruising of tubers in the Western Australian seed system have been identified. The level of damage seen on tubers is variable between growers. Despite the use of different harvesters, five impact points were common amongst all machines. These were (1) sites of tuber drops, and changes in belt (2) direction and (3) speed as well as (4) contact with other potatoes and (5) debris. Impacts ranged from low (< 50 G) to extremely high (> 200 G) during harvesting with the majority in the medium range of 50 – 100 G. Maximum drop heights of 10 - 15 cm are considered the industry standard above which damage is likely to occur but cultivars differ in their susceptibility to bruising.

Of all the impacts recorded, the site which consistently recorded the highest impact was the drop from bunker to bin. This site recorded the highest impacts as it had the highest drop point and the greatest number of tubers involved. To reduce this impact and therefore bruising and damage of potatoes it is necessary to change the way this occurs on harvesters by attaching padding or by changes the operator process.

Previous research has found that varieties differ in their susceptibility to damage and bruising as is the case in this study. Three varieties were harvested during the study; Atlantic, Bliss and Granola, with Atlantic being highly susceptible to bruising and Granola being tolerant. The knowledge that cultivars differ in susceptibility can be used by farmers to modify their harvesting practices to produce higher quality tubers.

Temperature at harvest is a key factor in the level of tuber bruising at or after harvest; generally the lower the tuber temperature the higher the level of bruising. The growers in this study harvested at a range of temperatures between 8.4 °C to 18.4 °C. Management of soil temperature during the crop was also varied with some growers having large variations between their minimum and maximum soil temperatures. Use of soil monitoring units will help aid growers in maintaining a relatively constant soil temperature and therefore minimise bruising.

2 Background

One aim of the Western Australian potato industry is to become a world renowned producer of high quality potato seed due to the state's freedom of many important potato pests and diseases. For example WA claims area freedom for potato cyst nematode, potato late blight, bacterial wilt and leafminer (*Liriomyza huidobrensis*). In addition to disease freedom, high quality seed potatoes need to be free from bruising. Bruising and mechanical damage caused during harvesting increases tuber susceptibility to breakdown and can lead to rots in storage and poor seed piece performance. The increased susceptibility to disease is due to the cut surfaces on the tuber providing entry points for pathogens. This is exacerbated if the cut surfaces are not properly cured (Morris *et al*. 2000). The amount of damage on a tuber is a result of a combination of factors including; cultivar, crop growing conditions, operating conditions at time of harvest and the level of technology used at harvest (Peters 1996).

There are two types of potato bruises: black spot and shatter bruise. Black spot bruise involves the damage of the tuber's cell contents and requires the tuber to be peeled to be visible (Henderson and Bennet 1999). Black spot bruise does not break the skin and results in a blue-black discolouration below the surface (Hyde *et al.* 1992). Shatter bruise involves damage to cell walls and breaks in the skin that are visible as cracking on the tuber surface (Henderson and Bennet 1999). The tissue around the crack also turns blue-black (Hyde *et al.* 1992). Shatter bruise can extend to the centre of the tuber and the broken skin is an ideal entry point for diseases (Henderson and Bennet 1999) that lead to deterioration of seed potatoes.

Environmental conditions which can affect potato bruising are under-irrigation, or dry soil, which leads to increased incidence of, black spot bruise while over-irrigation, or wet soil, has been associated with increased incidence of both black spot and shatter bruise in tubers.

One method used in potato supply chains overseas to measuring physical damage to tubers is the use of an instrumental sphere (IS) (Van Canneyt *et al.* 2003, Molema *et al.* 2000a, Hyde *et al.*1992, Lopresti and Thomson 1998). An IS can identify areas and locations along the supply chain where impacts occur at forces that lead to tuber damage. Identification of high impact locations enables the grower to modify the equipment or the speed at which the harvest or other handling operation occurs to minimise damage to tubers. The IS hasn't previously be used to measure harvest impacts in WA seed crops under local soil and climatic conditions.

We aim to review and analyse the production of seed potatoes in WA with an IS to determine where improved practices may be introduced to improve seed potato quality.

3 Objectives

One of the objectives of the project was to review the current seed production systems of the Western Australian potato industry under activity 2.5: Development of suitable training materials on quality seed propagation. The amount of damage on a tuber is a result of a combination of factors including; cultivar, crop growing conditions, operating conditions at time of harvest and the level of technology used at harvest (Peters 1996). The aim of this study was to identify how these factors affect the quality of WA seed potatoes.

4 Methodology

4.1 Site Location:

Crops analysed during this study were grown from Albany and Scott River on the South Coast of WA to Yarloop, north of Harvey as well as Manjimup and Pemberton (Table 4.1). Six seed potato crops were examined (4 Atlantic, 1 Bliss and 1 Granola).

Table 4.1: Details of crops investigated in this study including cultivar and crop location with GPS coordinates.

Crop number	Cultivar	Location	Position
1	Atlantic	Manjimup	34.15 S, 116.06 E
2	Atlantic	Pemberton	34.30 S, 116.00 E
3	Bliss	Pemberton	34.30 S, 116.00 E
4	Granola	Scott River	34.16 S, 115.12 E
5	Atlantic	Albany	35.02 S, 117.54 E
6	Atlantic	Yarloop	33.00 S, 115.93 E

4.2 Procedure

During harvest the IS was buried in the hill and harvested as a tuber would and all impacts from the soil to the bin stage of the harvesting process were recorded. For those harvesters with a bunker, the bunker drop to bin was performed separately. This information was instantaneously transferred via a sensor to a portable computer. Each harvest run and bunker to bin drop was attempted twenty times for statistical purposes. The information was downloaded onto a desk computer and statistically analysed. Soil moisture and temperature were automatically monitored through the harvest period.

4.3 Crop management

The six seed crops were managed by four different farmers and were planted in December 2009 and harvested from March to May 2010 (Table 4.3). Three different models of Grimme harvesters were used for the harvesting (Table 4.3) and each are described in more detail below.

Table 4.3: Crop planting date, harvest date and type of harvester used.

Crop number	Planting Date	Harvest Date	Harvester type
1	2/12/09	11/03/10	Grimme 75 series
2	14/10/09	8/03/10	Grimme SF series
3	14/10/09	15/03/10	Grimme SF series
4	19/12/09	14/04/10	Grimme GT series
5	15/12/09	15/04/10	Grimme 75 series
6	20/12/09	4/05/10	Grimme GT series

The harvesters used in Crops 1 and 5 were Grimme 75 series single row harvesters towed behind a tractor. The plan view of the harvester is seen in Figure 4.3. Sites where tubers change direction and or drop during harvesting are identified as below:

1. First short main web onto diviner web
2. First separator
3. Second separator
4. Bunker filling elevator drop
5. Bin filling from bunker drop

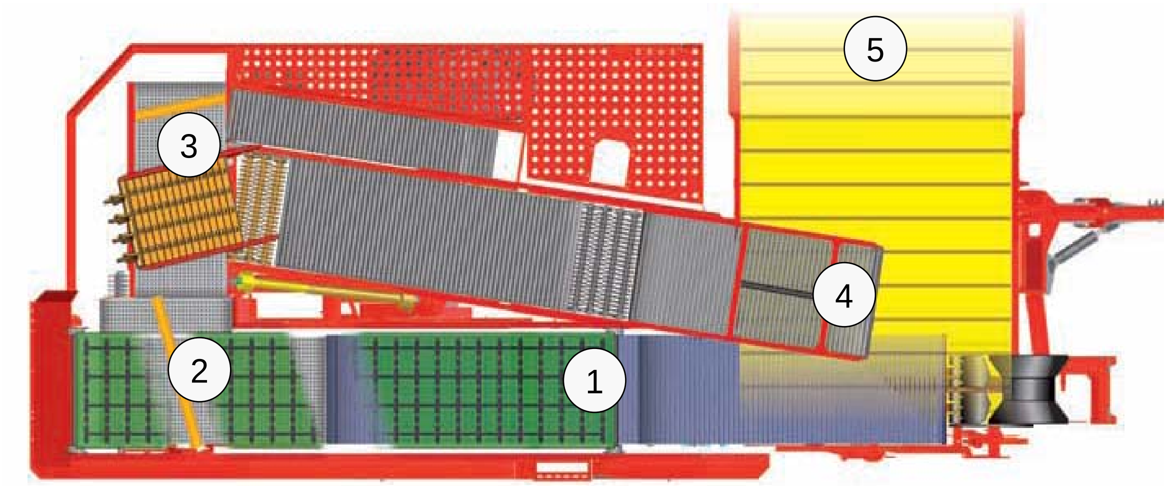

Figure 4.3. Overview of a Grimme 75 series harvester indicating impact points.

The harvesters used in Crops 2 and 3 were Grimme SF series twin row self propelled harvesters. The plan view of the harvester is seen in Figure 4.4. Sites where tubers change direction and or drop during harvesting are identified as below:

1. 1st short main web onto diviner web
2. Main web
3. 1st double extraction roller
4. 2nd double extraction roller
5. Bunker filling elevator drop
6. Bin filling from bunker drop

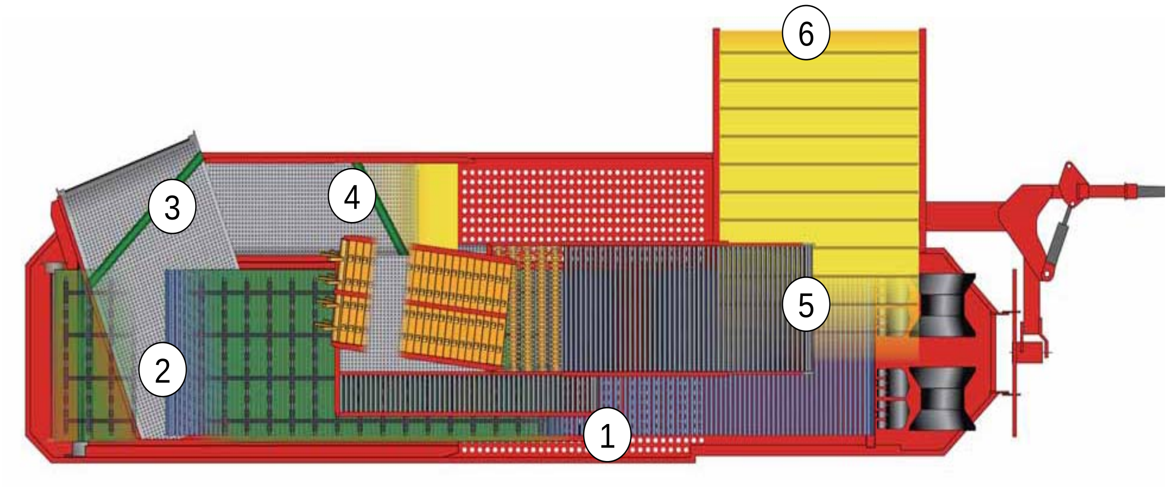

Figure 4.4. Overview of a Grimme SF series harvester indicating impact points.

The harvesters used in Crops 4 and 6 were Grimme GT series 2 row trailed harvesters. The side view of the harvester is seen in Figure 4.5. Sites where tubers change direction and or drop during harvesting are identified as below:

1. Intake web onto first main web.
2. First main web onto second main web.
3. 2nd main web onto star roller separator.
4. Transfer web to cart elevator
5. From elevator to bin.

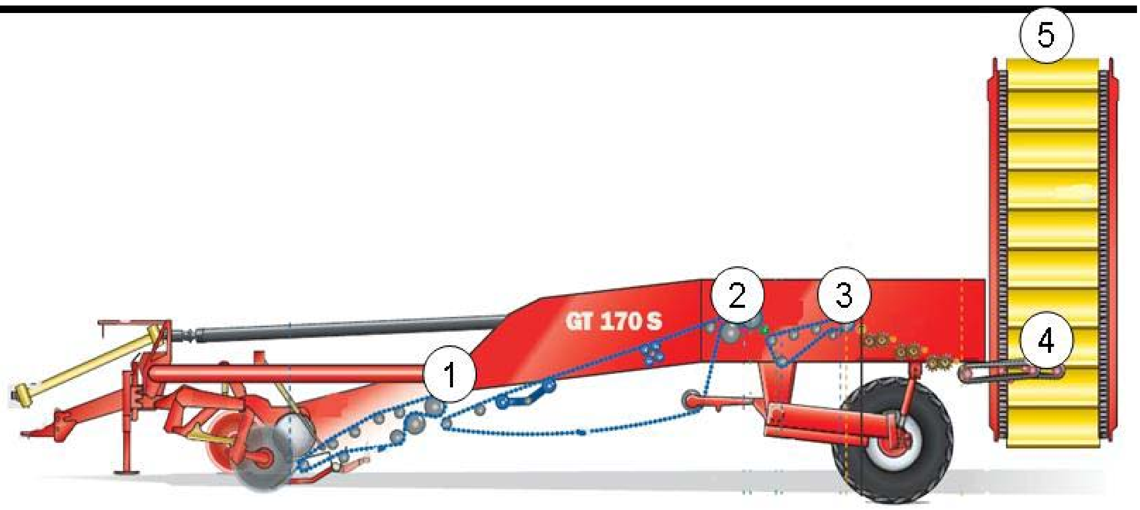

Figure 4.5. Sideview of a Grimme GT series harvester indicating impact points.

4.4 Measurements:

4.5 Instrumental sphere and calibration.

The IS used was designed and manufactured by Sensor Wireless Inc and is known as the Smart Spud™. This IS contains a tri-axial (x, y, z-axis) accelerometer that measures changes in acceleration over time and reports this as peak acceleration in gravitational (G) forces. The information from the Smart Spud™ is recorded via a receiver and sent to a portable computer where the data can be downloaded. G is a measurement of gravitational units where 1 G = 9.81 m/s^2. The higher the level of G force measured the higher the severity of the impact. Both round and oblong polyethylene casings can be used with the Smart Spud™ depending on what shape of potato is to be harvested.

The Smart Spud™ was calibrated to the bruise type and severity of Atlantic and Granola potatoes grown under WA conditions. Both varieties were dropped from incremental 10 cm heights up to 100 cm using a pendulum device (Mathew and Hyde 1997). There were 10 replicates per drop height and both the bud and stem end were impacted. 48 hours after using the pendulum the potatoes were examined and peeled to determine type of bruise and severity (Henderson and Bennett 1999). The same Smart Spud™ was used with the same round polyethylene casing in this study to keep the results consistent.

4.6 Soil moisture, irrigation and temperature monitoring:

Volumetric soil water (% v/v) was monitored automatically at 3 depths (0-15, 15-30 and 30 cm) and 15 minute intervals using stainless steel volumetric water content probes (Campbell Scientific, SC 625, based on time domain reflectometry (TDR)) inserted at 30 degrees at 0 - 15 and 15 - 30 cm or horizontally at 30 cm in the soil early post planting and prior to crop emergence. Soil temperature was monitored automatically at a depth of 15 cm using a separate temperature probe (109 L) whilst rainfall and irrigation was recorded in 0.2 mm increments using a 'tipping bucket unit (*Ecowatch*® 7852). A tensiometer (Irritrol ®) placed at 30 cm soil depth was used to measure soil tension in kPa via a pressure transducer. The tension measured at 30 cm was correlated with volumetric soil moisture measured by the TDR probe inserted at 30 cm horizontally as described above. All the monitoring units were connected to a logger (CR 200) via a cable and data downloaded via a telephone modem (Maxon 5100). Computer software 'R-Logger', developed using the freely available 'R' program, allowed irrigation timing, depth and soil moisture to be summarized via a graphical interface and emailed as a PDF to participating growers. The unit was powered by a 7.5 Ah, 12 volt sealed lead acid battery recharged by a 10 watt solar panel and all components were housed in a safe case. At the time of harvest the current soil temperature was directly measured using a hand held temperature probe.

4.7 Data analysis

From the calibration of the IS and potato varieties grown under WA conditions the G force readings can be grouped into the following thresholds:

Low impacts: < 50 G

Medium impacts: 50 - 99 G

High Impacts: > 100 – 1149 G

Very high impacts: 150 – 199 G

Extremely high impacts: >200 G

Analysis of variance (ANOVA) and non linear regressions were performed on the data to determine whether there was any difference between growers, difference between harvest speeds and growers, relationship between temperature and level of bruising and the relationship between grower harvest speed and level of bruising.

5 Achievements against activities and outputs/milestones

Objective 2: Develop and implement low-cost schemes that significantly improve the access of Indonesian farmers to quality potato seed.

no.	activity	outputs/ milestones	completion date	comments
2.5	Development of suitable training materials on quality seed propagation for capacity building of seed producers, and on benefits and use of quality potato seed for potato growers	Appropriate training materials available to seed producers	Survey completed 2010	Review current Indonesian and Australian seed production systems and findings of baseline survey. Survey report produced identifying key areas of impact along supply chain. Develop appropriate training materials. Results of surveys presented to workshops in 2009 and 2010. Information presented to industry at association meetings

PC = partner country, A = Australia

6 Key results and discussion

6.1 Results

6.1.1 Varietal differences in response to impacts

Black spot bruise began appearing on the Atlantic seed at a 20 cm drop height and progressively increased until 60% of tubers were damaged at 60 cm (Figure 6.1). After this maximum black spot bruise fell to 0% at 100 cm. Shatter bruise was first seen at a 50 cm drop height and then rapidly increased to 100% at 80 cm. Granola seed did not show any bruising until 60 cm where both black spot and shatter bruise appeared and progressively increased until 100% of the seed were affected at 90 cm drop heights (Figure 6.2).

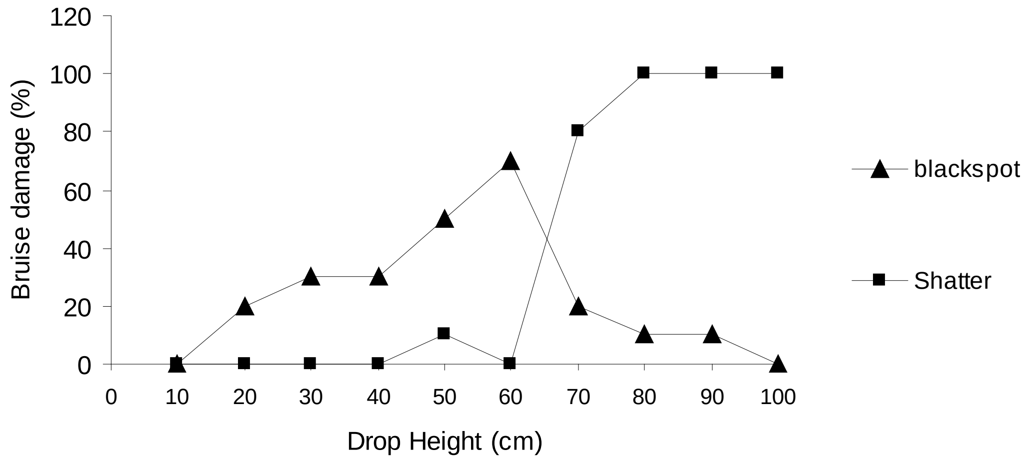

Figure 6.1: Black spot and shatter bruise of Atlantic tubers at each drop height.

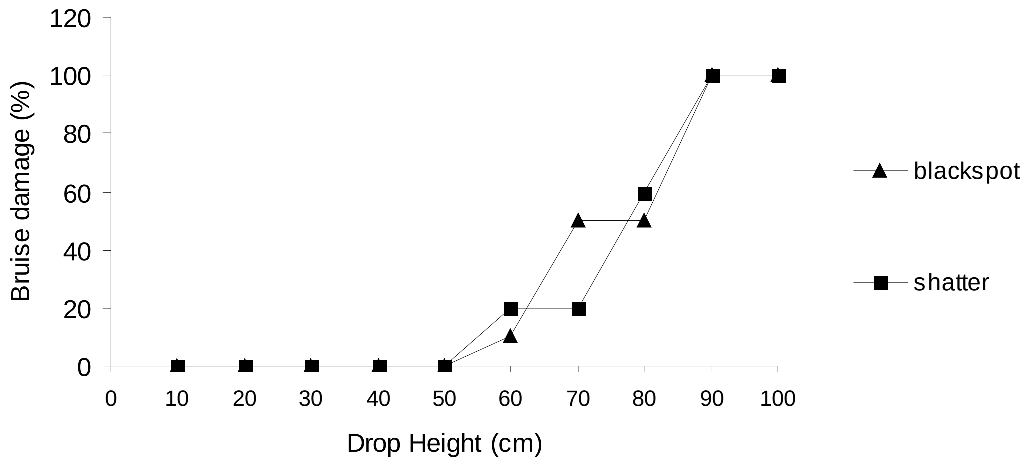

Figure 6.2: Black spot and shatter bruise of Granola tubers at each drop height

6.1.2 Instrumental sphere calibration

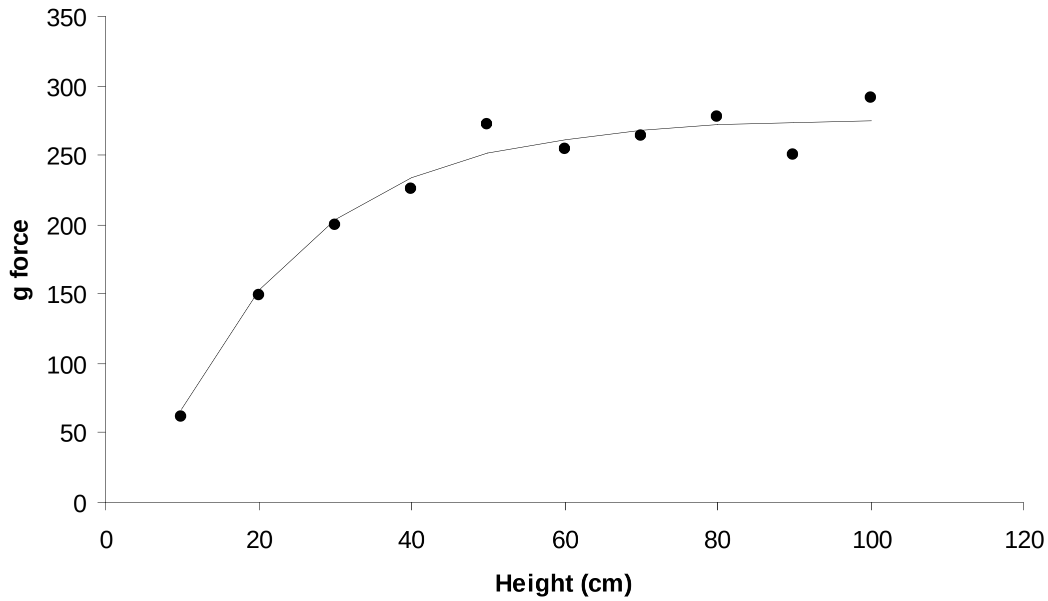

Figure 6.3: The G force readings from the Smart Spud™ with the round casing at each height increment and line of best fit y = 276.62 - 365 exp(-0.053x), R^2 = 96.

The Smart Spud™ was calibrated at each height and indicated at 10 cm a value of approximately 50 G (Figure 6.3). Initially as drop height increased G force increased rapidly until the 50 cm drop height where any subsequent increase in drop height did not correspond with a large increase in G force. As a result an exponential curve could be fitted to the data to predict the G force for any subsequent drop height.

6.1.3 Instrumental sphere and variety

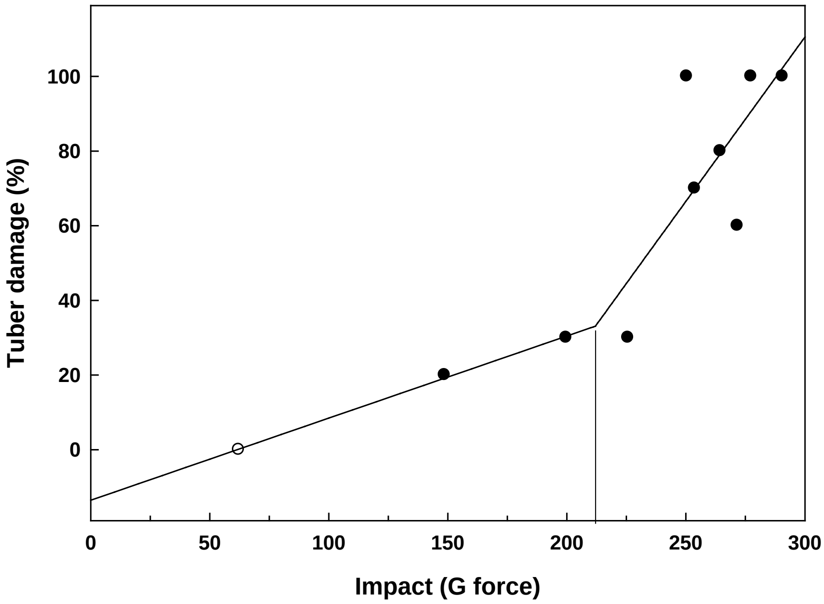

Figure 6.4. Relationship (2 split lines) between tuber impact (G force) and % bruising in Atlantic tubers with a pulp temperature of 15°C. The vertical line intercepts the x axis at the level of impact (212 G) above which significant tuber damage is first observed (threshold). Equations:

for line 1; y = 33.1 + 0.22 (x - 212) where x < 212 and

for line 2; y = 33.1 + 0.88 (x - 212) where x > 212 (R^2= 0.7).

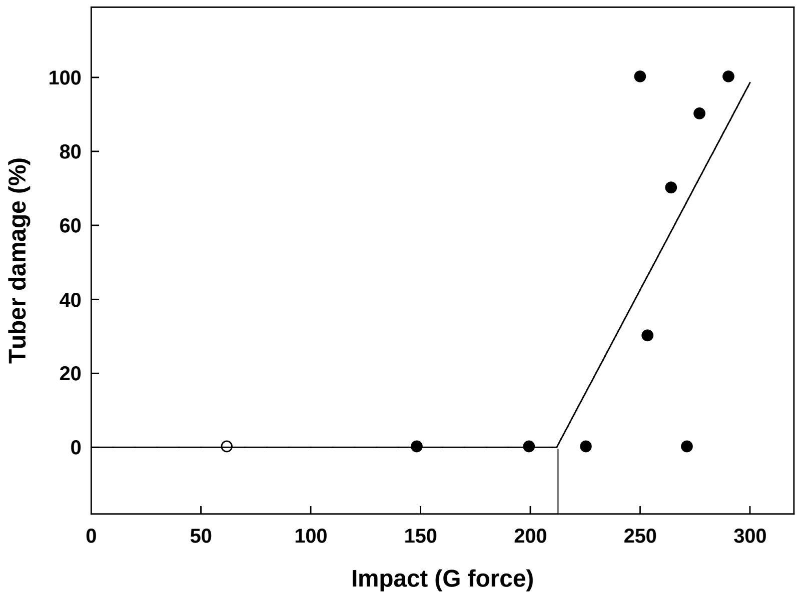

Figure 6.5. Relationship (2 split lines) between tuber impact (G force) and % bruising in Granola tubers with a pulp temperature of 15°C. The vertical line intercepts the x axis at the level of impact (212 G) above which tuber damage is first observed (threshold). Equations:

for line 1; y = 0 where x < 212 and

for line 2; y = 1.12 (x - 212) where x > 212 (R^2= 0.30).

6.1.4 Crop harvest and post-harvest measurements

Atlantic

Averaging the combined data for Atlantic shows there were 18 harvest runs and 15 bunker drops per farmer (Table 6.3a). Average time taken for the IS to travel through the harvester was 50 seconds and the average temperature was 11.7 °C. The bruising of the Atlantic tubers can be predicted from these results using the equations shown in Figure 6.4. Predicted percentage of tubers bruised was 4.0% with a range from 1.9 to 6.7%.

Table 6.3a. Instrumented sphere harvesting measurements of 5 individual Atlantic crop plus mean values during harvesting. The average acceleration is used to predict the percentage of tubers bruised using the equations shown in Fig 6.4.

Measurement	Crop					Mean
	1	2	5a	5b	6	
Harvester						
No. runs	20	23	12	16	20	18
No. impacts > 50 G	16	22	6	9	42	15
No. imp > 50 G/run	0.8	1.0	0.5	0.6	2.1	0.8
Bunker						
No. runs	21	17	22	15		15
No. impacts > 50 G	42	20	20	10		10
No. imp > 50 G/run	2.0	1.2	0.9	0.7		1.2
Combined Harvester and bunker						
No. impacts > 50 G	58	42	26	19	42	37
No. imp > 50 G/run	1.4	1.1	0.8	0.7	2.1	1.2
Average acceleration (G)	81	82	74	77	92	81
Predicted bruise % (From Fig 6.4)	4.3	4.5	2.7	1.9	6.7	4.0
Avg time per run (sec)*	49	43	49	40	67	50
Tuber harvest temp (°C)	18.4	12.4	8.4	8.4	11.1	11.7

Granola

The Granola data shows of the 22 harvest runs (Table 6.3b) the average time taken for the IS to travel through the harvester was 52 seconds and the temperature was 11.1 °C. The bruising of Granola tubers can be predicted using the equations shown in Figure 6.5. Predicted percentage of tubers bruised was 0%.

Table 6.3b. Instrumented sphere harvesting measurements of one Granola crop during harvesting. The average acceleration is used to predict the percentage of tubers bruised using the equations shown in Fig 6.5.

Measurement	Crop 4
Harvester	
No. runs	22
No. impacts > 200 G	0
No. imp > 200 G/run	0
Bunker	
No. runs	
No. impacts > 200 G	0
No. imp > 200 G/run	0
Combined Harvester and bunker	
No. impacts > 200 G	0
No. imp > 200 G/run	0
Bruising of sample (%)	60
Predicted bruise % (From Fig 6.5)	0
Avg time per run (sec)*	52
Tuber harvest temp (°C)	11.1

Crop verses G force > 50.

The majority of impacts greater than 50 G on the harvesters were 50-99 G or medium range impacts, with Crops 2, 3, 4, 5a, 5b all recording 100% impacts in this range (Figure 6.6, top graph). Crop 6 had impacts on the harvester that were in the 100-149 G, 150-199 G and > 200 G ranges and this lead to the average of all crops being represented in those ranges. The higher impacts detected in crop 6 led to the highest predicted bruise level for Atlantic of 6.7% of tubers bruised (Table 6.3a).

Only Crop 3 had 100% of bunker drops in the 50-99 G range whilst Crops 4 and 6 are not represented as there was no bunker on the harvester (Figure 6.6, middle graph). Crop 5b had the highest number of impacts > 200 G for the bunker drop whereas Crop 2 had 35% of impacts in the high impact range (100-149 G). Crop 1 and 5a had impacts in the very high impact range (150-199 G). Crop 5b used the same machinery as crop 5a, the difference was a faster harvester driver. The predicted bruising for these crops was 1.9% and 2.7% respectively showing that a change of operator can increase bruising by 142%.

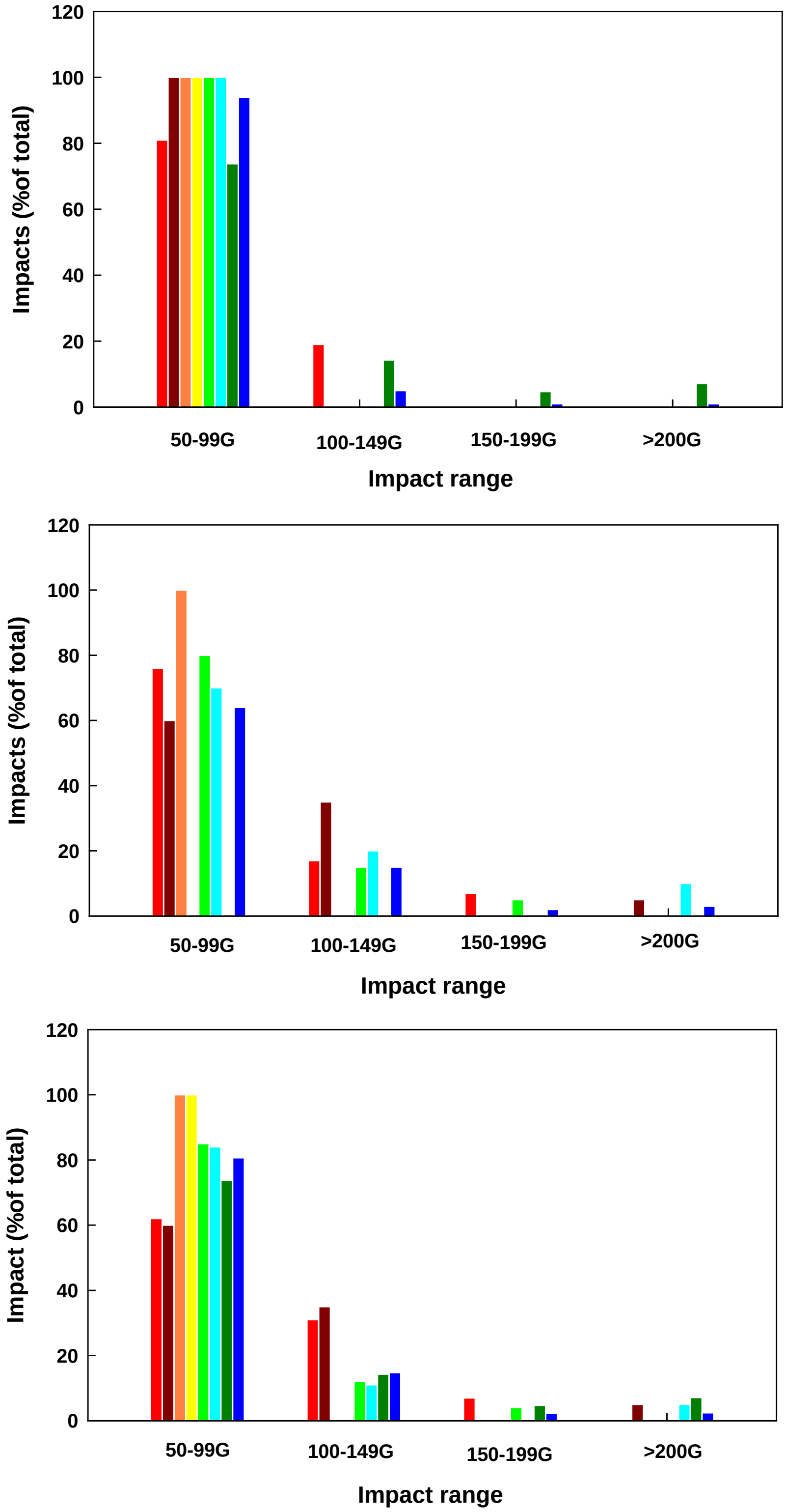

Figure 6.6. Percentage of impacts greater than 50 G from the harvester (top graph), from the bunker (middle) and the combined (bottom) for the 6 different crops. Separate colours represent separate growers with Crop 1 = red, Crop 2 = brown, Crop 3 = orange, Crop 4 = yellow, Crop 5a = light green, Crop 5b = turquoise, Crop 6 = dark green, Average = dark blue.

There were significant differences between growers and the combined number of impacts greater than 50 G per run for the harvester and bunker drops (P = 0.001) (Figure 6.7). Crop 6 had significantly higher number of impacts > 50g than any other crop with 2.1

impacts, followed by Crops 1 (1.4 impacts) and 2 (1.1 impacts). Crops 3 (0.4 impacts), 4 (0.4 impacts) and 5 (0.8 and 0.7) impacts were not significantly different to one another but were significantly lower than Crops 6, 1 and 2.

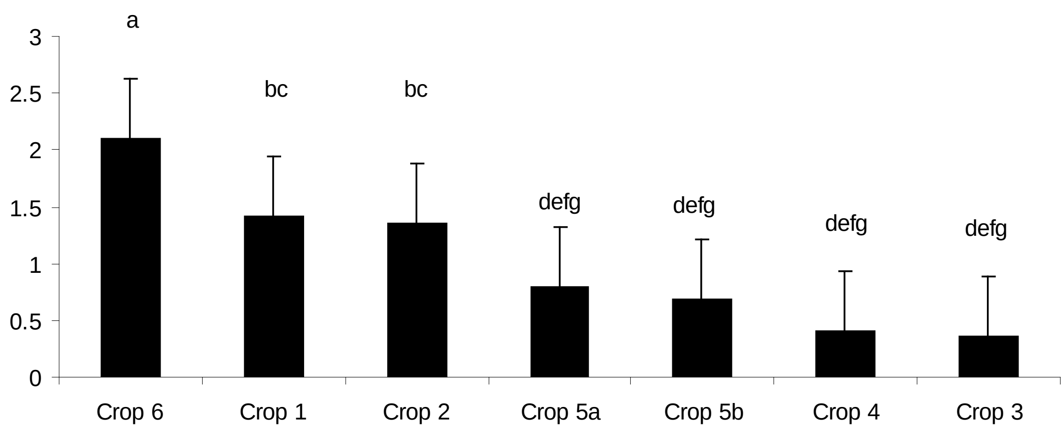

Figure 6.7. The average number of combined impacts >50 G per run for all crops. LSD = 0.53

Bunker versus harvest.

There is a significant difference between the number of impact events greater than 50 G at the bunker drop compared with the harvester impacts for all crops (p = 0.039) (Figure 6.8). The bunker to bin drop averaged 1.2 impacts of >50 G every drop whereas the harvester only averaged 0.89 impacts >50 G every run.

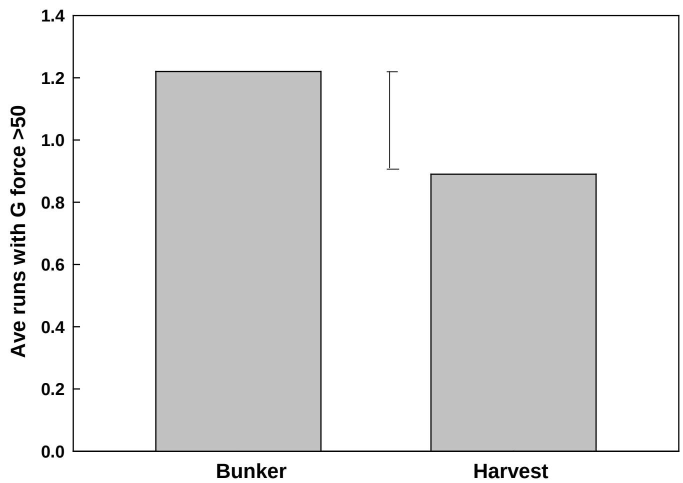

Figure 6.8. Average impacts > 50 G for the bunker to bin drop and the harvest runs for all crops. LSD = 0.31.

Soil temperature, moisture and tension.

Crop 6 had the highest mean soil temperature of the crops in the study at 21.5 °C and a highest soil temperature of 30.6 °C (Table 6.4). All crops had a mean soil temperature of between 19.2 and 21.5 °C. Crop 2 had the highest soil moisture of 35.2% with a mean of 21.8% and this meant had the highest soil tension at -10.2 kPa. Crop 5 was the driest at only 8.3% soil moisture with the lowest tension at – 37.5 kPa.

Table 6.4. The mean, median, minimum and maximum soil temperature, moisture and tension for all 6 crops.

Measurement	Crop 1	Crop 2	Crop 3	Crop 4	Crop 5a,b	Crop 6
Temp (°C)						
Min	13.7	5.8	13	15.8	15.2	14.7
Max	28.8	41	27.4	24.9	23	30.6
Mean	20.5	19.3	19.2	19.9	19.8	21.5
Median	20.1	19.6	19	19.9	20	21.4
Soil moisture (%)						
Min	7.8	16.4	8.8	12	4.9	10.7
Max	18.8	35.2	24.7	29	17.5	28.2
Mean	10.8	21.8	13	16.6	8.3	14.8
Median	10.3	21.2	12.6	16.6	6.5	14.3
Soil tension (kPa)						
Min	-86	-68	-58	-78	-59	-67
Max	-15.1	-0.06	-13.4	-1.1	-1.2	-0.6
Mean	-29.5	-10.2	-13.4	-15	-37.5	-23
Median	-22.8	-7.6	-11.6	-16.5	-50	-19

6.2 Discussion

Three different types of harvesters were used in the study and based on the IS data 4 to 5 impact points were identified for each, excluding the bunker drop. These impact points occurred where there was a change in direction of the chains or a drop greater than 10 cm leading to the tubers either bumping into each other or the guards surrounding the chains. This lead to impacts ranging from 50 G or 10 cm drops to > 200 G or the equivalent of a 30 cm drop for some of the crops. It is recommended that tubers are not dropped from heights greater than 10 – 15 cm as this is the standard industry bruise height (Blaesing and Kirkwood 2004) but this will differ with the differing susceptibility of cultivars. Our calibrations of bruising in the cultivars Atlantic and Granola against drop height show that the impacts points observed would cause damage to Atlantic but not Granola.

The bunker drop had significantly larger G force readings than the harvester readings. The bunker drop consistently produced G force readings > 50 G and three of the crops with > 200 G, indicating that the bunker drop represents a significant damage point for seed potato producers.

Three different cultivars were harvested during the study. Using a pendulum bruising device similar to that used by Mathew and Hyde (1997) on WA grown Atlantic and Granola tubers it was found that Atlantic is highly susceptible to bruising (Figure 6.1) whilst Granola was more tolerant (Fig 6.2). This confirms tests done for bruising susceptibility under European growing conditions for both Atlantic and Granola. Atlantic was found to be moderately resistant to external damage and low to medium resistant to internal bruising (European cultivated potato database 2010). Granola on the other hand was found to be resistant to very resistant to external damage and shows medium to very high resistance to internal bruising (European cultivated potato database 2010). Hence growers in WA will need to adjust their machinery according to the variety in which they are harvesting to prevent potential loses associated with bruising.

It is recommended that soil temperature at harvest should be between 10 and 18 °C to avoid excess bruising (Blaesing and Kirkwood 2004). The soil temperatures at harvest ranged from 8.4 °C to 18.4 °C during this study and therefore some growers were harvesting outside the recommended guidelines.

The results of this study indicate that harvest damage to seed potatoes was in the range of 1.9 to 6.7% for Atlantic. This variability is the result of differences in growth conditions of the plants, mechanical equipment used, operators of the equipment as well as the conditions of the soil at the time of harvest. The majority of damage recorded was in the medium impact range (50-99 G) for all crops.

Seed potato growers in WA have several options available to minimise the bruising seen on tubers. The first is to assess impacts by using an IS and to make adjustments to machinery to reduce the size and number of these impacts through physical modifications to their machinery or through refinement of the operating settings. During this study we found an assessment of a harvester would take approximately 3 hours. Other ways to minimise damage includes described removing as much soil as possible on the primary chain and loading the rear cross, elevator and boom chains to capacity so that tubers cushion each other (Blaesing and Kirkwood 2004). Removal of soil on the primary chain is a plausible option for seed potato growers in WA using any one of the three machines examined in this study; it would just require the machine operator to be closely aware of soil moisture content, soil texture and weeds. A more difficult task would be to ensure the chain capacity of tubers as this requires training harvester operators, many of whom are casual backpacker workers, in maintaining chain speed in the harvester whilst determining the optimum level of tubers on the chains and continuing to sort the tubers.

7 Impacts

7.1 Scientific impacts

The IS survey results show opportunities for growers to develop better harvest management techniques to improve seed potato quality particularly in the area of chain speed.

Cultivar susceptibility is a major factor in the level of bruising and mechanical damage that appears on tubers. Different cultivars are grown under WA conditions and the results from this study and previous research reveals that they differ considerably in their susceptibility to bruising.

Soil temperature and tuber temperature were found to differ vastly between growers and crops. Although some of this appears to be the result of different soil type it is apparent that soil temperature is managed differently through irrigation in WA and this has an effect on the level of bruising and mechanical damage seen on the tubers. Several growers had large differentials between their minimum and maximum soil temperatures during the crop and this is an area where efficiency can be gained through more education and the use of soil moisture monitoring equipment.

Of the damage recorded during harvesting the largest impacts were recorded from the bunker drop to the bin. It was consistently found that the impacts at this site were in the high G force range for the majority of growers. Improvement in the handling of potatoes in this area to minimise impacts would represent a significant step towards reducing mechanical damage of tubers in the WA supply chain.

7.2 Capacity impacts

By highlighting the areas where damage or potential damage can occur, this study has increased the capacity of WA seed potato growers to produce higher quality seed potatoes. Growers will be more aware of the impact of harvester set-up, variety, soil management and irrigation techniques on the level of mechanical damage seen on tubers and potential this has on yield and market development. Results of the study have been presented to growers. The IS team will be available to WA seed potato growers who wish to assess their harvesting operations.

7.3 Community impacts

This study will lead to a more efficient and productive seed potato industry for WA. Improved efficiency and productivity will lead to an industry with a reputation as an internationally recognised producer of high quality seed potatoes. Results of this will be increased seed potato sales interstate and internationally.

7.4 Communication and dissemination activities

Table 7.4. Analysis of WA seed supply chain communication and dissemination activities.

Date	Personnel	Organisation & Position	Location	Activities
May 09	Andrew Taylor	Plant pathologist	Perth	Present research information to the potato industry development council
Aug 09	Andrew Taylor Rachelle Crawford	Plant pathologist Development Officer	Bunbury	Grower and industry meeting outlining key achievements and results of study.
Oct 10	Rachelle Crawford	Development Officer	Bunbury	Grower and industry meeting outlining key achievements and results of study.

8 Conclusions and recommendations

8.1 Conclusions

This study was successful in identifying the areas of impact during harvesting that lead to bruising and mechanical damage of potato tubers. Bruising and mechanical damage is variable in WA depending on the cultivar grown, irrigation, soil management, temperature control and harvester type.

8.2 Recommendations

Investigate the use of padding material to prevent impacts > 50 G from occurring at the bunker to bin drop. Padding will reduce the drop height of impacts and therefore minimise the level of G forces applied to the tubers and reduce bruising and mechanical damage.

Growers will be aided by the use of more soil temperature monitoring equipment to maintain soil temperature between the recommended 10 and 18°C. The monitoring units will provide constant feedback to growers that enable them to manage soil temperature more efficiently using irrigation practices. Soil temperature monitoring units will also aid growers in determining that tuber temperature at harvest is within industry recommendations to prevent further bruising.

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10 Attachments

10.1 Annex 1:

Crop 1

The results of the impact severity are presented in Tables 6.2, 6.3 and 6.4. Of the total impacts from the harvester 16 were greater than 50 G which equates to 0.8 ≥ 50 G impact every run on average (Table 6.2). Forty percent of total runs had an impact of medium severity and 15% of runs recorded a high impact. Of the impacts greater than 50 G 81% were in the medium range (50 – 99 G) and the remainder 19% were high (100-149 G) (Figure 6.10). Maximum impact recorded from the harvester was 112 G.

Impacts from the harvester bunker to the bin recorded 42 impacts greater than 50 G which equates to 2 impacts >50 G per run on average (Table 6.3). Of the 21 bunker drops 57% were recorded as a medium impact, 19% a high impact and 14% a very high impact. Seventy six percent of impacts greater than 50 G were medium impacts, 17% were high and 7% were very high (Figure 6.10). The highest impact recorded was 181.6 G.

When the harvester data and bunker data was combined there were 58 recordings of impacts >50 G (Table 6.4). The percentage breakdown of runs where the various impacts occurred is presented in Figure 6.10.

On average it took 49.35 seconds for the Smart Spud™ to travel from the short main web to the drop into the bunker; location 4 on Figure 6.1. At the time of harvest the internal tuber temperature was approximately 18.4°C.

Soil conditions

The topsoil (0-15 cm) was classified as a sandy loam with 73% sand, 19% clay, 8% silt and field capacity (FC) of approximately 30% (v/v).

Temperature

The mean soil temperature at 15 cm was 20.5 °C, (median 20.1 °C) and the range from a minimum of 13.7 °C on the 04/02/10 to a maximum of 28.8 °C on the 28/12/09 (Figure 6.2)

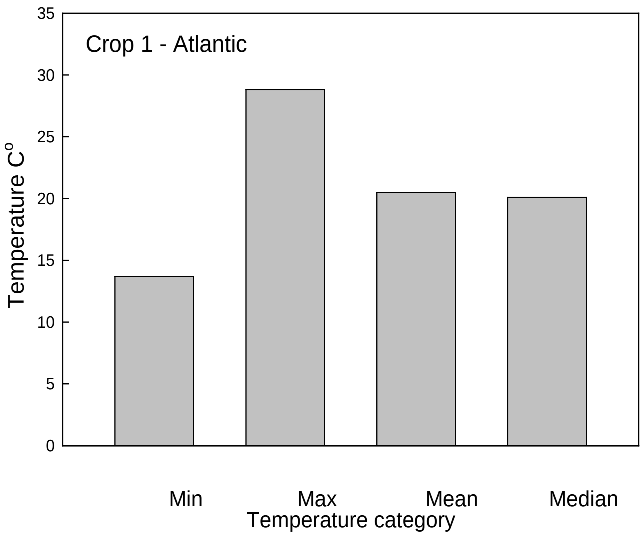

Figure 6.2. Soil temperature information for crop 1.

Soil moisture and tension

Mean volumetric soil moisture at 15cm depth on the site was 10.8%, the median 10.3% and it ranged from a minimum of 7.8% on the 07/02/10 to a maximum of 18.8% on the 18/01/10. Key soil moisture data is also available for other depths (attachment).

Mean soil tension at 15cm depth on the site was -29.5 kPa, the median -22.8 kPa and it ranged from a minimum of -86 kPa on the 08/02/10 to a maximum of -15.1 kPa on the 13/01/10. Soil tension was less than -40 kPa 15% and -20 kPa 60% of the crop period.

Crop 2

There were 22 impacts from the harvester operation that recorded a reading of ≥50 G during crop 2 (Table 6.2). This represents a ≥50 G impact every run on average and all of these were in the medium impact range. The highest recorded impact was 91 G. Seventy eight percent of runs recorded impacts that were in the medium range while the remainder 22% were low impact (<50 G) (Figure 6.10).

The drop from the bunker to the bin showed 35% of runs had either medium or high impacts and 6% had extremely high impacts (Table 6.2). There were 20 impacts ≥50 G and of these 60% were medium impacts, 35% high and 5% extremely high (Table 6.3). Highest recorded impact was 219.9 G.

The percentage breakdown of the combined harvester and bunker drop runs for crop 2 is presented in Figure 6.10. Medium impacts were recorded in 54% of all runs followed by high impacts at 35%.

Temperature of the tubers at harvest was 12.4°C and on average it took 42.8 seconds for the Smart Spud™ to move from location 1 to location 5 (Table 6.4).

Soil conditions

The top-soil(cm) was classified as a sandy loam with 71% sand, 20% clay, 9% silt and a FC of 36% (v/v).

The mean soil temperature at 15 cm was 19.3°C, the median 19.6°C and the range from a minimum of 5.8°C on the 28/11/09 to a maximum of 41°C on the 18/01/10 (Figure 6.4)

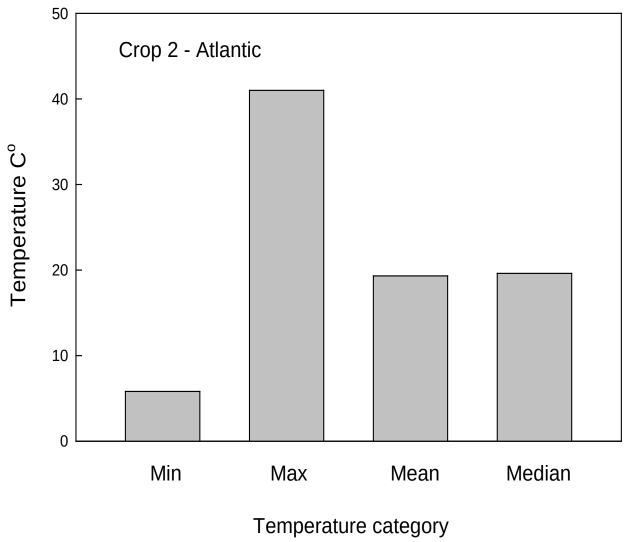

Figure 6.4. Temperature information for crop 2.

Soil moisture and tension

Mean volumetric soil moisture at 15cm depth on the site was 21.8%, the median 21.2% and it ranged from a minimum of 16.4% on the 11/12/09 to a maximum of 35.2% on the 24/12/09. Key soil moisture data is also available for other depths (attachment).

Mean soil tension at 15cm depth on the site was -10.2 kPa, the median -7.6 kPa and it ranged from a minimum of -68 kPa on the 06/12/09 to a maximum of -0.06 kPa on the 11/12/09. Soil tension was less than -40 kPa 2% and -20 kPa 5% of the crop period.

Crop 3

As with Crop 2 a two row, a self propelled Grimme harvester was used to harvest this crop (Figure 6.3). The IS was run through the harvester 22 times and from the bunker to the bin on 11 occasions. The IS identified 6 locations where impacts occurred during the harvesting operation.

Of the harvester runs for crop 3 only 4 were ≥ 50 G and of these all were of medium impact (Table 6.2). This equates to 0.2 impacts of ≥ 50 G occurring every run on average. Eighteen percent of runs had an impact of medium severity with 77.2 G being the highest recorded reading.

Of the bunker drops there were only 8 that were ≥ 50 G and all of these were medium severity impacts (Table 6.3). The highest recorded impact was 88.2 G and there was on average 0.7 impacts ≥ 50 G every runs. Sixty-four percent of total runs recorded an impact of medium severity whilst the remainder were low impacts (Figure 6.10).

When the data is combined the percentage breakdown of the impacts indicates only low and medium impacts occurred during crop 3 (Figure 6.10). Medium impacts accounted for 70% of all impacts recorded.

Tuber temperature at the time of harvest was 12.7°C and the average time it took the Smart Spud™ to travel from location one to location 5 (Figure 6.3) was approximately 47.1 seconds.

Soil conditions

The top-soil (cm) was classified as a sandy loam with 71% sand, 20% clay, 9% silt and a FC of 36% (v/v).

The mean soil temperature at 15cm was 19.2°C, the median 19.0°C and the range from a minimum of 13°C on the 28/11/09 to a maximum of 27.4°C on the 1/03/10 (Figure)

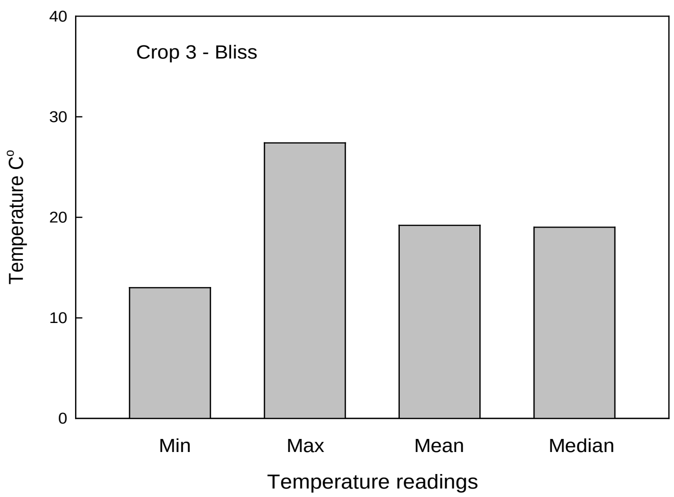

Figure 6.5: Temperature information for crop 3.

Soil moisture and tension

Mean volumetric soil moisture at 15cm depth on the site was 13.0%, the median 12.6% and it ranged from a minimum of 8.8% on the 05/03/10 to a maximum of 24.7% on the 25/11/09. Key soil moisture data is also available for other depths (attachment).

Mean soil tension at 15cm depth on the site was -13.4 kPa, the median -11.6 kPa and it ranged from a minimum of -58 kPa on the 11/12/09 to a maximum of -13.4 kPa on the 27/12/09. Soil tension was less than -40 kPa 2% and -20 kPa 7% of the crop period.

Crop 4

The IS was run through the harvester on 22 occasions from the soil to the bin. Five impact points were identified from the runs where 64% of runs only recorded low impacts and 36% recorded medium impacts (Table 6.2). There was a total of 9 occasions where an impact of >50 G occurred that equates 0.4 impacts of this size every run. All impacts >50 G were in the medium impact range (50-99 G) (Figure 6.10) and the average of these impacts was 66 G with the maximum recorded being 83.5 G.

The tuber temperature at harvest was on average 11.1°C whilst on average it took 52.4 seconds for the tubers to move from impact point 1 to the bins (Table 6.4).

Soil conditions

The mean soil temperature at 15cm was 21.3°C, the median 20.9°C and the range from a minimum of 14°C on the 25/04/10 to a maximum of 31.7°C on the 6/01/10 (Figure 6.7)

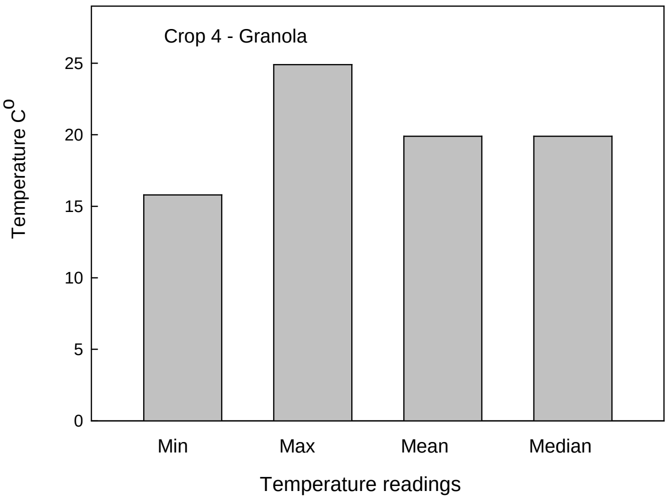

Figure 6.7. Temperature information for crop 4.

Soil moisture and tension

Mean and median volumetric soil moisture at 0-15cm depth on the site was 16.6% and it ranged from a minimum of 12% on the 12/04/10 to a maximum of 29% on the 22/03/10. Key soil moisture data is also available for other depths (attachment).

Mean soil tension at 15cm depth on the site was -15.0 kPa, (median -16.5 kPa) and the range from a minimum of -78 kPa on the 11/02/10 to a maximum of -1.1 kPa on the 23/03/10 (incomplete data set). Soil tension was less than -40 kPa 2% and -20 kPa 7% of the crop period.

Crop 5a

A single row harvester (Figure 6.1) was used to harvest this crop. With the first operator harvesting the crop there were a total of 12 harvester runs and 22 bunker drops. Of the harvester runs 58% recorded low impact only and the remainder 42% was medium impact. A total of 6 impacts occurred above 50 G with 100% of these being in the medium range (50-99 G) (Figure 6.10). This equates to 0.5 impacts of greater than 50 G occurring every run with an average impact of 64.6 G and a highest impact of 86.2 G.

Of the bunker to bin drops 32% were low impacts only, 55% were medium impact, 14% high impact (100-149 G) and 5% were very high impacts (150-200 G) (Table 6.3). Twenty of the drops were above the 50 G threshold which equates to 0.9 impacts of this nature every drop. Of the twenty impacts above 50 G, 80% were of medium impact, 15% high and 5% very high impacts. Average G force above 50 was 83.1 G with the maximum impact recorded being 168.4 G.

When the data from the harvester and bunker are combined 40% of runs recorded only low impacts, 48% were medium impact, 9% were high and 3 % were very high (Figure 6.10).

Tuber temperature at harvest was 8.4°C and on average it took 49.2 seconds for the IS to move from impact point 1 to the bunker, impact point 5 (Table 6.4).

Soil conditions

The mean soil temperature at 15cm was 19.8°C, the median 20.0°C and the range from a minimum of 15.2°C on the 13/04/10 to a maximum of 23°C on the 6/11/09 (Figure 6.8)

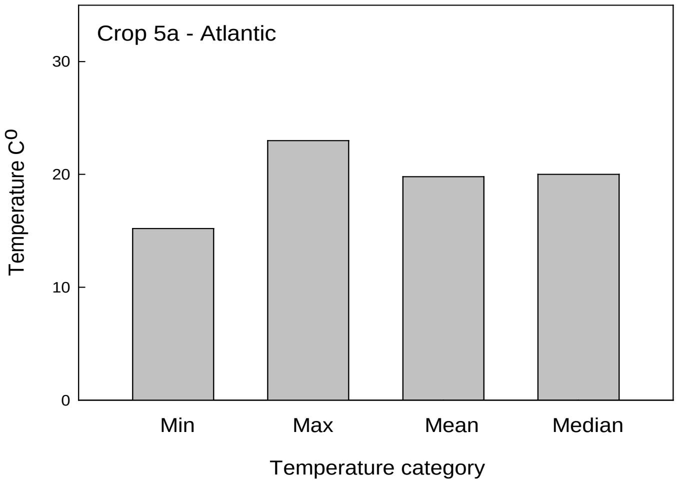

Figure 6.8. Temperature information for crop 5.

Soil moisture and tension

Mean volumetric soil moisture at 0-15cm depth on the site was 8.3% (median 6.5%) and the range from a minimum of 4.9% on the 01/03/10 to a maximum of 17.5% on the 31/12/09. Key soil moisture data is also available for other depths (attachment).

Mean soil tension at 15cm depth on the site was -37.5 kPa, (median -50.0 kPa) and the range from a minimum of -59 kPa on the 10/02/10 to a maximum of -1.2 kPa on the 03/04/10. Soil tension was more than -20 kPa 100% of the crop period.

Crop 5b

With the second operator working the harvester a total of 16 harvester runs occurred and 12 bunker runs (Table 6.2). Of the harvester runs 56% were low impact only and the remainder 44% were medium impact. There were 9 impacts above 50 G and of these all were of medium impact. The 9 impacts equate to 0.6 impacts of 50 G or above every run with an average of 65 G and a maximum of 80.5 G.

Of the 12 bunker drops 33% were low impact only, 58% recorded a medium impact, 17% were high impact and 8% were extremely high impact (>200 G). Ten impacts were recorded that were greater than 50 G that equates to 0.8 of these impacts every drop. Of the ten drops 70% were medium impact, 20% were high impact and the remainder 10% was extremely high impact. Average impact greater than 50 G was 88.9 G and the maximum impact recorded was 202.9 G.

When the harvester runs and bunker drops were combined for this operator there were 43% of runs of low impact, 46% medium impact, 7% high impact and 4% extremely high impact (Table 6.3).

Tuber temperature at the time of harvest was 8.4°C and it took on average 40.2 seconds for the IS to move from impact point 1 to impact point 5 (Table 6.4).

Crop 6

The harvester used in this crop was the same as that used for Crop 4 (Figure 6.6) and therefore no bunker drop. There were 20 harvester runs with 10% having low impact only, 70% medium impact, 30% high impact and 10% of runs having very high impact and extremely high impacts (Table 6.2).

There were a total of 42 impacts greater than 50 G for this crop that equates to an impact of this magnitude every 2.1 runs. Of the 42 impacts approximately 74% were medium G force, 14% were high impact, 5% were very high impact and 7% were extremely high impact (Figure 6.10). The highest recorded reading was 314 G with the average G force above 50 was 92.2.

Tuber temperature at the time of harvest was 11.1°C and it took on average 67.4 seconds for the sphere to move from impact point 1 to impact point 5 (Figure 6.10).

Soil conditions

The mean and median soil temperature at 0-15cm was 21.5°C,and the range from a minimum of 14.7°C on the 25/04/09 to a maximum of 30.6°C on the 06/01/10 (Figure 6.9).

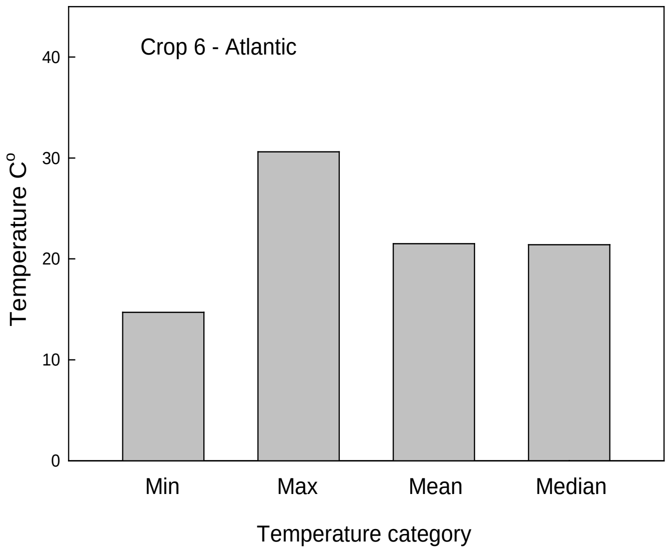

Figure 6.9. Temperature information for crop 6.

Soil moisture and tension

Mean volumetric soil moisture at 0-15cm depth on the site was 14.8%, (median 14.3%) and the range from a minimum of 10.7% on the 02/05/10 to a maximum of 28.2% on the 22/03/10. Soil moisture data is also available for other depths (attachment).

Mean soil tension at 30cm depth on the site was -23.0 kPa, the median -19.0 kPa and it ranged from a minimum of -67 kPa on the 08/02/10 to a maximum of -0.6 kPa on the 27/03/10.

Table 6.2. The impact data recorded from the IS from the harvester and combined average data.

Harvester	Crop							
	1	2	3	4	5a	5b	6	Ave
No. of runs through equipment	20	23	22	22	12	16	20	19
Avg time taken per run (sec)*	49.4	42.8	47.1	52.4	49.2	40.2	67.4	50
Impacts (% of total runs with:)								
low impacts only	45	22	82	64	58	56	10	48
medium impacts	40	78	18	36	42	44	70	47
high impacts	15	0	0	0	0	0	30	6
very high impacts	0	0	0	0	0	0	10	1
extremely high impacts	0	0	0	0	0	0	10	1
Impacts medium and greater								
Number impacts >50 G	16	22	4	9	6	9	42	15
Avg number > 50G impacts/run	0.8	1.0	0.2	0.4	0.5	0.6	2.1	1
Average acceleration (G)	78	65.1	61.8	66	64.6	65.0	92.2	70
Maximum impact (G)	112.0	91.0	77.2	83.5	86.2	80.5	314.0	121

Table 6.3. The impact data recorded from the IS from the bunker and combined average data.

Bunker	Crop					
	1	2	3	5a	5b	Ave
No. of runs through equipment	21	17	11	22	12	12
Impacts (% of total runs with:)						
low impacts only	10	24	36	32	33	19
medium impacts	57	35	64	55	58	38
high impacts	19	35	0	14	17	12
very high impacts	14	0	0	5	0	3
extremely high impacts	0	6	0	0	8	2
Impacts medium and greater						
Number impacts >50 G	42	20	8	20	10	17
Avg number > 50G impacts/run	2.0	1.2	0.7	0.9	0.8	1
Average acceleration (G)	84	99	70.8	83.1	88.9	71
Maximum impact (G)	181.6	219.9	88.2	168.4	202.9	144

Table 6.4. The combined impact data recorded from the IS during the total potato harvesting operation.

Combined harvester & bunker	Crop							
	1	2	3	4	5a	5b	6	Ave
No. of runs through equipment	41	40	33	22	34	28	20	31
Tuber temp at harvest (°C)	18.4	12.4	12.7	11.1	8.4	8.4	11.1	11.8
Impacts (% of runs with)								
low impacts only	4	5	30	64	41	46	10	28
medium impacts	52	54	70	36	50	50	70	55
high impacts	29	35	0	0	9	7	30	16
very high impacts	14	0	0	0	3	0	10	4
extremely high impacts	0	6	0	0	0	4	10	3
Impacts medium and greater								
Number impacts >50 G	58	42	12	9	26	19	42	30
Avg number > 50G impacts/run	1.4	1.1	0.4	0.4	0.8	0.7	2.1	1
Average acceleration (G)	81	82.1	66.3	66	73.9	76.95	92.2	77
Maximum impact (G)	181.6	219.9	88.2	83.5	168.4	202.9	314.04	180

Australian Government

Australian Centre for International Agricultural Research

Final report appendix 7

title

AGB/2005/167 Potato seed system development - alternative potato seed supply system for Indonesia

prepared by

Peter Dawson

co-authors/ contributors/ collaborators

1 Executive summary

The lack of affordable quality seed is a major constraint to increased potato productivity in Indonesia. The established government certified seed scheme only supplies a small percentage of demand. It is thought that the high seed degeneration rates found in Java will prevent this scheme from increasing its output of seed. The threat of potato cyst nematode will also constrain seed supply as conditions in Java favour the spread of this pest, even into the seed production areas. Other seed sources are discussed and the development of a partial seed scheme based in the Sembalun Valley of East Lombok is proposed. The partial seed scheme comprises the importation of G4 Granola seed from PCN free areas which meet Indonesian's quarantine requirements. The imported seed would be cool stored on arrival in Indonesia. The unique conditions of the Sembalun Valley makes it the most suitable area to grow on the imported seed. The area has been surveyed for PCN and none was found. The major potato production takes place in the dry season on paddy soils. These soils provide protection against the establishment of PCN. The area grows processing potatoes using freshly imported seed every year. The area has moderate degeneration rates which is an advantage over the high degeneration rates found in Java. The area has additional capacity to produce potatoes on the paddy soils. A partial seed scheme would complement the current processing production and augment the Indonesian government's certified potato seed supply. The costs of the seed will be lower than for imported seed while the Sembalun seed growers will increase their income compared with their processing crops. The horticulturists' group at Sembalun will need training in seed potato production and seed marketing. They will also need assistance in obtaining credit to support the venture. The Indonesian Ministry of Agriculture will need to issue import permits for the Granola seed which is to be used for this scheme. This opportunity offers a feasible means to increase quality seed supply with seed cost lower than freshly imported seed. If successful this model could be used to expand the partial seed scheme to other areas of Indonesia.

2 Background

Crops of potatoes are most commonly planted using small tubers from a previous crop. Seed potatoes are a bulky product and their multiplication rate is low so they are expensive. If a farmer wants to plant half a hectare at a density of 30 cm between plants with rows 80 cm apart she will need 21,000 tubers for seed. Small seed tubers are favoured due to their lower cost as seed potatoes are usually sold by weight. If seed tubers are 30 g she needs to buy just 630 kg of seed. If seed tubers are 50 g then she will need to spend more as she will have to buy over 1 tonne.

Potato tubers are roughly 80% water and 20% starch and so are an ideal refuge for many pests and diseases. The pests and diseases can easily be transferred from one crop to the next, often referred to as one generation to the next, via the seed tubers. Pests and diseases can multiply in the seed tubers or subsequent crop. So pests and disease levels in a seed-line will increase with greater generation. This increase in pest and disease levels is known as seed degeneration.

When the crop producing the seed tubers is mature the tubers are dormant; the buds which are in the eyes, are inhibited from sprouting. Only after a period of storage will dormancy be overcome and with sprouts appearing from their eyes the tubers are ready to plant. The growth and storage conditions of the seed tubers also influence the growth of the plant that grows from the seed tuber. That is why appropriate growing and storage conditions are required to produce high performance seed. The post harvest care of seed is so important that a system describing the dormancy stages, or physiological age (p-age) stages, of the seed tubers has been developed (ACIAR Project AGB/2005/167 Annex 11 Post Harvest). Seed tubers of the same chronological age can have different p-age due to storage conditions and growth history and therefore can perform differently in the field.

So to summarise potato seed tubers;

- are slow to multiply,
- are expensive,
- are prone to pests and diseases,
- must be stored correctly and
- must be planted at the right physiological age.

3 Objectives

To review the potato seed supply in Indonesia and to identify a lower cost scheme that will significantly improves access of Indonesian farmers to quality potato seed.

4 Methodology

Literature review and review of project findings.

5 Achievements against activities and outputs/milestones

Objective 2: To develop and implement low-cost schemes that significantly improve the access of Indonesian farmers to quality potato seed.

no.	activity	outputs/ milestones	completion date	comments
2.5	Development of suitable training materials on quality seed propagation for capacity building of seed producers, and on benefits and use of quality potato seed for potato growers	Appropriate training materials available to seed producers Addendum to current potato ecological production guide and FFS exercise manula on use of quality potato seed produced.	2010	Review of Indonesian seed supply completed and alternative partial seed supply scheme proposed to augment existing seeds schemes. Revised seed potato information published in *Kentang Peralatan Teknis* (Potato Technical Toolkit) and Factsheet *Kista nematoda* kentang di Indonesia and DVD *Pencegahan terhadap nematoda sista kentang* produced.

PC = partner country, A = Australia

6 Key results and discussion

6.1 Review of Indonesian potato seed schemes.

6.1.1 Potato seed schemes

Schemes have been developed to assure the performance of seed potatoes. These schemes have specialist seed potato farmers located in areas selected for the low levels of pests and diseases. Areas low in pest and diseases have low degeneration rates and produce “cleaner” seed. Potato seed schemes are based on disease free planting material which is usually derived from pathogen tested tissue culture. These schemes involve the subsequent field bulking of the initially disease-free potato seed-line over several generations. This has to be done to reduce the cost of the seed produced because the disease-free starting material is expensive and potatoes have low seed multiplication rates. These seed schemes also have measures to uphold the authenticity of their product through inspection and labelling systems.

Strategies have been developed to avoid pests and diseases in seed potatoes, they include;

- starting with pest and disease free seed tubers,
- preventing the introduction of diseased material into seed production areas (biosecurity).
- growing seed crops in isolation from other potatoes and related (Solanaceous) crops,
- growing seed crops in areas where long rotations between crops is possible,
- limiting the number of generations of seed bulking to limit exposure to pests and diseases,
- controlling movement within fields from low generation crops to higher generation crops,
- avoiding pests by growing in cool areas, often in highlands at high latitudes,
- reducing diseases by roguing (removing diseased plants) crops with trained disease observers, and
- monitoring pests and killing crops early to avoid pest infestations that occur as the growing season progresses.

Strategies to reach and maintain a suitable p-age of the seed tubers include;

- matching seed production times and storage treatment to commercial cropping areas, for example in Western Australia seed harvested in April and stored at ambient temperature is matched to commercial crops planted in July while the same seed placed in cool storage after harvest is suitable for October planting in later growing areas.
- harvesting seed potato crops only after the skin has had time to harden or set,
- developing gentle handling techniques to avoid damaging seed tubers,
- controlling pests and diseases in storage facilities to prevent seed piece deterioration,
- developing storage techniques that deliver seed to buyers at the correct p-age. This may include warm storage to break dormancy or conversely to prolong storability the use of diffuse light storage or cool storage,
- seed treatments to influence sprout characteristics of seed tubers. This may involve chitting (knocking off the first dominant sprouts) or cutting seed tubers to speed up shooting.
- Developing new seed areas to meet the requirements of new developments in seed potato demand.

Strategies to maintain the authenticity of seed sold include;
- the development of seed inspection schemes,
- the development of seed labels and
- the development of seed marketing associations.

Additionally, most successful seed producers have a close association with potato variety breeding and development. This has been very useful because many problems of commercial potato production, be they pest, disease or abiotic factors, have been overcome through the careful selection of new varieties. One example is the widespread adoption of potato cyst nematode resistant varieties in Europe.

6.1.2 Indonesian seed potato production

In 2010 Indonesia produced 1,176,304 tonnes of potatoes from 71,238 ha (Badan Pusat Statistik 2010). The amount of seed required for this area is 106,857 tonnes using a seed planting rate of 1.5 t/ha (Annex 2 Baseline Economic survey of potatoes Fig 6.3b). The area of seed crop required would be 6,476 ha assuming the seed yield was the same as the average Indonesian yield of 16.5 t/ha.

Seed sources used in Indonesia have been described recently by Jayasinghe (2003) and Fuglie *et al.* (2005). There is a government certified seed potato system, imported seed, private sector tissue culture seed and informal seed. The informal seed is where the tubers produced by farmers outside the formal regulated seed production sector are saved for their own seed use (Fuglie *et al.* 2005). The proportion of 180 farmers surveyed by Fuglie *et al.* (2005) who use these various seed sources is given in Table 1. The majority of farmers used informal seed with only a small minority using seed from other sources.

In this project's 2007 agronomic baseline survey in Java the 11 growers who used G4 Certified seed paid an average of 7,273 Rp/kg. The 13 growers who used informal seed (local non-certified) paid an average price of 6,692 Rp/kg. The three growers who used imported seed paid an average of 9,333 Rp/kg while the NTB growers who were supplied imported seed by Indofood-Fritolay paid Rp 10,500 /kg. No growers in the baseline survey used seed from a private company.

Government seed system

The government certified seed system is based on pathogen-tested tissue cultures. This means that it is based on potato test tube plants in which no pests and diseases were found after laboratory, or pathogen, testing. As the test tube plants grow they can be divided and multiplied. When sufficient test tube plants have been produced they are potted out as plantlets. These are grown in a screen house which gives protection against insects. The plantlets produce tubers which are known as minitubers or Generation 0 (G0) planting material of the scheme. Indonesian seed centres include the Potato Seed Development Bureau Technical Implementation Unit located at Pangalengan, West Java and the Kledung Horticultural Seed Centre, near Wonosobo in Central Java.

Table 1. Source of seed used by Farmers in Indonesia.

Seed source used	% of farmers using the source*	
	Fuglie *et al.* (2005)	Baseline survey 2007
Use own seed (Informal seed)	81%	28%
Buy seed from other farmers (Informal seed)	29%	
Buy imported seed	9%	33%
Buy seed from private company	6%	0%
Buy Government Certified Seed	0%	39%

* Total may be more than 100% as some farmers use seed from more than one source.

This system is designed to reduce seed-borne disease such as virus. Early generation crops are grown from pathogen tested seed then bulked in screen house protected from aphids which can spread virus diseases. The importance of virus disease was shown by this project's baseline survey which found:

- a significant relationship between the higher incidence of potato leafroll virus (PLRV) and lower yield in West Java (ACIAR Project AGB/2005/167 Appendix 1 Fig 6.45).
- Central Java growers with crops free from virus had higher yields (19 t/ha) than growers with virus (10 t/ha) (ACIAR Project AGB/2005/167 Appendix 1 Fig 6.43).
- West Java, crops without virus had higher yields of 24 t/ha than the 9 t/ha of crops with virus ($P < 0.10$) (ACIAR Project AGB/2005/167 Appendix 1 Fig 6.44).

The Kledung Horticultural Seed Centre (KHSC) potato seed production system is summarised in Table 2. Plantlets and G0 are grown in sterile media in screen houses to prevent infection by pests and diseases. The screen house crops are monitored for virus infection with specific serological tests known as ELISA tests. After the first generation (G1) the seed crops are grown in fields to the standards of the Agency for Seed Control and Certification (BPSB). The later generations can also be grown away from the KHSC by cooperating seed potato growers under the auspices of the Seed Potato Production Alliance. Pre-planting soil tests for PCN are undertaken for all BPSB supervised seed potato crops. For field crops the rotation is 18 months between potato crops (Fuglie *et al.* 2005). At Kledung the interval between potato crops is 9 months (Pak Aris, personal communication).

The amount of seed produced under the Government system only meets a fraction of the Indonesian seed demand. For example the Pangalengan Potato Seed Development Bureau Technical Implementation Unit would like annual G4 seed production to be 6,420 tonnes to supply 25% of the needs of West Java potato farmers, i.e. to enable all farmers to renew their seed with G4 every four years (Rusbandi, personal communication). However production of G4 in 2006 was 1,452 tonnes (Rusbandi, personal communication), enough for just under 1,000 ha which would allow seed renewal only every 17 years. Rasmikayati and Nurasiyah (2004) report that this seed source meets only 3.5% of the seed potato demand.

Practices not appropriate for good seed production were common in Indonesia and these will prevent this seed source from expanding according to Jayasinghe (2003). He further reported that none of the seed institutions studied selected suitable sites for field multiplication of potato seed. Aphid populations, soil analysis, pathogen distribution and history of crops grown were not considered when selecting seed multiplication sites. Often potato seed fields were located among Solanaceous crops such as tomato, pepper and eggplants. Also different generations were multiplied in the same locality. At KHSC soil diseases such as common scab are visible on seed tubers produced in screen houses and in the field (Andrew Taylor, personal communication).

Table 2. Seed potato production flow for Central Java seed potato scheme.

Generation	Names	Location	Inspection	Material produced (Indonesian name)
Starting material	Meristem culture	KHSC* tissue culture laboratory	ELISA	Plantlets
	Plantlets	KHSC screen house grown in sterile media	ELISA	G0
G0	Minitubers	KHSC screen house grown in sterile media	ELISA	G1 Source seed (Benih sumber BS)
G1	Source seed Benih sumber	KHSC field	BPSB†	G2 Basic seed (Benih dasar BD)
G2	Basic seed Benih dasar	KHSC field	BPSB	G3 Foundation seed (Benih pokok BP)
G3	Foundation seed Benih pokok	Specialist seed potato farmers	BPSB	G4 Extension seed (ES) (Benih sebar ES)
G4	Extension seed Benih sebar	Sold to farmers		

* KHSC = Kledung Horticultural Seed Centre.
† BPSB = Agency for Seed Control and Certification.

The price of the government certified G4 seed is set at three times the current price of ware potatoes but these seed prices did not cover the actual seed production costs and so the system requires subsidies (Fuglie *et al.* 2005). Rasmikayati and Nurasiyah (2004) confirm the subsidisation and add that imported seeds are taxed through [service] taxes on tradable inputs. In the 2007 agronomic baseline survey in Java, the 11 growers who used G4 certified seed paid an average of 7,273 Rp/kg while the eight growers who used G5 certified seed (presumed to be once-grown G4 certified seed) strangely paid more at an average of Rp 8,313/kg.

The government seed system has very close links with IVEGRI which has a potato variety breeding and evaluation program. IVEGRI have released 18 potato varieties (Anon 2010) with two crisping varieties, Margahayu and Kikondo released in 2008 (Karjadi 2008). Adoption has been low though as shown by the 2007-08 baseline surveys of potato farmers in four provinces; of 88 respondents, 67 grew Granola, a German variety, 20 grew Atlantic, an American variety, and two grew Agria, another European variety. There are numerous socio-economic factors limiting the widespread adoption of new potato cultivars in developing countries, most importantly market forces and the lack of functioning seed systems to produce the planting material needed for distribution (Forbes 2009).

The government seed system concentrates on pest and disease freedom and not physiological performance of the seed. The storage of potatoes in Indonesia has developed to serve the informal system where farmers can store seed in the dark for 3 to 4 months without treatment to ensure the seed is of suitable p-age at planting time. Certified seed performance would improve if storage systems were developed to ensure seed was at an appropriate p-age for planting. In West Java the agronomic baseline survey found that higher yield was associated with shorter sprouts, an indication of young p-age (See ACIAR Project AGB/2005/167 Appendix 1 Fig 6.9). Similarly in NTB higher yield was associated with shorter sprouts; yields of 40 t/ha were obtained from seed with sprouts of about 3 cm while a lower yield of 27 t/ha was associated with 8 cm sprouts. The baseline survey also found an association of higher yield with diffuse light storage in West Java (27 t/ha) compared with storage in light storage (15 t/ha) (See ACIAR Project AGB/2005/167 Appendix 1 Fig 6.13).

Imported seed

Seed potatoes may be imported into Indonesia under a permit granted by the Ministry of Agriculture. After potato cyst nematode (PCN) was found Indonesia in 2003 (Mulyadi *et al*. 2003) the Indonesia Ministry of Agriculture reviewed the areas from which seed potatoes could be imported. Potatoes can now only be imported from areas that meet the Indonesian Agricultural Quarantine Agency requirements for PCN freedom as well as other requirements. This means that sources of imported seed are more restricted, being; Western Australia and South Australia (AQIS 2008), Canada (Pusdatin 2010) and Scotland (Scottish Government 2009). Most of the imported seed is the crisp processing variety Atlantic for PT Indofood-Fritolay. Recent quantities imported have averaged just over 2,500 tonnes annually with a low of 2,280 t in 2009 and a high of 2,944 in 2008 (Badan Pusat Statistik 2011). Australian seed exporters report that they cannot obtain import permits for the Granola variety (Iwan Gunawan, Tom Fox, personal communication).

In the project's 2007 agronomic baseline survey in Java the three growers who used imported seed paid an average of Rp 9,333 per kg. In East Lombok, where imported Atlantic seed is supplied to Indofood-Fritolay, growers repay the seed cost of Rp 10,500 per kg from harvest proceeds (BPTP NTB 2009).

Private sector tissue culture seed

As a result of the 1997 Asian financial crisis the Indonesian Rupiah dropped from 2,500 to roughly 9,000 to the US dollar (Oanda 2011). This meant that prices of agricultural imports surged. Potato seed imports declined by about 66% from 3,000 tonnes in 1997 to 1,000 tonnes in 1998 (Fuglie *et al.* 2005). This led to interest in seed potato production from private enterprise. However these operations were often sidelines to floriculture and due to poor performance of both tissue culture and screen house operations most of these facilities failed (Jayasinghe 2003). There is new interest in this seed source to replace some of the imports of Atlantic seed. The company PT Puncak Biotek currently has a contract with Indofood-Fritolay (Direktorat Jenderal Hortikultura 2010) selling plantlets direct to farmers or farmer groups who bulk the plantlets in screen houses. This method was being tested by Kelompok Horsela, the East Lombok Horticulturist Farmer Group, in 2010.

No growers in the baseline survey used private enterprise tissue culture seed so no price has been recorded. However the system relies on growers transplanting the plantlets into beds in tunnel houses, with storage of the minitubers until planting time. So the cost of private enterprise tissue culture plantlets would reflect only a part of the cost of this seed.

Imported seed

Informal seed is the tubers produced by farmers outside the regulated seed production sector that are saved by farmers from their previous harvest to plant their next crops. Periodically they may purchase other farmer's tubers. Fuglie *et al.* (2005) found that farmers renew a portion of their seed every fourth season and 85% bought seed within seven seasons of continuous use. The small tubers (20 – 40 g) are selected for seed from the ware crop. The management is the same as for ware crops which means this seed is produced without the usual seed crop management practices of hygiene, roguing, biosecurity or official inspection (Fuglie *et al.* 2005, Jayasinghe 2003). Seed store conditions usually do not allow the seed to cure, to be easily inspected and sorted (See Appendix 11 Post Harvest). Field testing for pathogens like PCN are not undertaken. The only qualities of this seed appear to be its availability and its price. Jayasinghe (2003) reports that "…farmers usually realize that they planted poor quality seeds after one and a half months from planting but by then it is already too late …"

Potato cyst nematode

PCN has been found to have established in Indonesia since data was collected for the reviews of the Indonesian seed potato system by Jayasinghe (2003) and Fuglie *et al.* (2005). This pest is the most serious challenge currently facing Indonesian potato farmers because:

- it is well adapted to potatoes,
- it can reduce yields substantially,
- the common management tools used in developed countries which include;
    - PCN free seed,
    - resistant varieties,
    - long rotations with non-host crops,
    - fumigants and nematicides plus
    - quarantine and biosecurity barriers,

  are not available for Indonesian farmers.

PCN was first reported in East Java in 2003 and the species identified as *Globodera rostochiensis* (Indarti *et al.* 2004, Mulyadi *et al*. 2003a). PCN was then found in Central Java (Mulyadi *et al*., 2003b) and Pangalengan in West Java (Mulyadi *et al.* 2010). The other species of PCN, *G. pallida*, is reported to have been found in Banjarnegara, Central Java (Lisnawita, 2005). The spread and population build up of PCN has been most rapid in Central Java near Banjarnegara and Wonosobo where continuous, year round cropping of potato occurs. Spread of PCN continues in Java due to a lack of understanding of the pathogen, its lifecycle and management by farmers and facilitators.

A vital tool for the management of PCN in Indonesia will be to have a supply of PCN free seed for those areas of Indonesia which currently remain free of the pest. The Indonesian government certified seed scheme and imported seed only supply about 4% of the country's seed demand (Fuglie *et al.* 2005, Rasmikayati and Nurasiyah 2004). The remaining seed demand is fulfilled by the informal system which has no controls or checks for PCN and so has a risk of spreading the pest. There is an urgent need to expand the availability of PCN free seed in Indonesia.

Varieties

The main Indonesian variety is Granola which is for table or ware consumption while Atlantic makes up only a few percent of production and is grown for crisp processing. Granola is a German variety while Atlantic is from America. Growers and potato industry stakeholder report that Atlantic is more prone to virus disease than Granola. This is documented in ACIAR Project AGB/2005/167 Annex 11 Post harvest where growers said:

- "It is difficult to grow Atlantic seed because of disease problems. The first generation of plants show 0.5% symptoms of "mosaic" virus, while the next generation consistently shows 60%".
- that "*Phytophthora infestans* infections are a massive problem especially in the wet season and it is difficult to grow Atlantic seed because it is very susceptible to late blight."

Tests by Science and Advice for Scottish Agriculture (SASA) show that there is not much difference between the varieties in disease resistance (Table 4). However they report that Granola has greater resistance to PVA than Atlantic which in turn has less tuber resistance to potato late blight than Granola.

Table 4. Characteristics of Granola and Atlantic determined by Science and Advice for Scottish Agriculture (SASA 2011a & b) as reported in their on-line *European Cultivated Potato Database*.

Characteristic	Granola	Atlantic
Cooking		
Crisp suitability	poor	good
Cooking type	multipurpose	floury
Growth		
Dormancy	very long	medium
Disease resistance		
Fungus		
PLB foliage	low	low to medium
PLB tubers	medium	low
Bacteria		
Common scab	low	medium to high
Virus		
PVA	very high (9)	high (7)
PVX	low (3)	high (7)
PVY	low (3)	low (3)
PLRV	low to medium (4)	high (7)
Pest resistance		
PCN *Globodera rostochiensis* race 1	high	high
PCN *Globodera pallida* race 1		very low to low
PCN *Globodera pallida* race 2		low

6.1.3 Dreams versus reality in the tropical potato industry

In the sport of cycling there is a wish to have strong, light, and cheap equipment. However suppliers respond with, “pick any two”.

Students of the potato industry in the tropics have a similar wish exemplified in the quotes below.

> “… the major constraint in potato production in Indonesia is the lack of good quality and cheap seeds.” (Jayasinghe 2003)

> “One of the major constraints facing potato … production in the humid tropics is a lack of low-cost, quality seed.” (Fuglie *et al.* 2005).

In the Introduction it was stated that “Potatoes are a bulky product and their multiplication rate is low so they are expensive.” It is probably best to not dwell on price but to concentrate on appropriate quality because “The quality of the seed potato tubers is the most important yield determining factor that can be influenced by the farmer and also the most important yield constraint in many potato growing countries” (Struik & Wiersema 1999 page 29). So, to people asking for cheap and good seed, an appropriate response might be “pick one”. Jayasinghe (2003) shows that farmers understand this well as when he reports that “A majority of farmers are willing to pay for expensive seeds as long as these are of good quality." This is supported by findings of the agronomic baseline survey of the project where it was found that higher yield (58% relative maximum yield) was associated with purchased rather than own seed (48% relative maximum yield) (See ACIAR Project AGB/2005/167 Appendix 1 Fig 6.12).

There have been considerable efforts to supply the Indonesian potato industry with a reliable seed supply of high quality. Quality is an imprecise term but for seed it may best be defined as seed which itself does not constrain current or future production. Usually this is understood to mean having disease and pest levels which don't constrain yield and having the vigour to allow rapid growth.

In low yielding regions seed quality may not have to be the highest possible. The cost of purchasing the highest quality seed may not be repaid if lack of soil moisture constrains yield. Similarly if crops die early because potato late blight cannot be controlled the best seed in the world on its own will not raise yields. The aim should be to provide seed that will not constrain production but which has the potential to allow farmers to increase their crops potential and management improves. The characteristics of the seed sources available to Indonesian farmers which constrain or increase their cropping potential will be examined.

The seed sources compared

Fuglie *et al.* (2005) concluded that imported seed was the most economical and reliable source of high quality seed. However they suggested that weaknesses were:

- a loss of foreign exchange,
- a greater likelihood of inadvertent introduction of exotic seed-borne pests and diseases,
- choice limited to foreign varieties.

The last dot point describes the current situation where the standard variety Granola is German while the standard processing variety Atlantic is North American. If this is a weakness of imported seed it is also a weakness of the current seed supply system. The second dot point about the risk of exotic seed-borne pests and diseases is always a concern when importing seed. However this risk can be reduced by quarantine risk assessments and ensuing Phytosanitary Certificate requirements stipulating imported seed is to come from areas where pests and disease exotic to Indonesia are known not to occur.

Fuglie *et al.* (2005) found that government certified seed was heavily subsidised meaning this source was unlikely to expand to meet seed demand. The subsidisation is also discussed by Rasmikayati and Nurasiyah (2004). It is thought that if expansion was possible, technical sustainability problems would surface as occurred in the private tissue culture seed sector (Fuglie *et al.* 2005). Jayasinghe (2003) found none of the seed institutions studied had taken adequate precautions to select suitable sites for field multiplication of potato seed and consequentially seed fields with 30% bacterial wilt infection are common. In Central Java a survey of root-knot nematode in seed production fields from 20 villages was conducted and 16 of the villages had 100% of fields infested while the remaining four villages had 70% of fields infested (Suri & Jayasinghe (2003).

Now that PCN is found close to the seed production areas of Kledung and Pangalengan it must now be considered a threat to the government certified seed system. The short rotation used means that PCN will probably build up if introduced to these areas. The limits of the accuracy of the soil test for PCN means that PCN will not be detected until it is already well established and thus already had a high chance of having been spread through seed movement.

The length of rotation required to ensure PCN does not build up in a potato cropping system on well drained soils like Kledung and Pangalengan has not yet been determined.

However Mulyadi *et al.* (2010) in work for this project found that in well drained terrace soils the number of PCN cysts declined by 89% after 180 days while the number of eggs declined only by half after the same period (see also ACIAR Project AGB/2005/167 Appendix 5 Figs 6.3.4 & 6.3.5). The rotation between potato crops at the Kledung and Pangalengan seed centres varies from 9 to 18 months respectively (274 – 547 days). This means that PCN will build up if it is inadvertently introduced to these sites.

Where a rotation is not long enough to prevent PCN building up diagnostic tests are not accurate enough to give early enough warning to prevent the spread of the pest. For example the PCN testing procedure used in the Indonesian seed scheme is a soil test. When this test is done using 150 x 5 ml sub samples per ha it can detect down to a level of 20 PCN cysts per ml of soil (Wood *et al.* 1983). This level is considered to be the economic threshold for crop loss (Collins *et al.* 2010) which is only reached after several infested crops have been grown. So by the time that this level of cysts has built up the pest will have already had the chance to spread with the seed harvested previously from the field when PCN was present but not detectable. PCN can cause reduction in yield of up to 30% without any significant signs of crop damage (Anon. 1991).

The private sector tissue culture seed was not profitable for most companies and so was not sustainable. The private sector seed production was also found to be plagued with technical deficiencies that compromised its quality and probably contributed to this sector's lack of support by the industry (Jayasinghe 2003). He found all but one seed institution studied had facilities for media preparation and sterile handling operations and consequently tissue culture fungal contamination rates were 20 – 60%

The informal seed is of uncertain quality. Jayasinghe (2003) found that none of the farmers he interviewed had faith in the quality of locally produced seeds as they had already proven to themselves through experience that this seed source is of low quality. In addition farmer storage of seed potatoes is poor with little attempt at grading, sorting and proper ventilation for curing (Jayasinghe 2003).

A comparison of the seed sources discussed above is presented in Table 3. Some important short comings have been shaded and are discussed.

1. Only the informal seed meets demand. The government certified seed and the private tissue cultured seed require field bulking. In Indonesia the certified seed is produced in major potato production centres. There is no protective isolation from other potato and Solanaceous crops and rotations. Suitable land is scarce and rotations are of insufficient length to reduce pest and disease build up. Imported seed cannot meet demand because importers cannot obtain import permits for Granola seed (Iwan Gunawan, personal communication).

2. The government certified seed and the private sector tissue culture seed do not provide adequate protection against the spread of PCN. Although fields are tested for PCN before seed can be accepted for certification by BPSB, the test for PCN will only detect this pest after it has built up to relatively high levels. By this time the pest would have been spread via the seed produced from previous crops in the field when the pest was present but undetectable. The rotations used in seed production in Indonesia are too short to protect against the build up of PCN if it is inadvertently introduced to the seed areas. Imported seed from areas known to be free of PCN and which have long rotations will provide seed with the lowest risk of introducing and spreading PCN. Imported seed may also be the only short term source of varieties resistant to the strain of PCN found in Indonesia. Three populations of PCN have been identified to species and race (ACIAR Project AGB/2005/167 Appendix 5 development of potato seed system – potato cyst nematode Section 6.2) and they were found to be *Globodera rostochiensis* Ro2. This pathotype is uncommon but has been found in New York State in the United States of America (Halseth 2006) and there is a potato breeding program developing resistant varieties to PCN Ro2 at Cornell University in New York.

3. In "1' above it was noted that there is no protective isolation from other potato and Solanaceous crops like chilli and tomato and that rotations are of insufficient length to reduce pest and disease build up. This means that the degeneration rates of field multiplied seed in Indonesia are high.

4. The cost of seed is high. Imported seed was the most expensive at 6,000 to 13,000 Rp per kg but government certified seed was also costly at around 7,000 to 8,000 Rp per kg even though it is subsidised.

The short comings in the seed sources are due to the adoption of systems that are not suited to the Indonesian conditions rather than the execution of these systems. The government certified seed system has been based on a system that was developed in temperate areas with low seed degeneration rates and where there is the capacity for isolation and long rotations between potato crops.

In the temperate regions of the world where potato seed schemes first developed it was possible to control isolation and rotation requirements through government regulations. Such regulation is not as easily achieved in developing countries. The following example from the Philippines illustrates this well. The Buguias Seed Farm was established through a German Technical Agency (GTZ) funded project with the Philippine Bureau of Plant Industry which started in 1977 (Crissman 1989). It was set up to be the foundation seed production centre for the Cordillera Administrative Region in an isolated forested area far from cropping land. The author visited the BSF in 1999 and it was no longer surrounded by forest but by potato fields. The establishment of this potato seed centre attracted farmers to the area. They probably thought it must be a good location for potato crops if the government seed farm is being established there. In addition the farmers would have realised that if they grew crops near the seed farm they would have an increased opportunity to obtain improved seed. So in a situation beyond the control of the BSF the farmers moved in, cleared the forest and established potato crops. So a site that had originally been selected carefully could now appear to have been selected poorly. The fault was not with the scheme managers but with the scheme being inadvertently sabotaged by opportunistic farmers.

Similarly the small supply of Indonesian government certified seed may be a fault of the supply system being unsuited to Indonesian conditions. This scheme was established with the help of the Japanese International Cooperation Agency (JICA) who planned to establish a seed system based on limited generations starting with pathogen tested seed. However these schemes were developed in temperate areas where a number of field bulkings could be done without the rapid degeneration of seed stocks. The Indonesian system appears to be let down because suitable field bulking areas with low degeneration rates are not available.

The answer to the supply of quality seed from areas where degeneration rates are high is to limit the number of field multiplications and reduce degeneration rates by careful site selection and grow varieties resistant to the main degeneration causes.

6.1.4 Partial seed programs

Partial seed programs have been devised to overcome the problems of seed production in areas of high degeneration where 3 to 4 field generations are not possible without seed degradation (Struik & Wiersema 1999). Partial seed schemes are based on imported seed which is multiplied for a limited number of generations in isolated areas where seed quality can be kept at a reasonable level.

The requirements of a partial seed system are described by Struik & Wiersema (1999). They are:

- good growers' organisations to multiply the seed,

- selection of imported seed class according to number of in-country multiplications required,
- physiological age of the imported seed must suit planting time,
- field multiplications need to be supervised under a quality control system,
- one field generation only until seed growers have gained experience in the production of good quality seed,
- monitoring of customers'(ware growers') response to seed produced,
- modification made to the system after considering the experience of seed growers and seed buyers.

The benefits of this system are that seed quality and quantity increases and there are lower risks of ending up with either low quality seed or with too small quantities of seed.

An example of the partial seed program established in Tunisia is described by Struik & Wiersema (1999). In Tunisia three crops a year are grown; winter, spring and autumn. For the spring crop imported seed is used as its p-age is ideal. Basic seed class E is imported from the Netherlands for multiplication. This is fifth field generation seed equivalent to Western Australian G5 certified seed, Scottish Pre-basic 4 seed or Canadian Elite 4 seed (Dawson & Lancaster 2008). The spring seed crop is planted as early as possible in spring in mid January using imported seed. The p-age of the imported seed is ideal since it is harvested in October around 4 months before the planting time in Tunisia. The Tunisian spring seed crops are inspected by an organisation within the Ministry of Agriculture. The seed crops are killed early to prevent aphid spread virus contamination and harvest occurs in May. The seed is stored in the shade under straw to avoid excessive dehydration. The seed is used for the August/September planted autumn crop.

Table 3. Comparison of various qualities of four seed potato sources used in Indonesia.

Quality	Seed type			
	Government	Private	Informal	Imported
Availability				
Demand met	no	no	yes	restricted by requirement for import permit
Market adoption (%)*				
from baseline survey	39	0	28	33
from Fuglie *et al.* (2005)	0	6	110	9
Price (Rp/kg)				
baseline survey	7,273 – 8,313		6,692	6,000 – 13,000
Fuglie *et al.* (2005)	3 x WJ ware price = Rp 6,543/kg (2007) Price is govt. subsidised			
Pest & disease				
Pathogen tested	yes	yes	no	yes
PCN test	yes	(laboratory product)	no	yes
Efficacy of rotation for PCN protection?	too short	(laboratory product) field multiplications undefined	too short	effective
Availability of PCN resistance varieties	long term prospect	long term prospect	no	available in the short term
Degeneration risk	high	high (includes tissue culture)	high	low
Degeneration notes	Later generation bulking relies on cooperating seed growers where site selection has been found to be wanting (Jayasinghe 2003)	Relies on field bulking with risk of degeneration, especially if grown by inexperienced farmers Poor execution has led to low quality seed	Seed already older than G4 and so degeneration has already occurred.	First field bulking in Indonesia so should not be affected by degeneration
Physiological age	Ambient stores can keep freshly harvested seed for 4 months. No assessment of appropriateness of p-age after this storage has been made.			Cool storage is required after importation to avoid high waste that occurs in ambient stores due to rapid physiological aging of middle aged seed and insect infestation

* Total is more than 100% as some farmers use seed from more than one source.

The seed tubers are de-sprouted (chatted) before planting to break apical dominance to increase stem number. This system produces seed for the autumn's crop that yields significantly higher than the farmers' informal seed as it has improved health and better physiological condition.

6.1.5 Proposed partial seed system to augment Indonesian potato seed supply

There is an opportunity to increase the supply of high quality potato seed in Indonesian by augmenting the Indonesian government certified seed supply system with a partial seed program. The requirements for a partial seed program set out above by Struik & Wiersema (1999) are met if the partial seed system is based in the Sembalun Valley of East Lombok with the use of seed imported from PCN free areas of Australia.

The scheme would be based on imported Granola seed from an area free of PCN which has low seed degeneration rates. The imported seed would be cool stored after arrival in Indonesia to prevent deterioration while quarantine checks are carried out. The seed would then be multiplied once in the Sembalun Valley which has medium seed degeneration rates compared to the high degeneration rates found in Java. PCN has also not been found in the Sembalun Valley. The once-grown seed would be used to supply PCN free areas of eastern Indonesia. This additional supply of PCN free seed will help to stop the spread of PCN and so prolong the use of the susceptible varieties Granola and Atlantic. It is expected that this partial scheme could provide lower priced seed compared to imported seed with only slightly reduced quality. It will increase the supply of PCN free high quality seed to Indonesian potato growers.

Currently the area produces Atlantic potatoes for Indofood-Fritolay. This is done through a partnership between the company and the farmers' group Kelompok Horsela. Indofood-Fritolay supply some cropping inputs, like Atlantic potato seed from Canada and Australia, and capital to buy chemical fertiliser and pesticides through Kelompok Horsela management group, the costs of which are repaid by the farmers after harvest. The Horsela Farmers' Group management guarantee in return the quality target that's requested by PT Indofood. Kelompok Horsela is a well organised group that has successfully supplied Indofood-Fritolay for four years.

Seed produciton could be carried out in conjunction with the processing crop. There is sufficient area as the paddy soils are 1,105 ha and in 2010 only 15% was used for potato production. The processing crop would have to be grown to seed standards but as this crop already uses imported seed this requirement should be easily met.

More detailed explanation of aspects of this partial seed scheme follows.

PCN protection

This scheme will provide better protection against the spread of PCN than other schemes operating in Indonesia. The relatively new potato area of the Sembalun Valley only produced small amounts of potatoes up to 2006; for example just 131 ha was grown in 2001 and production ranged from 28 to 44 ha in the four years to 2005. Since then farmers have started growing the potato variety Atlantic on a larger scale for Indofood-Fritolay. The Atlantic crops have been planted with imported seed from PCN free areas supplied by Indofood-Fritolay. The small size of the Sembalun Valley means that it is feasible for a partial seed program to be based there as all seed could be replenished annually from a clean imported source.

PCN has not been found in the highland Sembalun Valley on the Island of Lombok in NTB Evidence for this came from a PCN soil survey which was undertaken from July to November 2008. Soil samples were taken on an intensive 3 x 3 pace grid. From a total of 454 samples examined, no cysts of potato cyst nematode were found in the potato cropping area of Sembalun. (ACIAR Project AGB/2005/167 Appendix 5 Development of seed supply system – potato cyst nematode. Section 6.1).

The Sembalun Valley is characterised by the production of dry season potatoes in paddy fields following the wet season highland rice crop harvest. This is a key feature because this cropping system gives good protection against PCN. In similar flooded highland paddy soils in Central Java it was shown that PCN cysts drastically decrease by 99% after 30 days and reach zero at 60 days (Table 4). The cysts and eggs seem to be very susceptible to breakdown and death in flooded condition. In comparison the number of the cysts in terrace soil decreased by 87% within the first 30 days but after this the rate of decline decreased. A similar finding was made for viable PCN eggs. In flooded paddy soil viable PCN eggs drastically decreased with 16% remaining after 30 days and none being detected after 60 days. Whereas eggs in the terrace soil were still detectable at 180 days at the end of the experiment (Table 4). The preceding rice crop which is flooded for 3 months will therefore provide good protection against PCN because any cysts or eggs introduced to the site will be killed. If only seed from PCN free areas is introduced to the Sembalun Valley then the area will remain free of the pest. An annual potato cropping program on these soils will have low risk of spreading PCN.

Table 4. The average number of cysts and viable eggs at 30; 60; 90; 120; 150; 180 days after burying(DAB) the bags in paddy and terrace soil. (Appendix 5, Table 6.9).

Treatments	Initial population	Days after burying					
		30	60	90	120	150	180
Cysts							
In paddy soil	140	0.8	0	0	0	0	0
In terrace soil	160	20	44	27	12	15	21
Eggs							
In paddy soil	464	72	0	0	0	0	0
In terrace soil	426	204	237	187	190	163	176

Reduced degeneration

If the partial seed scheme is based on one field bulking in the Sembalun Valley then the seed produced will have less degeneration than the G4 government certified seed which is in short supply. The imported seed would be grown in Western Australia where G4 infection rates are less than 1% (DAFWA 2009) and where conditions have been recognised as being the best in the world for disease free seed bulking (Schmiediche quoted in Dawson *et al.* 2003). This seed is once-grown at Sembalun where degeneration rate is moderate compared with Java. Evidence for this is that Atlantic growers in Java report degeneration rates are high with virus levels increasing from 0.5% to 60% of plants in one season (See Section “Varieties” above). In the Sembalun Valley degeneration rates for Atlantic are moderate with 12% infection in once-grown seed (ACIAR Project ABG/2005/167 Appendix 7 FIL - potatoes NTB). Also in the Sembalun Valley only 11% of the sites had aphids compared with 53% in Central Java and 44% in West Java. (ACIAR Project AGB/2005/167 Appendix 1 Table 6.8).

The likely outcome is illustrated in Figure 1. Under the high degeneration rates of Java one field generation planted with G2 government certified seed with 0.5% infection will end up as G3 with 60% infection. Whereas imported seed bulked once in the Sembalun Valley which has a moderate degeneration the seed will end up as G5 with 12% infection. The degeneration rate in the Sembalun Valley could be expected to drop once the processing growers there were trained in seed production techniques.

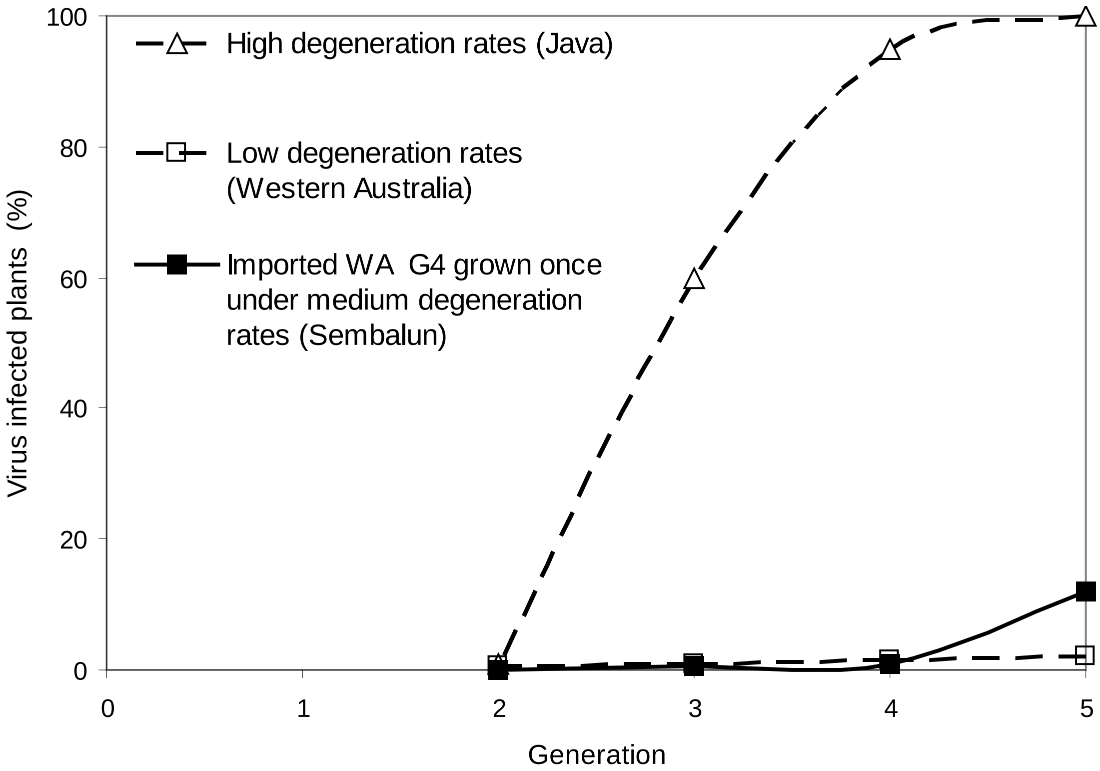

Figure 1. Virus infection of plants of seed line generations grown under different degeneration conditions. Under high degeneration conditions of Java the virus infection of Atlantic reaches over 60% in G3, the first field generation. If the Atlantic is grown from imported G4 seed where the infection is less than 1% and then under a medium degeneration rate of 12% as found at Sembalun then the G5 will have 12% infection. This is better quality than the G3 Indonesian seed which is already at 60% infection.

Reduced cost

A partial seed program should be able to provide seed at a lower price than imported seed. An average gross margin for Atlantic processing crop grown at Sembalun from imported seed was compiled for the economic baseline survey (ACIAR Project AGB/2005/167 Final report Appendix 2 Baseline economic survey of potatoes) from a survey of 28 growers. This gross margin has been used to develop gross margins for hypothetical once-grown imported Granola seed production at Sembalun (Table 5). It is assumed that half the Granola production will be seed size and sold at seed price while the remainder will be sold as wares. Granola production costs are assumed to be similar to Atlantic. However cool storage costs for holding seed before planting and for storing one third of the seed produced are included for the Granola enterprise. Seed price is set at twice the Indofood-Fritolay price of Rp 2,700 per kg. To ensure that the once-grown seed is available for a range of planting times the budget allows for the cool storage of one third of the seed produced. These costs would be passed on to the seed buyer and amount to Rp 7,300/kg for 6 months storage. This may mean that seed cool stored for 6 months may have to be sold at the high price of Rp 12,700 per kg. This price is more expensive than freshly imported seed but cool storage will supply seed ready for planting in March and April when imported seed from Australia was not available and when alternative Indonesian seed supplies have a risk of introducing PCN.

The gross margin for the Atlantic processing crop is Rp 16.1 million per ha based on a sale price of Rp 2,700 per kg. The Granola seed/ware crop based on a seed price of Rp 5,400 per kg (twice the ware price of Rp 2,700/kg) with 50% of sales as wares at Rp

2,700/kg produces a gross margins of Rp 44.1 million per ha which is nearly three times higher than the Atlantic gross margin.

Table 5. Gross margins for Granola once-grown imported seed production at Sembalun based on those of Atlantic from a survey of 28 growers (BPTP NTB 2009). It is assumed that half the Granola production will be seed size. The yield and costs of Granola are assumed to be similar to Atlantic. However cool storage costs for holding seed before planting and for storing 1/3 of seed produced after harvest are included for the Granola enterprise. Seed price is set at twice the Indofood price of Rp 2,700/kg.

Budget item	Atlantic for Indofood	Granola 50:50 ware & seed & 1/3 seed cool stored
	(Sale prices shown in bold)	
Yield (t/ha) – processing or ware	21.0	10.5
Price (Rp/kg)	**2,700**	**2,700**
Income (Rp/ha)	56,757,817	28,378,909
Yield (t/ha) – seed shed stored	0	7.0
Price (Rp/kg) (2 x 2,700)		**5,400**
Income (Rp/ha)		37,838,545
Yield (t/ha) – seed cool stored	0	3.5
Price (Rp/kg) (2 x 2700 + 7,300 cool store cost)		**12,700**
Income (Rp/ha)		44,495,326
Total income (Rp/ha)	56,754,000	110,712,779
Costs (Rp/ha unless shown otherwise)		
Seed (cost/kg)*	10,500	9,450
Seed	21,564,471	19,408,024
Seed cool storage (imported seed before planting)	0	2,464,511
Fertiliser	3,716,338	3,716,338
Pesticide	7,940,392	7,940,392
Labour	6,258,650	6,258,650
Other	1,203,761	1,203,761
Cool storage 1/3 seed produced (Rp 7,300 kg for 6 months)	0	25,576,053
Total costs	40,683,612	66,567,729
Gross Margin (Rp/ha)	16,074,205	44,145,050
($AUD/ha) (Rp 8990 = 1 AUD 2 Mar 2011)	1,788	4,910

* Cool stored seed price is reduced as there is less waste.

This partial seed method is a way to improve quality seed supply at a lower cost to freshly imported seed which has already been shown to work in Indonesia (Dawson *et al.* 2004). Sembalun offers several other advantages in that it is small and isolated and its whole area can be planted with renewed seed every year. However the potato growers in the Sembalun Valley are new to seed potato production and there would need to be considerable development and training to enable them to reap the full potential of their situation.

Development required for the Sembalun Valley to host a partial seed program

The Sembalun Valley has been shown to be free of PCN in November 2008 and its paddy soils were shown to be able to prevent the establishment of PCN (Mulyadi *et al.* 2010) so the area has the potential to become PCN free seed production area. The interest in potato production at Sembalun has led to a minority of farmers, maybe 15 out of 220, bringing in uncertified seed from Java in 2009 and plant it in the wet season away from the paddy fields on sites that will be susceptible to PCN. There needs to be measures introduced to prevent this happening and to maintain the Sembalun Valley's freedom from PCN. In addition a seed potato scheme needs to be introduced. Appropriate steps to support the development of a partial seed scheme in the Sembalun valley are described below.

- Introduction of seed production rules which would include appropriate rotations. Support Dinas Pertanian NTB and Kelompok (Tani) Horsela (Horticulture Sembalun Lawang) to develop seed production regulations for Sembalun. These must include appropriate rotation times, locations (periodically flooded soils) and ongoing testing to ensure claim of PCN freedom can be justified.

- Planned production to ensure local seed supply meets demand. To support BPTP NTB to help Kelompok Horsela ensure demand for seed potatoes can be met from local certified seed potato production. This must include improved storage for local seed potatoes. This strategy is recognised to be a more practical defence than quarantine laws against the spread of disease (Crissman 1989). This improved local seed availability will require improved storage so that seed ready for planting will be available from February until October. BPTP NTB will support Kelompok Horsela to achieve this goal.

- Obtain Ministry of Agriculture support for the scheme to enable import permits for Granola seed to be obtained.

- Improved storage to assist with maintaining quality of local seed so that it is available from February to October.

- Regulations restricting the movement of potatoes into the Sembalun Valley other than official seed potatoes from PCN free areas. Support Dinas Pertanian NTB and BPTB NTB to prepare proposal for Provincial regulations to be introduced to control the movement of potatoes into Lombok Timur

- Assist with marketing of seed to PCN free areas with planning times that suit the p-age of the seed produced. Assist with helping the farmers obtain credit to support the partial seed scheme.

- Monitor the performance of the seed crops in the Sembalun Valley and the performance of this once-grown seed in other regions to determine the efficacy of the partial scheme.

7 Conclusions and recommendations

The unique conditions of the Sembalun Valley makes it a suitable candidate to be the base for a partial seed scheme to augment the Indonesian government's certified potato seed supply scheme for the following reasons:

- The area has been surveyed for PCN and none was found.
- The major potato production takes place in the dry season on paddy soils. These periodically flooded soils provide protection against the establishment of PCN.
- The area has moderate degeneration rates which is an advantage over the high degeneration rates found in Java.
- The area grows processing potatoes using freshly imported seed every year.
- The area has additional capacity to produce potatoes on the paddy soils. A partial seed scheme would compliment the current processing production.
- The costs of the seed will be lower than for imported seed while the Sembalun seed growers will increase their income compared with their processing crops.

However the Horticulturist Farmer group will need:

- training in seed potato production and seed marketing, and
- assistance in obtaining credit to support the venture.

This opportunity offers a feasible means to increase the supply of high quality potato seed at a lower cost than freshly imported seed. If successful this model could be used as a model to expand the partial seed scheme to other areas of Indonesia.

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Final report appendix 8

title	AGB/2005/167 Farmer initiated learning - potatoes Java
prepared by	Ian McPharlin and Andrew Taylor
co-authors/ contributors/ collaborators	Peter Dawson, Peter Ridland, Rudolf de Boer, Mien Pakih, Ir Dadan Hidyat, Mulyanto SP, Dedi Wahid, SP, Ir Juju Rukmana MM, , Farmer groups: WJ: Medal Sawargi, Perjuangan Tani Mukti, Karya Mandir,i Suka Haji, Mukti Tani, Barokah Tani, Sauyunan, Mitra Mukti, Mekar Tani II, Mekar Tani Muda, CJ: Tunas Harapan Jaya Farmer group guides: WJ: Asep Rohiman, Sopanji, Iwan Setiawan, Ending Sahidin, Rahmat, Nandang, H, Ir.Ade, Suryana, Ayat. H, Encu Sofian, Dayat Suhendra, Endang Nuryaman, H.Otang, Pepen Efendi, Asep Koswara, Oji Setiadi, Ade Rubini, Wahyudin, Amang Taryana, Supiadi, Asep Budi DS, CJ: Hari Sudrajat AMd, Muslim.

1 Executive summary

Major limits to potato yield were identified in a survey of growing conditions and practices in four provinces of Indonesia from 2006 to 2009. Although numerous limits to yield were identified the most important were PLB (potato late blight) management, seed quality, Integrated Pest Management (IPM) of LMF (leafminer fly) and soil pH/fertility. Improved management options of these factors were tested in learning-by-doing plots (LBDs) as part of Farmer Initiated Learning (FIL) activities in West Java (WJ) in 2008/2009 and 2009/2010. FIL is where farmers in the LBDs undertake simple standardised but rigorous experiments to test one management change against standard practice and was developed after reviewing Farmer field school (FFS) activities in CJ and WJ during 2008. Coordination meant that LBDs were repeated between FIL groups. When similar results are obtained from different FIL groups the outcomes are more convincing.

The performance of certified G4 Australian Granola seed (Aust) was compared with certified G4 Indonesian seed (Indo), local and farmer group seed (2009/2010 only) in the wet seasons of 2008/2009 and 2009/2010. In 2008/2009 in addition to comparing Granola seed sources the effectiveness of lime (as dolomite and calcium carbonate) was evaluated as part of the same LBDs at the same FIL sites. In 2008 /2009 because of issues with seed quality the 3 seed sources only were compared on 3 sites in addition to the seed source x lime LBD sites. Yields from Granola crops grown with Aust seed were lower than either Indo or local seed in the first series of seed source x lime LBDs in WJ however Aust seed yielded as well as Indo seed and more than the local seed in the additional LBDs in 2008/2009 and as well as the Indo seed and higher (not statistically significant) than local or group seed in 2009/2010. BCA (benefit:cost analysis) was higher on average in crops grown from Aust seed than Indo seed which was higher than local seed. Follow up LBDs in 2009/2010 showed yield and economic performance (gross margins and BCA) of crops grown from Aust and Indonesian seed to be comparable and higher than either crops from group or local seed. These results show that Australian seed can be used to provide an additional source of high quality seed. The seed will be safe as it is free of PCN and other important pathogens like bacterial wilt and potato late blight. The quality of seed from Australia is further enhanced due to the low number of generations used compared to other exporting countries. The use of imported seed will help Indonesia protect potato production areas that are currently free of PCN by increasing the availability of high quality seed.

The response to applied ‘limes’ either as dolomite or calcium carbonate to LBD plots in 2008/2009 was variable between sites and plots on sites. On one acidic site there is an indication that there may have been a positive yield and economic response (BCA) to applied calcium carbonate at 3 t/ha but not 6 t/ha. On other sites the response to the limes was variable and no consistent conclusions could be drawn on the benefits of lime application on yield or BCA. This LBD therefore didn’t conclusively clarify findings of the baseline survey that soil acidity was contributing to lower yield in potato crops in Java. The timing of application (i.e. the interval between lime application and planting) and variable quality of the lime could have contributed to the inconsistent responses to the applied limes. The variable quality of the seed, especially the Aust seed in 2008/2009 as mentioned, could have also contributed to the variable responses to the applied limes. The importance of soil acidity in potato production in Indonesia still needs to be resolved. With the high concentration of extractable Al in Indonesian potato producing soils and the sensitivity of potatoes to high soil Al, experiments with different sources and more rates of lime on a known site of low pH (< 5.0) are needed.

2 Background

One of the project aims was to use the baseline agronomic and economic surveys in the first phase of the project to identify the major limits to yield. These constraints were then to be used as the focus topics for FIL (Farmer Initiated Learning, previously referred to as Farmer Field Schools) learning-by-doing (LBD) activities in the next phase of the project. These FIL LBD activities form part of the ToT (training of trainer) program under objective 1 (Adapt and apply robust integrated crop production, pest management and post harvest handling systems for potatoes and Brassicas suited to Javanese conditions): Activity 4:'Season-long ToT for potato-cabbage ICM FFS facilitators and Activity 6: Implementation of multiple cycle FIL that engage farmer groups in season long learning and adaptive research throughout consecutive Brassica and potato cropping seasons.

The baseline agronomic survey of potatoes identified numerous factors associated with higher yield or conversely numerous factors that limited yield in the four provinces studied from 2007 to 2009 (ACIAR Project ABG/2005/167 Appendix 1. Baseline agronomic survey of potatoes). To be most effective it was decided to focus on a few major areas rather than try and address a whole range of possibly important factors in the FIL activities. The baseline agronomic survey found that the major factors limiting yield in WJ and CJ were potato late blight (PLB) management, seed quality, IPM management of insect pests such as leafminer fly (LMF, *Liriomyza huidobrensis*) and soil pH/nutrition management. Therefore these four constraints were investigated in FIL LBD activities. The high ranking of PLB and seed quality as major limits to yield in the baseline survey supports previous surveys by potato experts where the most important production limits to potato yield and quality in SE Asia, including Indonesia, were sanitary quality of seed, PLB, bacterial wilt, viruses (potato virus Y (PVY), and potato leafroll virus (PLRV)) and their vectors and the high cost and low availability of good quality seed (Maldonado *et al.* 1998, Fuglie *et al.* 2005, Fuglie 2007).

The PLB pathogen usually proliferates in moist conditions (rain, light drizzle, dew, high humidity) in the temperature range 10 to 25 °C. These conditions are common in the tropical highlands where most of the potatoes are grown in Indonesia. PLB infects the potato from emergence to maturity and if poorly controlled in a susceptible variety can lead to total crop loss. In the survey growers reported using a range of fungicides of different trade names and active ingredients as well as methods and frequencies of application for the control of PLB. The FIL LBD focussed on comparing two programs; the standard grower practice versus an ACIAR designed program based on the use of fungicides with known efficacy in controlling PLB using applications of fungicides with a contact mode of action in rotation with fungicides with both contact and systemic modes of action.

The baseline economic survey showed seed and its preparation constitute the major cost of production of potatoes in Indonesia (ACIAR Project ABG/2005/167 Appendix 2. Baseline economic survey of potatoes). The supply of affordable good quality seed is recognised as a major factor limiting yield improvement in Indonesia. There are at least four sources of seed available to the Indonesian farmer including government certified seed usually sold at the G4 stage, G4 seed bulked from tissue cultured material from private companies, G4 imported seed and uncertified, informal seed from 'non' seed farmers (referred as 'local' seed from the 'informal' seed scheme). As cost of certified seed is high and availability is low most seed used by farmers is informal seed. The baseline survey showed farmers used seed from a number of sources and generations. The 'Seed' FIL LBD focussed on comparing yield and profit from Indonesian certified G4 seed, imported certified G4 seed, uncertified informal seed available in the farmer group as well as the local informal seed normally used by the farmer.

Varietal tolerance to key pests, integrated pest management (IPM), seed management, followed by soil erosion, fertility and post harvest handling were ranked as the main potato research priorities in Indonesia in a review in 2002 (Dimyati 2002). It was noted that some pests such as LMF once ranked as a secondary pest had now become primary pest of potatoes (Setiawati and Uhan 1997 cited in Dimyati 2002). LMF was accidentally introduced into SE Asia from South America in the early 1990s and rapidly spread attacking potatoes, red kidney beans, Indian mustard, other Solanaceous crops and weeds. The chemical measures taken to control key pests and diseases have in the past shown to be expensive and inefficient with the use of broad spectrum pesticides compounding management difficulties (van de Fliert *et al*. 1999). The economic baseline survey showed increased expenditure on chemicals leads to declining profits. The LMF LBD focussed on comparing two programs ; the grower practice typical in the local area versus an ACIAR designed program to enable a combination of chemical and biological control through parasitism based on the use of selective insecticides with known control of LMF but ‘soft’ on predators of LMF.

Agronomic factors like soil fertility and pH, although not unimportant, are often not ranked highly in surveys of yield constraints because of the dominant effects of disease and pest problems in potato production in the tropics. However work in Vietnam showed that the adoption of both improved agronomic practices and the use of high quality seed will result in higher yields and profits than the use of either factor alone (McPharlin *et al.* 2003).

3 Objectives

3.1 Farmer Field School training

The aims of the FFS undertaken in the second year of the project were to:

- To improve skill and knowledge of farmers in production of potatoes and seeds potatoes using learning-by-doing methods.
- To share their own experiences as part of capacity building in developing their ability towards the capability to and sharing process from each other experiences and from improved technology generated from research institute.
- To discuss and show the beneficial of applying ICM in order to establish GAP and other standards.
- To revitalized and empower the farmers groups in order to develop their ability in using or access the technology potato and cabbage farming systems.

3.2 FIL Training

The FIL objectives which evolved from the experiences gained in the FFSs were to enable the farmers themselves to evaluate the benefit of new management techniques in an more objective and efficient manner using simple experimentation.

The objective of FIL is to train the farmers to carry out their own evaluations of management factors that may lead to yield and quality improvement. LBD plots are a convenient method of achieving this. In this project the LBD plots are designed in such a way to evaluate a small number of management factors in each activity rather than comparing many factors such as when two completely different management programs covering all aspects of agronomy are compared. Whilst multifactor comparisons have a place it was decided focusing on fewer factors would be more fruitful as a training exercise in a more experimental use of LBDs to improve yield and profit.

The farmers are trained in the techniques of basic experimental design and understand what a ‘treatment ‘and ‘control’ plot is and the importance of replication, randomisation and site selection. They are also trained in the techniques of collecting soil and plant samples, identification of pests and diseases and assessment of their infestation, incidence and severity as well as data collection and recording.

4 Methodology

4.1 ICM FFS 2007/08

4.1.1 Training of the trainer West Java

Experienced facilitators and guides for the farmer field schools were selected and their competencies were assessed in August 2007.

4.1.2 FFS Oct 2007 – Feb 2008 West Java

Ten Farmer Field School groups were to be organised in West Java. The curriculum for each group is shown in Table 4.1. Two guides were to facilitate each FFS, one was an official from Dinas Pertanian and the other was an experienced farmer.

4.1.3 FFS Central Java

Ten FFS were performed in the Wonosobo and Banjarnegara districts of CJ during 2008. Only four farmer groups from Banjarnegara reported on their progress from these FFS.

Sekar tani

The aim of the Sekartani group for their FFS was to discover how to grow high quality seed. To do this they trialled the use of two different potato late blight regimes, a farmer modified regime and the conventional practice regime. The conventional regime involved eight sprays of Curzate, two sprays of Previcur, four sprays of Manzate and four sprays of Octanil. The comparison plot involved two sprays of Curzate, two sprays of Octanil and one spray of manzate. Both plots involved the use of G4 seed.

Bukit Madu

Bukit Madu tested two sources of seed throughout their comparison with certified and local seed, the certified being used in experimental plot and the local in the farmer plot. Both seed sources were G4 Granola. In addition to the experimental plot group tested three applications of plant growth promoting rhizobacteria (PGPR) at planting, 20 days after planting and 30 days after planting.

Trubus

The Trubus group looked at the use of IPM versus conventional practices to control insects. The IPM plot consistent of applications of biological controls and pesticide applications based on threshold levels of pests and diseases. The pest and disease control of the conventional plot was not indicated.

Tunas Harapan Jaya

The aim of this group was to look at two different seed sources, certified G4 granola was used in the experimental plot and local uncertified G3 seed was used in the conventional plot. The experimental plot included PGPR and staking whereas the conventional plot did not.

Table 4.1. Farmer field school curriculum 2007-08.

Week	Activity
-3	Coordination of sub-district work force
-2	Coordination of village workforce
-1	Coordination of farmer group workforce
1	Commencement test. What's this? Pest/disease/natural predators in potatoes General agro-ecosystem (soil, water, humidity, pests, diseases, natural predators, wind, sun and plants)
2	Agro-ecosystem observations (climate, pests and diseases, natural predators) 30 days after planting foliage growth phase. Bio-pesticides Group dynamics
3	Ecosystem observation Method of sampling. Group dynamics (menggambar bersama)
4	Agro-ecosystem observations 37 days after planting. Measuring soil pH. Group dynamics (menara sedotan)
5	Agro-ecosystem observations 44 days after planting. Balanced crop nutrition. Group dynamics (Nine dots).
6	Agro-ecosystem observations 51 days after planting. Insect zoo. Group dynamics.
7	Agro-ecosystem observations 58 days after planting. Viruses and their vectors. Group dynamics (Samson and Delilah).
8	Agro-ecosystem observations 65 days after planting. Tuber development phase. Group dynamics (The sinking ship).
9	Agro-ecosystem observations 72 days after planting. Weather and disease Group dynamics (Composing drawings).
10	Agro-ecosystem observations 79 days after planting. Monitoring insect traps. Group dynamics (Guess the number).
11	Agro-ecosystem observations 86 days after planting. Economic threshold. Group dynamics
12	Agro-ecosystem observations 95 days after planting. Tuber maturity phase. Group dynamics.
13	Farmer gathering/Field day
14	Evaluation. Closing test. Closing.

4.2 FIL seed by lime LBD plots 2008/2009

More rigorous field comparisons using LBD demonstration plots for the wet season potato crop in WJ 2008/09 was devised from an ACIAR project meeting in Lembang in August 2008. These plots involved three separate management comparisons (PLB, soil pH and seed quality. The design on all sites was:

1. Three sources of seed in the main plots (6 x 20 m or 4 x 30 m). The three seed sources are referred to as (1) Local (local farmer seed), (2) Indo G4 (certified G4 seed grown in Indonesia) and (3) Aust G4 (G4 certified seed imported from WA and grown in a known PCN free area).

2. Five sources and rates of liming materials (dolomite and lime as calcium carbonate, $CaCO_3$ at 2 rates plus nil-lime controls) as the sub plots with 1 replicate.

3. Two PLB plots on most sites (5 x 10 m), to demonstrate different late blight treatments, adjacent to the main seed x lime LBD plots.

The LBD was repeated on 10 sites (2 in each of the two sub-districts of Bandung and 2 each on the three sub districts of Pangalengan).

Soil samples were collected from 0 – 15 cm soil depth from each site prior to planting and after harvest and submitted to IVEGRI for pH (H_2O), %C and particle size measurements to monitor the change in pH with the lime treatments.

Lime was applied as either calcium carbonate at 3.1 or 6.0 t/ha or as dolomite at 2.96 to 5.65 t/ha to the relevant plots (with no lime applied to the control plots) about 1 month before planting and incorporated to 30 cm.

Aust G4 seed was harvested on 10 May 2008 in Manjimup, Western Australia. It was left to cure for 3 weeks then cool stored until early September. On 2 September it was graded and packed then shipped to Jakarta in a refrigerated container.

The crops were grown at each site using the normal agronomic practices of the farmer group.

A comparative economic analysis on the use of the 3 different source of seed was carried out 3 of the agronomic LBDs sites.

ACIAR team members from Australian Institutions visited the FFS sites with staff of Indonesian partners in December 2008, January, February, March and April 2009 covering crop stages from just after emergence to harvest.

4.3 FIL seed and PLB LBD plots 2009/2010

Experience from the 2008/2009 round of LBD plots led to simplification of the methodology. LBDs were designed which dealt with one management issue only.

As there was no significant response to applied lime in the 2008/2009 LBDs it was decided to focus on seed and PLB management in 2010/11. The final design on all sites in 2010/2011 was 4 sources of seed in plots 4 x 20 m. The 4 sources of seed were local farmer's own informal seed (Local), informal seed from the farmer group (Group), Indonesian certified G4 seed (Indo G4) and imported certified G4 seed (Aust G4). The

LBD was repeated on 5 sites in West Java. The farmer groups and sub-districts locations where; Anugrah in Pangalengan , Tunas Tani in Kertasari, Tanijaya in Garut, Medal Sawargi in Garut and Barokah Tani in Garut. The PLB spray regime during the seed plots was solely ACIAR based.

In separate LBDs adjacent to the seed LBDs two PLB treatments (ACIAR versus Farmer Practice) were compared.

A guidebook for facilitators of these FIL LBDs was produced and named *Kentang Peralatan Teknis ACIAR Proyek AGB/2005/167* (DAFWA 2010). In English this is *Potato Technical Toolkit ACIAR Project AGB/2005/167*. This book contained:

- an explanations of the FIL methodology of objective experiments,
- an LBD design for comparing ACIAR PLB management against conventional management,
- an LBD design for comparing seed sources,
- an LBD design for production on acid an near neutral soils,
- an LBD design for IPM,
- an LBD design for testing increased potassium (for at NTB).
- tally sheets for recording important measurements,
- background information on PLB, seed, soil pH, IPM and potassium.

4.4 FIL seed 2010

Aust G4 seed was again harvested in April 2009 in Manjimup, Western Australia. It was left to cure for 3 weeks then cool stored until early November. It was packed on 11th November 2009, transported to Perth airport where it was cool stored then airfreighted on 17th November 2009 to Jakarta.

A comparative economic analysis on the use of the 3 different sources of seed was carried out at 3 of the FIL LBD sites.

4.5 Monitoring potato late blight infection.

The incidence (% of total number of plants infected) of PLB was recorded in each seed source plot at each site at 3 crop stages; 30 cm plant height, row closure and flowering. PLB severity on a scale from 0 (no PLB observed) to 100 (all plants dead) (DAFWA Potato Technical Toolkit, Chapter 5, Results-Table 7) was also recorded at the same time.

4.6 FIL Central Java.

A total of 10 FIL potato plots were to be conducted in Central Java, four in Wonosobo and six in Banjarnegara, in 2009 using the FIL guidelines.

5 Achievements against activities and outputs/milestones

Objective 1: To Adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas/Alliums suited to NTB and Sulsel conditions.

no.	activity	outputs/ milestones	completion date	Comments
1.6	FIL adaptive potato research	Potato LBD reports	Y4 m 5	Results apply to Potato LBDs in WJ only

PC = partner country, A = Australia

6 Key results and discussion

West Java

6.1 ToT 2007-2008

The training requirements for the FFS guides were identified in August 2007 (Hidyat *et al.* 2007). Competencies were assessed in 146 specialised areas of potato and cabbage production as well as group dynamics. These included: site selection, seed selection, agro-ecosystem observation, potato and cabbage pests and diseases, natural predators, threshold levels, biological control agents, spray technology, balanced fertiliser, compost production, farming business analysis, GAP and group dynamics. The assessment showed topics where candidates' competences needed improvement and these areas were targeted in the ToT. Half or more of the candidates were found to be competent in 37 of the 146 topics. This indicates that the FFS should concentrate on fewer topics as well as provide a system for guide self-improvement.

Because most of master trainers had previously attended ToT for potato and cabbage, it was agreed by participants that ToT duration of 2 weeks (12 days) was appropriate.

One ToT was held at provincial level in September 2007. The curriculum was developed after the assessment of participants competencies and is shown in Table 6.1.

Table 6.1. Curriculum for Training of the Trainer for Farmer Field School Facilitators 2007.

Level	Description
Basic	Land preparation Seed selection Plant management Observation and agro-ecosystem evaluation
Main	Introduction to pests (golden nematode; *Myzus*, thrips) Introduction to diseases (late blight, wilt; virus) Introduction to natural enemies Balanced fertilizer Spraying technique How to make compost/organic manure How to develop and use biological agents or biological pesticide How to observe pest and diseases Simple farming system and analysis GAP and other international standards
Optional	Net working and working together inter group farmers Developing creativity Ice breaking How to develop communication

6.2 ICM FFS 2007-2008

Ten FFS were run in West Java in 2007-08. The locations and facilitators for each FFS group are shown in Table 6.2. At these sites the field was split to compare conventional farmer practice with integrated crop management.

Table 6.2. Locations and guides of West java Farmer Field Schools 2007/08.

District	Sub-district	Farmer group	Official	Farmer guide
Garut	Cikajang	Medal Sawargi	Asep Rohiman	Sopanji
		Perjuangan Tani Mukti	Iwan Setiawan	Ending Sahidin
	Cisurupan	Karya Mandiri	Rahmat	Nandang, H
		Suka Haji	Ir Ade Suryana	Ayat. H.
	Pasir Wangi	Mukti Tani	Encu Sofian	Dayat Suhendra
		Barokah Tani	Endang Nuryaman	H.Otang
Bandung	Pangalengan	Taruna Tani Sauyunan	Pepen Efendi	Asep Koswara
		Mitra Mukti	Oji Setiadi	Ade Rubini
	Kertasari	Mekar Tani II	Wahyudin	Amang Taryana
		Mekar Tani Muda	Supiadi	Asep Budi DS

Two FFS sites were visited by Australian team members in February 2008. The first was the Barokah Tani Farmer Group Field School plots and the second was the Taruna Tani Sauyunan group.

6.2.1 Improved potato late blight control

At both sites the conventional farmer management produced the better looking crop with greater foliage cover (Fig 6.1). At the two sites the ICM plots had not controlled late blight as well as the conventional plots. The fungicides applied at the FFS plots at Taruna Tani Sauyunan are shown in Table 6.3. This shows that for the ICM plot only four botanical fungicides were applied well after the conventional spraying commenced. The conventional spray program showed an over-use of fungicides. For example 'conventional spray 2' combined Acrobat and Daconil which applied one systemic (translaminar) active ingredient with two protectants; the mancozeb component of Acrobat plus the chlorothalonil of Daconil. Similarly 'conventional spray 6' combined Equation, Daconil and Acrobat which meant that two systemic active ingredients cymoxanil, dimetomorph and three contacts; famoxadone, chlorothalonil and mancozeb were being applied at the same time. CIP PLB control recommendations for Peru for susceptible varieties under high pressure (Cáceres *et al.* 2007) will be more suited for the similar Indonesian situation. These are:

- First spray at 80% emergence (if emergence is uneven apply spray at 50% and 100%). This is best done with a systemic as it will best protect rapidly expanding tissue of a young plant.
- Alternate use of at least two systemic fungicides (each alternated with contact). Use one translaminar instead of systemic to reduce costs.
- Spray intervals 5 - 7 days after a contact or translaminar, 7 - 14 days after a systemic (depends on disease pressure and systemic used).
- Each systemic should be used only a maximum of 3 times in the season.
- Phenylamide fungicides (metalaxyl and mefenoxam should not be used as Indonesian PLB strains are resistant to this fungicide.

Figure 6.1. Farmer Field School plots of Barokah Tani Group (left) and Taruna Tani Sauyunan (right) in February 2008. Both sites compared conventional farmer practice with integrated crop management (ICM or PHT in Indonesian). At both sites the ICM plots were more affected by late blight than the conventional plots. The ICM spray program appears to be inadequate and at Taruna Tani Sauyunan where crop health in the ICM plot may have been exacerbated by an application of tobacco leaf spray at a phytotoxic concentration.

Using these CIP recommendations the spray program used at the FFS at Taruna Tani Sauyunan (Table 6.3) can be improved. The following changes to the conventional fungicide program would appear to provide an appropriate spray program for the ICM plot. The numbers relate to the sprays shown in Table 6.3.

1. The first spray of curative (translaminar) Acrobat is appropriate. This should be applied at 80% emergence assuming even emergence. Then after 5-7 days…
2. Only Daconil (protectant) would have been sufficient. Then after 5-7 days…
3. Acrobat alone could have been used (systemic for high disease pressure with susceptible varieties). Then after 7-14 days…
4. Only Daconil (protectant) sufficient. Then after 5-7 days…
5. Equation as an alternative systemic. Then after 5-7 days…
6. Only Daconil (protectant) would have been sufficient. Then after 5-7 days…
7. Equation is appropriate, then after 7-14 days…
8. Daconil (protectant) sufficient. Then after 5-7 days…
9. Acrobat ok on its own. Then after 5-7 days…
10. Daconil (protectant) sufficient.
11. Daconil replaced by Equation to keep alternating systemic-contact pattern. Then …
12. Repace Acrobat with Daonil. Then …
13. Replace Acrobat with other systemic as Acrobat has been used three times, then...
14. Replace Equation with Daconil.

Table 6.3. Pesticide applications used in FFS at Taruna Tani Sauyunan in 2007/08. Fungicides considered redundant are shown in italic in the 'Conventional plot' column. If these are omitted this program is suitable as an ICM program with reduced applications of fungicides but similar efficacy. This program alternates systemic fungicides (which incorporate a contact fungicide in their formulation) with contact only fungicides.

#	Integrated crop management		Conventional farmer practice	
	Fungicide	Insecticide	Fungicide	Insecticide
1			Acrobat	
2			*Acrobat* + Daconil	
3			Acrobat + *Daconil*	
4	Botanical		*Acrobat* + Daconil	Marshall
5			Equation	Marshall
6			*Equation* + Daconil + *Acrobat*	
7	Botanical	Agrimec	Equation	Agrimec
8			*Equation* + (replace with Daconil)	Agrimec
9	Botanical	Agrimec	Acrobat + *Daconil* +	Agrimec
10	Botanical	Trigard	*Acrobat* + Daconil	Trigard
11			*Daconil* (replace with Equation)	Trigard
12			*Acrobat* (replace with Daconil)	Trigard
13			*Acrobat* (replace with other systemic)	
14			*Equation* (replace with Daconil)	

Acrobat a.i. = dimetomorph (translaminar) + mancozeb, reasonable curative with good to very good protectant, good to very good rainfastness
Daconil a.i. = chlorothalonil protectant with good to very good rainfastness
Equation a.i. = famoxadone + cymoxanil, protectant & curative with good to very good rainfastness
Marshall a.i. = carbosulfan

This ICM program above requires 14 fungicide applications compared to the 21 applications used by conventional farming practices of the Taruna Tani Sauyunan farmer group. The baseline economic survey of potatoes (ACIAR Project AGB/2006/167 Appendix 2 Baseline economic survey of potatoes) showed there was no correlation of pesticide expenditure with yield. Rationalising potato late blight spray programs will help to reduce pesticide applications without reducing disease control efficacy.

The use of botanical fungicides to control PLB as shown in Table 6.3 is promoted widely in Indonesia. Experimental evidence for the use of these sprays was not found. However in Indonesia use of traditional medicinal cures is common and it appears these cures extend to crops. Effective PLB control with a betel nut botanical fungicide was reported by Lologau *et al.* (2003). Their application of betel nut extract commenced 30 days after planting while spraying of synthetic fungicides used as a comparison began after a control threshold of 1 lesion per 10 plants was reached. This threshold is now considered too high (e.g. see Cáceres *et al.* 2007). The yield of the treatments was very low at 5.4 t/ha for the control, 6.3 t/ha for the botanical treatment and 6.9 t/ha for the thiophanate-methyl synthetic fungicide. An alternative conclusion from this work that might better fit the data presented was that all spray treatments were applied too late after the disease had established and thus all were equally ineffective and so the disease destroyed the crop. Stronger experimental evidence is warranted before botanical fungicides are recommended as a control for PLB in Indonesia.

6.2.2 Improved pest control

The pesticides used at the Barokah Tani farmer group ICM FFS are shown in Table 6.4. There was very little difference in insecticide use between ICM and conventional treatments in first 60 days. The ICM control methods used in the FFS ICM plots at Barokah Tani farmer group were not following best practice for leafminer control. Faults were that:

- Broad-spectrum insecticides were being used in both plots early. This would have adversely affect natural enemies because broad-spectrum insecticides (pyrethroids, organophosphates) are notorious for eliminating parasitoids and exacerbating leafminer problems). Cyromazine and abamectin are better alternatives as they are effective against larvae and are relatively safe against parasitoids.
- Need to use appropriate treatments for pests observed. Treatment for *Liriomyza* should have been delayed until larval mines appeared - not just on presence of adult flies (egg extrusion in young plants reduces infestation).
- Worldwide, *Myzus persicae* is normally highly resistant to many insecticides. Aphid outbreak in conventional treatment is typical after pyrethroid use.
- Omission of systemic insecticides for sucking insects (aphids and thrips) (imidacloprid would be very useful, especially seed application at planting).
- In the ICM plot, more cultural controls for *Liriomyza* should be tested - as outlined by Tantowijoyo and van de Fliert (2006), for example: sanitation, trap crops of beans, hilling up to bury pupae, healthy plants to maximise egg extrusion and rotation with non-host crops such as maize and sweet potato.

Table 6.4. Spray programs for leafminer (*Liriomyza huidobrensis*) control used in ICM and conventional plots in the Barokah Tani Farmer Field School.

DAP	Insecticide applied		Pest numbers					
	ICM	Conv- -entional	Liriomyzus huidobrensis		Myzus persicae		Thrips palmi	
			ICM	Conv	ICM	Conv	ICM	Conv
29			0	0	0.2	2	0.1	0
36	Buldok	Buldok	0	0	8	12	0.1	0
43	Buldok	Buldok	0	0	24	10	0	0
50	Lannate	Lannate	4	4	50	>100	0	0
57	Agrimec	Agrimec	2	12	25	>100	9	0
64	Botanical	Agrimec	16	6	10	>100	2	0
66		Agrimec						
71	Trigard	Trigard	14	16	10	10.1	0	0
78		Lannate	11	1	6	7	0	0
81			12	3	13	0.1	0	0

Lannate is broadspectrum carbamate (Du Pont)
Agrimec a.i. abamectin (Novartis)
Trigard a.i. cyromazine (Syngenta)
Buldok is a broad spectrum pyrethroid.

6.2.3 Economic outcomes

Economic outcomes of the ICM and conventional treatment plots of nine of the FFS groups are shown in Table 6.5. The benefit:cost ratio (BCR) of the ICM plot at Berokah Tani was less than the conventional plot 1.9 versus 2.4, because of its lower yield of 11.7

t/ha versus 17.1 t/ha. This result was to be expected due to the failure to control PLB in the ICM plot. However the Taruna Tani Sauyunan group which also had early death of the ICM plot reported that the BCR for this plot was 1.50 while the BCR of the conventional plot was 1.45. There certainly would have been reduced yield in the ICM plot at this site but the high input costs of the conventional plot negated this yield advantage.

The other eight sites reported an improved BCR in the ICM FFS plots (Table 6.5). However the reasons for the improved BCR were not identified. The FFS methodology of comparing and ICM plot against a conventional practice plot means that many management changes occur between the two plots and so the causes of yield and profit differences are difficult to identify. For example at Taruna Tani Sauyunan changes between the ICM plot and the conventional plot includes differences in: fertiliser rates, fertiliser type, fungicides and time of application and insecticides.

Table 6.5. Enterprise economic returns of FFS ICM and conventionally managed plots in West Java 2007-08.

Group	Measurements	ICM plot	Conventional plot
Taruna Tani Sauyunan, Bandung			
	Total input costs Rp/ha	26,392,857	33,534,643
	Benefit: cost ratio	1.50	1.45
Mitra Mukti/Marea Mukti, Bandung			
	Total input costs Rp/ha	38,750,000	48,748,500
	Yield (t/ha)	23.5	25.0
	Income (Rp/ha @ Rp 2,500/kg)	58,750,000	62,511,500
	Benefit: cost ratio	1.5	1.28
Mekar Tani Muda, Bandung			
	Total input costs Rp/ha	10,200,000	13,900,000
	Yield (t/ha)	10.8	8.7
	Income (Rp/ha @ Rp 2,600/kg)	27,950,000	22,620,000
	Gross margin	1,775,000	872,000
	Benefit: cost ratio	2.74	1.62
Mekar Tani II, Bandung			
	Total input costs Rp/ha	14,825,000	17,830,000
	Yield (t/ha)	14.5	12.4
	Income (Rp/ha @ Rp 2,600/kg)	37,804,000	32,110,000
	Benefit: cost ratio	2.55	1.80
Barokah Tani, Garut			
	Total input costs Rp/ha	15,000,000	17,906,000
	Yield (t/ha)	11.73	17.05
	Income (Rp/ha @ Rp 2,500/kg)	29,325,000	42,625,000
	Benefit: cost ratio	1.9	2.38
Mukti Tani, Garut			
	Total input costs Rp	1,500,500	1,791,000
	Yield (t/ha)	15.01	14.96
	Income (Rp/ha @ Rp 2,500/kg)	37,525,000	37,400,000
	Benefit: cost ratio	2.50	2.09
Karya Mandiri, Garut			
	Total input costs Rp/ha	19,215,000	24,185,000
	Yield (t/ha)	13.72	12.78
	Income (Rp/ha @ 2,000/kg)	27,440,000	25,560,000
	Benefit: cost ratio	1.43	1.06
Suka Haji, Garut			
	Total input costs Rp/ha	12,211,538	20,192,308
	Yield (t/ha)	9.7	9.9
	Income (Rp/ha @ 2,500/kg)	24,326,923	24,759,615
	Benefit: cost ratio	1.99	1.23
Medal Sawargi, Garut			
	Total input costs Rp/ha	31,862,500	41,775,000
	Yield (t/ha)	30.0	32.5
	Income (Rp/ha @ Rp 2,500/kg)	75,000,000	81,250,000
	Benefit: cost ratio	2.35	1.94
Perjuangan Tani Mukti, Garut			
	Total input costs Rp/ha	31,655,000	42,187,500
	Yield (t/ha)	24.9	23.5
	Income (Rp/ha @ 2,500/kg)	62,187,500	58,687,500
	Benefit: cost ratio	1.96	1.39

6.2.4 Farmer development

Farmers reported that the FFS meetings improved farmer's knowledge and skills of potato production through observations and conclusions based on joint decisions and through direct practice. The farmers reported that they had;

- Learnt to observe and analyse problems of potato production,
- Learnt about improved land preparation,
- Learn to work with nature when producing potatoes,
- Used pesticides in a wiser manner, and
- Improved pest and disease management.

The farmers reported that they wanted to learn more about:

- Soil analysis,
- Seed care and information,
- Investigation of pest and disease agro-ecosystem/Improved pest and disease management, and
- How to increase yield,

The most important sources of information were reported to be:

- Extension Service Officer.
- Local guide
- Other farmers.
- Pesticide Formulator.
- Listening, looking, carrying out.

6.2.5 Future ToT outcomes

A debriefing of FFS guides identified the following problems:

- Understanding of pests and diseases by farmers still needs improvement,
- Understanding of natural predators also needs improvement,
- Understanding threshold control levels needs improvement,
- Better control strategies for pest and diseases need to be developed.

The following solutions to these problems were suggested by the FFS guides:

- Guides facilitate farmers to know and understand the nature of potato pests: green peach aphid (*Myzus persicae*), thrips sp, LMF and potato tuber moth (PTM, *Phthorimaea operculella*),
- Guides facilitate farmers to know and understand the nature of potato diseases: (*Phytophthora infestans*, *Pseudomonas solanacearum*, *Fusarium* sp and virus),
- Guides direct role of natural predators in controlling crop pests with the use of an insect zoo to show at certain times natural predators can be taken advantage of,
- Guides be informed about the pest and disease thresholds for economic damage,
- Guides prepare a good and correct strategy to control pests and diseases so that they don't become resistant (right targets, right dose and right method and right time).

6.2.6 FFS improved to FIL

The short comings identified in the ICM FFSs where the causes for improved crop performance were difficult to identify were addressed by changing the FFS methodology. The change was for farmers' groups, with help from their guides, to set up a more rigorous though simple experiment to enable the farmers themselves to independently test the efficacy of new management techniques. This would also enable the farmers to continue learning about management techniques in groups led by extension officers and local guides who were respected sources of information.

A Potato Technical Toolkit was developed to allow Indonesian potato farmers to investigate new management techniques and to determine whether they improve the profitability of their enterprise. The Technical Toolkit was aimed at the Farmer Group guides. The Potato Technical Toolkit had several components:

- Information on how to set up a simple experiment that could be repeated at more than one site.
- A series of practical learning exercises (learning-by-doing plots) to enable farmer groups to compare new management techniques against conventional practices. The practical exercises included:
    - Potato late blight control
    - Comparison of seed potatoes
    - Integrated pest management
    - Soil pH
    - Potassium nutrition of potatoes
- Standard Operational Procedure for the learning-by-doing plots. This describes good agricultural practice to be used in management of the plots. This would reduce the risk of LBD failures by making sure factors other than those being tested were not limiting.
- Results-Tables. The tables are designed to record the information that will enable the LBD plots data to be analysed for yield and profitability.
- Written background information on the topics to be investigated. This information is designed for master trainers, farmer group facilitators and guides who can interpret this information and present it to the farmer groups.

This written information was supplemented with a DVD showing some of the management techniques that can be tested by farmers. The farmer group facilitators and guides should be able to answer farmer's questions about the DVD from information they have received in training and from the "Background Information" in the Potato Technical Toolkit.

This approach will allow the farmers to become their own experts in potato agronomy. We called this modification of the FFS approach Farmer Initiated Learning (FIL).

6.3 Seed and lime LBDs 2008-2009

6.3.1 Sites

There was a significant ($P < 0.001$) difference in mean yield between the sites due to a combination of different growing conditions and practices. The mean yields ranged from 7.6 t/ha at site 3 (Karya Mandiri) to 52.2 t/ha at site 10 (Mekar Sari) (Fig. 6.2).

6.3.2 Seed sources

The seed arrived in Jakarta on 20th September and was cleared from Customs, removed from the refrigerated container and trucked to the Garut ambient seed store on 25th September. It was held here at ambient conditions under quarantine until its release on 25th October when it was transferred to IVEGRI, then to Dinas Pertanian Bandung who forwarded seed to farmer field school at Garut. Photographs showed that Australian seed was physiologically old when it arrived and should not have been planted. However there did not appear to be many shoots on each tuber, only one or two. The seed upon removal from the refrigerated container would have overcome dormancy and begun to sprout. The daytime temperature in the store at Garut was recorded at 28 °C. Above 23 °C PTM takes four weeks to compete its lifecycle. At 37 °C this time is reduced to two weeks (Horne *et al.* 2002). The ambient storage conditions of high temperature, dark storage

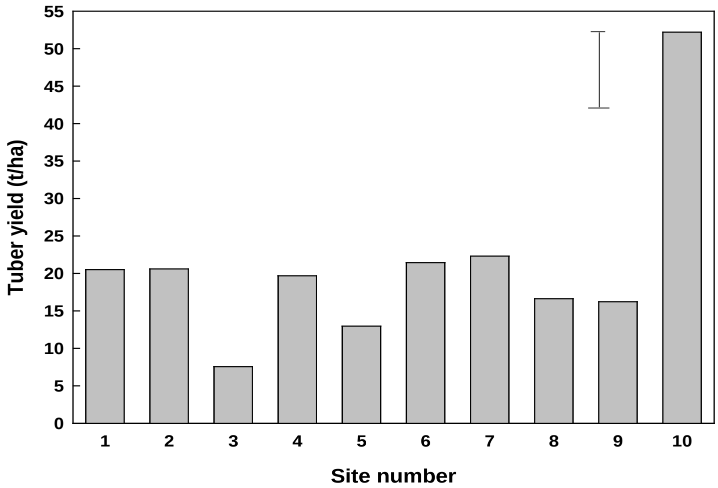

Figure 6.2. Mean potato tuber yield at different sites in the LBD plots in 2008/2009. Vertical bar is LSD (P<0.10) for difference between site yields.

and lack of protection from PTM would have allowed the seed to grow long shoots which lead to dehydration as well as infestation by PTM. The long time in storage not only damaged the seed, it also delayed planting time which would have affected crop performance.

The seed was received by farmers from 5th November to 20th December 2008 and again stored before use. Grower photos of plots showed poor germination of Australian seed with some setts rotting in the ground.

Imported and local seed had on average similar sprout length (4.0 cm) and number (3.5 to 4.0 per tuber) whilst certified seed had shorter (2 cm) and fewer sprouts (2.7 per tuber). The crops on most LBD sites were sown in November 2008 with 1 sown in December 2008 and 1 in January 2009. Harvest commenced in late February 2009 and was completed by March 2009.

Yield differences between plots sown with different sources of seed was not significant (P = 0.05) with Indo, Aust and local seed producing similar results of 23.1 t/ha, 18.8 t/ha and 20.9 t/ha (mean yield) respectively (Fig. 6.3) and Annex 1.

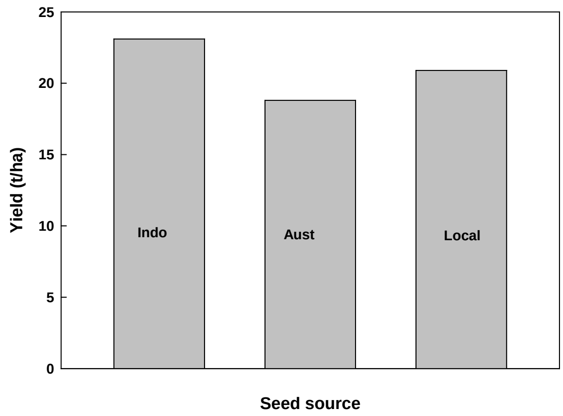

Figure 6.3. Mean potato tuber yield from different sources of Granola seed in the LBD plots in WJ in 2008/2009. 'Indo, 'Aust or 'Local' refers to certified Indonesian G4, certified imported Western Australian G4 or local seed (G unknown) respectively. There was no significant difference between the means.

6.3.3 Economic evaluation of seed sources

An economic analysis of the use of the different sources of seed for commercial production was carried out at 3 sites. The yield of crops varied from a mean of 33.2 t/ha for Aust G4 seed (range 14.2 to 60.1), of 32.2 t/ha (range 21.8 to 50.3) for Indonesian G4 seed and local seed a mean of 27.6 t/ha (range 16.4 to 46.3) (Table 6.6).

The BCA for Aust seed averaged 1.7 (range 0.9 to 2.8), the BCA for Indo G4 seed averaged 1.5 (range 1.4 to 1.7) while local seed had a BCA of 0.9 (range from 0.4 to 1.1) (Table 6.6). Despite the higher cost of the Aust G4 seed it provided higher average BCA than the Indo certified or local seed.

6.3.4 Lime rates and sources

Using the sites as replicates overall yield response to applied 'lime' as dolomite or $CaCO_3$ over the 9 sites, where results were reported, were not significant and variable, as expected, as not all sites were highly acidic (Table 6.7).

On one very acidic site at Warga Mandiri soil pH was 4.0 to 4.6 prior to liming and 5.2 to 5.6 after lime application. Here yield of the crop sown with Indonesian G4 certified seed was 35% higher (34.5 t/ha, $P < 0.1$) with 5.6 t/ha dolomite compared with nil-lime control (25.6 t/ha) and yield of imported seed was 16% higher (28.4 t/ha) with 3.1 t/ha of $CaCO_3$ compared with nil-lime control (24.4 t/ha) (Table 6.8). By contrast yield of plots sown with local seed was higher on the un-limed controls compared with lime treatments (Table 6.8). Mean yield and BCA (averaged across seed sources) was slightly higher (not significant) with the use of calcium carbonate at 3.1 t/ha compared with control and results with the higher rate of dolomite (5.6 t/ha) were similar to control. By contrast yields and BCA were lower (not significant) when calcium carbonate was applied at the higher rate (6 t/ha) and dolomite at the lower rate (2.96 t/ha).

Table 6.6. Yield, income, costs, gross margin and benefit: cost (BCA) of WA G4 and Indonesian G4 certified seed and local (uncertified) Granola seed at 3 farmer sites in WJ in 2008/2009.

Farmer Group	Seed Source	Seed Price* (Rp/kg)	Yield (t/ha)	Income (A) (Rp 000 000/ha)	Costs (B) (Rp 000 000/ha)	Gross margin (Rp 000 000/ha)	BCA (A/B)
Mekar Sari	Local	2,839	46.3	131	117	14	1.1
	Indo G4	4,251	50.3	214	187	27	1.1
	Aust G4	9,764	60.1	587	211	376	2.8
Wargi Mandiri	Local	2,871	16.4	47	44	3	1.1
	Indo G4	2,821	21.8	62	47	14	1.3
	Aust G4	2,936	25.3	74	56	18	1.3
Mukti Tani	Local	3,310	20.3	64	153	-88	0.4
	Indo G4	11,460	24.4	269	156	112	1.7
	Aust G4	11,016	14.2	156	179	-23	0.9
Means	Local	3,007	27.6	81	105	-24	0.9
	Indo G4	6,177	32.2	181	130	51	1.5
	Aust G4	7,905	33.2	272	149	124	1.7
Significance			ns			ns	
LSD (P = 0.05)			13.5			306	

Table 6.7. Mean yield of Granola grown under five lime treatments from nine sites in WJ 2008/2009*.

Lime treatment*	Yield (t/ha)
Control	17.6
Dolomite (2.96 t/ha)	16.5
Dolomite (5.6 t/ha)	18.2
Lime (3.1 t/ha)	18.4
Lime (6 t/ha)	17.1
Significance	ns
LSD	3.2

* Lime = $CaCO_3$.

Table 6.8. Yield, income, cost and gross margin (GM) for Granola crops with different sources and rates of application of lime on an acid site in WJ in 2008/2009. The site was Warga Mandiri and where soil pH ranged from 4.0 to 4.6 before liming and 5.2 to 5.6 after liming.

Treatment		Yield	Revenue	Cost*	GM
Lime	Seed	(t/ha)	(Rp 000 000 /ha)		
Control	Local	21.4	52.2	44.8	7.4
	Indo G4	25.6	62.4	44.8	17.6
	Aust G4	24.4	59.5	44.8	14.7
	Means	23.8	58.0	44.8	13.2
Lime (3.1 t/ha)	Local	19.0	46.3	45.4	0.9
	Indo G4	28.4	69.2	45.4	23.9
	Aust G4	28.4	69.2	45.4	23.9
	Means	25.3	61.6	45.4	16.2
Lime (6 t/ha)	Local	14.4	35.1	45.9	-10.8
	Indo G4	20.7	50.5	45.9	4.6
	Aust G4	24.9	60.7	45.9	14.8
	Means	20.0	48.8	45.9	2.9
Dolomite (2.96 t/ha)	Local	14.8	36.1	45.4	-9.3
	Indo G4	18.4	44.9	45.4	-0.5
	Aust G4	23.4	57.0	45.4	11.6
	Means	18.9	46.0	45.4	0.6
Dolomite (5.6 t/ha)	Local	12.3	30.0	45.8	-15.8
	Indo G4	34.5	84.1	45.8	38.3
	Aust G4	24.0	58.5	45.8	12.7
	Means	23.6	57.5	45.8	11.7

* Assume cost of lime at 3 and 6 t/ha is 0.58 and 1.07 million Rp/ha and Dolomite at 2.96 and 5.6 t/ha at 0.55 and 1.00 million Rp/ha in addition to standard operating cost of 44.8 million Rp/ha. The effect of lime is assumed to last for 3 years (6 crops) so 17% of cost is attributed to the first crop.

6.4 LBDs 2009/2010

6.4.1 Soil pH

Soil pH (H_2O) (0 – 15 cm) prior to planting and lime application ranged from 4.5 to 6.6 across all sites with a mean of 5.3 (Table 6.9). Soil pH increased from 4.5 to 5.6 after lime application on Tani Jaya but remained at 6.6 on Medal Sawargi. Soil pH values after lime application were not received for any other site.

Table 6.9. Soil pH (H2O) (0-15 cm) before and after lime application on 5 LBD sites in WJ 2009/2010.

Farmer Group site	Before planting	After harvest
	(pH in water)	
Angurah-P	5.1	-
Tunas Tani-K	4.5	5.6
Tani Jaya-G	5.5	-
Medal Sawargi-G	6.6	6.6
Barokah Tani-G	4.8	-
Mean	5.3	

* Last letter indicates subdistrict, G = Garut, K = Kertasari, P = Pangalengan

6.4.2 Seed quality

Seed was received by the FIL farmer groups from 9th to 15th December 2009 and stored before use. The seed arrived later than anticipated. This was due to delays in obtaining an import permit. An import permit was issued on 2nd September 2009. However this was after the last sea shipment of potato seed had left from Perth for Jakarta. An application was made to modify the permit to allow the seed to be airfreighted. This modified permit was issued on 3rd November 2209. The seed arrived in Jakarta on 17th November 2009. The Aust seed arrived in better condition than the previous season as it had been cool stored during its quarantine period rather than stored in ambient conditions as in the previous season (See section 6.3.2).

Aust and Indo seed used on all sites was G4 whereas Local seed was either G5 or G6 and Group seed was G3, G4 G5 or G6, with both sources uncertified, depending on site (Table 6.10). Aust seed was from the same source.

Table 6.10. Source and generation number of potato seed used by Farmer Groups in seed LBDs in WJ in 2009/2010.

Farmer group†	Seed source			
	Local	Group	Indo G4	Aust G4
Anugrah - P	Unknown (G6)	Balitsa (G5)	BPBK (G4)	WA (G4)
TunasTani - G	Own (G6)	Own (G3)	BBI (G4)	WA (G4)
Tani Jaya - G	Cisurupan(G6)	Pangalengan (G6)	Pangalengan (G4)	WA (G4)
Medal Sawargi - G	Cibuluh (G5)	Cigedug (G6)	Pangalengan (G4)	WA (G4)
Barokah Tani - G	H. Asep(G6)	Own (G5)	Rojak (G4)	WA (G4)

† Last letter indicates subdistrict; G = Garut, K = Kertasari, P = Pangalengan.

The mean weight of Aust seed tubers was 38 g and Indo seed was 32 g which was lower (P<0.07) than Local (60 g) or Group (53 g) seed (Table 6.11).

Table 6.11. Tuber weight of potato seed (grams) from each source used on 5 farmer group sites in seed LBDs in WJ 2009/2010.

Farmer group†	Seed piece size (g)			
	Local	Group	Indo	Aust seed
Anugrah-P	100	83	20	40
TunasTani-G	-	33	20	33
Tani Jaya-G	50	40	40	40
Medal Sawargi-G	50	67	40	38
Barokah Tani-G	50	40	40	40
Mean	60	53	32	38

† Last letter indicates subdistrict,;G = Garut, K = Kertasari, P = Pangalengan.

There was no significant difference in the sprout length of seed at planting with Aust and Local seed with an average length of 1.5 cm, Indo G4 seed 1.4 cm and local seed 1.8 cm sprouts (Table 6.12).

Table 6.12. Sprout length of potato seed (cm) at sowing from different sources used on 5 farmer group sites in LBD plots in WJ in 2009/2010.

Farmer group†	Sprout length (cm)			
	Local	Group	Indo G4	Aust G4
Anugrah - P	1.5	1.5	1.5	1
TunasTani - G	*	4	*	3
Tani Jaya - G	1	1	1	1
Medal Sawargi - G	2	2	1	0.5
Barokah Tani - G	-	0.5	2	2
Mean	1.5	1.8	1.4	1.5

† Last letter indicates subdistrict,;G = Garut, K = Kertasari, P = Pangalengan.

There was no significant difference in number of sprouts on potato seed at planting from the different sources. Sprout number was on average 2.6, 2.3, 1.9 and 2.1 cm for Aust, Indo, Local and Group seed respectively (Table 6.13).

Table 6.13. Length of sprouts (cm) on potato seed at sowing from different sources used on 5 farmer group sites in LBD plots in WJ in 2009/2010.

Farmer group†	Sprout number/tuber			
	Local	Group	Indo G4	Aust G4
Anugrah - P	2.50	1.5	3.00	2.50
TunasTan - G	*	4.00	*	4.00
Tani Jaya - G	2.00	2.00	3.00	3.0
Medal Sawargi - G	2.00	2.00	1.00	0.5
Barokah Tani - G	1.00	1.00	2.00	3
Mean	1.9	2.1	2.3	2.6

† Last letter indicates subdistrict,;G = Garut, K = Kertasari, P = Pangalengan.

Soil samples were collected from 0 – 15 cm soil depth from each site prior to planting and after harvest and submitted to IVEGRI for pH (H_2O), %C and soil particle size measurements to determine rate of lime to apply (before planting) and to monitor the change in pH with the lime treatments (after harvest). Lime was applied, as calcium carbonate, at the relevant rate from the Potato Technical Toolkit (DAFWA 2010) to increase soil pH from its initial level to 6.0 from the 10/11 to the 25/11/09 (Table 6.14).

Table 6.14. Rates of lime (& date applied), manure and fertiliser applied to each site prior to planting.

Farmer group†	Lime		Manure	NPK	Super
	(kg/ha)	Date applied	(t/ha)	(kg/ha)	
Anugrah-P	178	10/11/09	44.8	1280	142.8
TunasTani-G	22,500	25/11/09	0	2600	0
Tani Jaya-G	1,800	24/11/09	40	1600	0
Medal Sawargi-G	0		40	2000	0
Barokah Tani-G	8,640	18/11/09	25	1600	0

† Last letter indicates sub-district, G = Garut, K = Kertasari, P = Pangalengan.

The crops were grown at each site using the normal agronomic practices of the farmer group. The seed was sown at 30 x 70 cm on Anugrah, 40 x 75 cm on Tunas Tani, 30 x 80 cm on Tani Jaya and Meal Sawargi and at 35 x 80 cm on Barokah Tani (Table 6.15). All plots were weeded about 4 weeks after sowing. Harvest commenced in late February 2009 and was completed by March 2009 (Table 6.15).

Dates of 50% emergence ranged from 1/1/10 to 21/01/10, row closure from 13/01/10 to the 28/02/10 and senescence from the 27/01/10 to the 15/03/10 (Table 6.16).

Table 6.15. Plot size, plant spacing planting and harvest dates of LBDs on 5 farmer group sites in WJ in 2009/2010.

Farmer group†	Plot Size (m^2)	Planting date	Spacing (cm)	Harvest date
Anugrah-P	80	19/12/09	30 x 70	28/03/010
TunasTani-G	350	27/12/09	40 x 75	?
Tani Jaya-G	80 or 72	19/12/09	30 x 80	31/03/10
Medal Sawargi-G	80	19/12/09	30 x 80	29/03/10
Barokah Tani-G	80	18/12/09	35 x 80	19/03/10

† Last letter indicates subdistrict; G = Garut, K = Kertasari, P = Pangalengan.

Table 6.16. Dates of emergence, canopy cover and early senescence of Granola potato crops from 4 seed sources on 5 LBD sites in WJ 2009/2010.

Farmer Group†	Emergence (50%)				Row closure				Senescence			
	WA	Cert	Local	Own	WA	Cert	Local	Own	WA	Cert	Local	Own
Angurah-P	7/1	3/1	10/1	13/1	28/2	21/1	1/2	25/2	9/3	11/3	15/3	13/3
Tunas Tani-K	12/1	21/1	12/1	12/1	23/1	23/1	23/1	23/1	27/2	27/2	27/2	27/2
Tani Jaya-G	15/1	18/1	19/1	19/1	3/2	9/2	8/2	8/2	6/3	6/3	6/3	6//3
Medal Sawargi-G	1/1	3/1	7/1	4/1	13/1	13/1	13/1	13/1	?	9/3	?	?
Barokah Tani-G	3/1	3/1	8/1	8/1	29/1	29/1	5/2	29/1	8/3	8/3	3/3	3/3

† Last letter indicates subdistrict; G = Garut, K = Kertasari, P = Pangalengan.

There was no significant difference in stem numbers/plant between the different seed sources with the average stem number/plant being 3.3, 3.3, 2.9 and 2.8 for Aust G4, Indo G4, Local and Group seed respectively (Table 6.17).

Table 6.17. Number of stems/plant of Granola potato crops from 4 seed sources and 5 sites in LBD crops in WJ in 2009/2010.

Farmer group†	Stems/plant			
	Local	Group	Indo G4	Aust G4
Anugrah - P	2	3	3.5	3
TunasTani - G	4	3	3	3
Tani Jaya - G	3	3.7	3.8	4.8
Medal Sawargi - G	2.7	2.7	2.7	2.7
Barokah Tani - G	2.7	1.7	3.7	3.1
Mean	2.9	2.8	3.3	3.3

† Last letter indicates subdistrict, G = Garut, K = Kertasari, P = Pangalengan.

6.4.3 PLB Incidence

There was no significant difference in incidence (√ %) of PLB in crops grown from any seed source or at any crop stage (Table 6.18). There was a significant ($P < 0.01$) linear reduction in yield with % incidence of PLB at flowering but not other crop stages (Fig 6.4).

Table 6.18. Incidence of PLB (shown as the square root of the % incidence = √ %) in Granola potato crops at 3 crop stages and from 4 seed sources in LBD plots in West Java in 2009/2010. PLB % = (number of plants infected in each plot/ total number *100) %. Values are means of 5 LBD sites and presented as transformed (√) data.

Seed source	30 cm	Row Closure	Flowering	Source Means
		Seed source		
Local	2.52	2.93	3.23	2.93
Group	2.17	2.44	2.61	2.44
Indo G4	2.17	2.64	3.23	2.64
Aust G4	2.40	3.18	4.00	3.18
Stage Means	2.31	2.81	3.27	
Significance.*	ns	ns	ns	ns

* on transformed (√) data

6.4.4 PLB Severity

There was no significant difference in severity of PLB in crops grown from either seed source or at any crop stage (Table 6.19). Severity was on average 3.4, 5.0, 2.54 and 2.2 for Aust G4, Indo G4, Local and Group seed respectively.

Table 6.19. Severity of PLB in Granola potato crops at 3 crop stages and from 4 seed sources in LBD plots in West Java in 2009/2010. Severity = extent of PLB infection from 0 (no PLB) to all leaves dead (100).

Seed source	Crop stage			Seed source	
	30 cm	Row closure	Flowering	Means	Significance
Local	1.7	2.95	2.95	2.54	ns
Group	1.7	1.95	2.95	2.20	
Indo G4	2.2	4	4	3.4	
Aust G4	3.0	8	4	5	
Stage means	2.15	4.23	3.48		
Significance*		ns			

* For difference between seed sources at each crop stage.

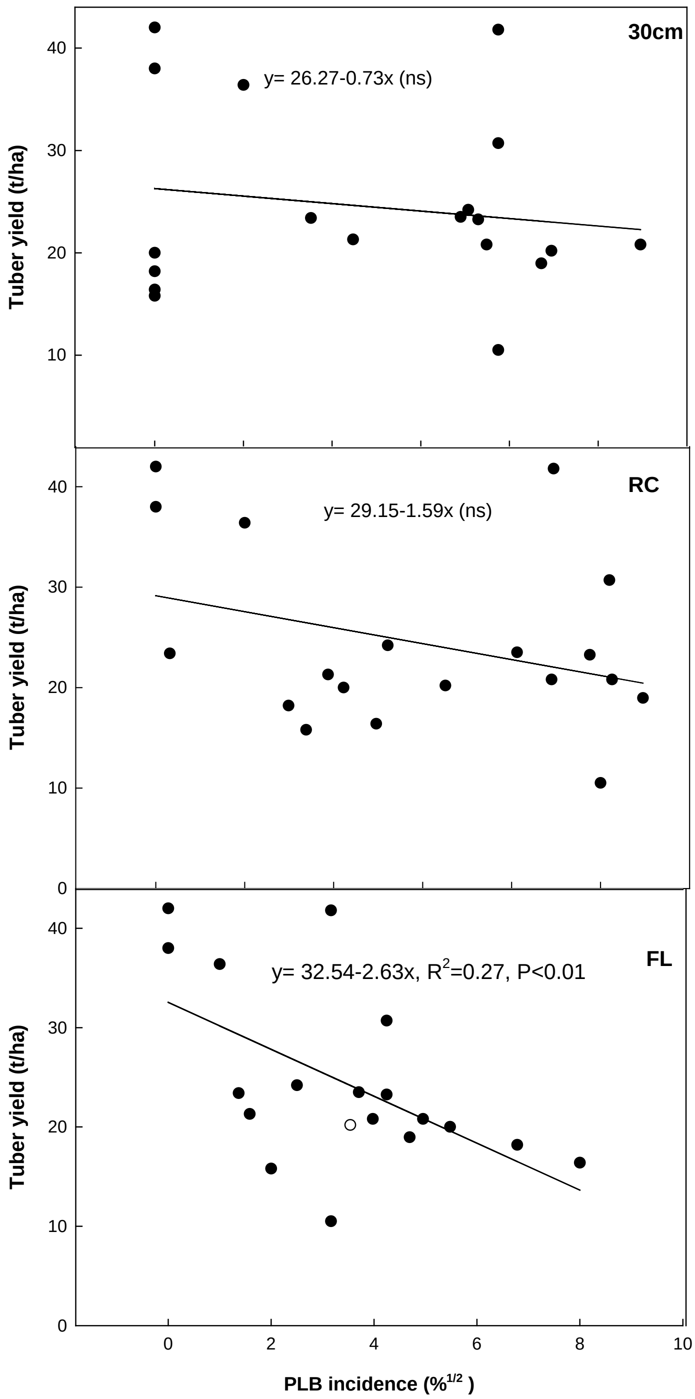

Figure 6.4. Linear regression between tuber yield and incidence (√%) of PLB in potato crops at 3 crop stages in LBD plots in West Java in 2009/2010. PLB % = (number of plants infected in each plot/ total number *100) %. Values are from 4 seed sources x 5 sites at each crop stage.

6.4.5 PLB spray recommendations

There were no results from the comparison between the spray regimes of the local farmers and the ACIAR recommended spray regimes for the two farmer groups who undertook these trials.

6.4.6 Tuber yield

Mean tuber yield ranged from 14.8 t/ha for crops using local seed to 19.4 t/ha for crops using Indo G4 seed (Fig.6.5). The yield of crops using Aust G4 seed, 17.7 t/ha, was comparable to crops using Indo G4 seed as there was no significant difference in yields between seed sources.

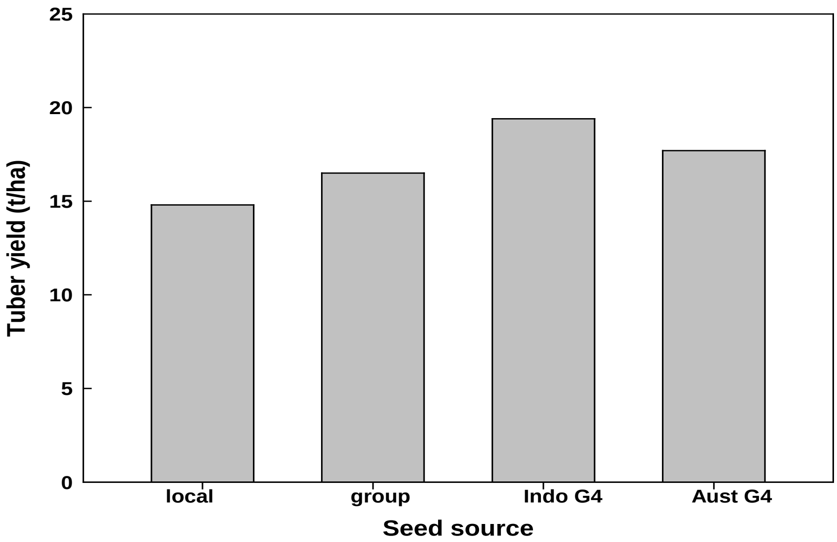

Fig 6.5. Mean tuber yield (t/ha) of Granola crops grown by four farmer groups from different seed sources in LDB plots in WJ 2009/2010. There was no significant difference between means.

Similarly there was no significant difference in income from the seed sources (Table 6.20). However as the price used to calculate income varied from site to site the performance of the seed is probably best assessed from the yield results.

There was a significant difference between the costs of the seed treatments with local farmer seed costs significantly lower than the costs for the Australian and Indonesian G4 seed treatments (Table 6.20). However this did not translate to improved gross margins for these cheaper treatments as statistical analysis showed no significant difference between seed treatment gross margins. Gross margins varied greatly; each seed treatment producing both positive and negative gross margins.

Table 6.20. Yield, income and costs from four potato seed sources tested by farmer groups in West Java during the wet season of 2009-10.

Seed treatment	Farmer Group plot†	Yield (t/ha)	Income	Costs	Gross margin
			(Rp 000 000/ha)		
Individual site results					
Local farmer seed	Anugrah - P	17.2	50.7	38.2	12.5
	Barokah Tani - G	19.0	31.3	34.8	-3.5
	Medal Sawargi - G	5.2	8.6	39.7	-31.2
	Tani Jaya – G	16.6	45.7	35.0	10.8
	Tunas Tani - K	-	-	-	-
Group seed	Anugrah - P	18.8	56.3	39.3	17.0
	Barokah Tani - G	18.8	43.3	34.6	8.7
	Medal Sawargi - G	9.5	21.1	39.9	-18.8
	Tani Jaya – G	18.9	50.6	43.7	6.9
	Tunas Tani - K	16.4	43.5	42.0	1.5
Indo G4	Anugrah - P	19.3	59.1	45.4	13.7
	Barokah Tani - G	17.7	28.8	39.6	-10.8
	Medal Sawargi - G	20.9	47.7	43.9	3.8
	Tani Jaya – G	19.3	50.4	39.0	11.4
	Tunas Tani - K	19.9	46.3	47.2	-0.9
Aust G4	Anugrah - P	16.1	47.5	46.6	0.9
	Barokah Tani - G	17.4	35.1	41.7	-6.6
	Medal Sawargi - G	15.4	37.9	45.8	-7.9
	Tani Jaya – G	18.8	50.4	41.0	9.5
	Tunas Tani - K	20.9	50.9	49.0	1.9
Averages & statistical analysis	Yield range (t/ha)				
Local farmer seed	5.2 – 19.0	14.8	34.7	37.8	-3.1
Group seed	9.5 – 18.9	16.5	43.0	39.9	3.1
Indo G4	17.7 – 20.9	19.4	46.5	43.0	3.5
Aust G4	15.4 – 20.9	17.7	44.4	44.8	-0.5
Significance		ns	ns	**	ns
LSD (P = 0.05)		4.5	12.1	3.1	12.7
Not certified (Local & Group seed)		15.7			
Certified (Aust G4 + Indo G4)		18.6			
Significance		ns‡			
LSD (P = 0.05)		3.0			

† Last letter indicates Subdistrict, G = Garut, K = Kertasari, P = Pangalengan
‡ ns P<0.10

Central Java

A comparison of the yield, income, costs and gross margins of the four farmer groups in Central Java can be seen in Table 6.21.

The conventional and experimental plots for the Trubus farming group reveal similar yields but the experimental plot had fewer costs and therefore higher gross margins. The savings were made in the experimental plot through reductions in fungicide and insecticide costs.

The Sekar Tani group had very low yields and therefore both their experimental and conventional plots were not profitable. The reason for this was that the crop died after just 57 days through the effects of late blight and bacterial wilt.

The Bukit Madu group experimental plot had a much higher yield than the conventional plot but a lower gross margin. This results from the much larger costs involved in purchasing the certified G4 seed and the additional applications of PGPR in the experimental plot.

The Tunas Harapan Jaya group reported losses in both the conventional and experimental plots. These loses are the likely result of potato cyst nematode (PCN) being present in the field. The conventional plot with non certified seed and no PGPR application was found to produce higher yields to offset the higher costs and therefore higher gross margin.

Table 6.21. Yield, income and costs from FFS plots in Central Java conducted during 2008.

Farmer Group	Treatment plot	Yield (t/ha)	Income	Costs	Gross margin
			(Rp/ha)		
Trubus	Conventional	18.0	2,970,000	1,860,000	1,110,000
	Experimental	18.5	2,970,000	1,645,000	1,325,000
Sekar Tani	Conventional	3	375,500	2,033,500	- 1,658,000
	Experimental	2	250,000	1,883,500	- 1,633,500
Bukit Madu	Conventional	13.4	1,327,750	953,750	1,410,800
	Experimental	20.4	1,865,000	1,707,500	1,110,500
Tunas Harapan Jaya	Conventional	9.3	1,107,000	1,805,600	-698,600
	Experimental	8.4	1,024,000	1,725,500	-701,500

6.5 Discussion

The 2008/09 FIL activities in West Java were successful as they introduced a refined learning-by-doing method which allowed the rigorous comparison of a limited number of management techniques against control techniques. This was an advance on the previous season where many management changes were tested against conventional management but the effects of the individual management changes could not be measured as shown at Barokah Tani Farmers' Group and Taruna Tani Sauyunan farmer group (See section 6.2 or Table 6.5).

In the seed and lime LBDs in the 2008/2009 season Granola yield was highly variable across the 10 FIL sites with yields from difference sources of seed ranging from 5.3 to 60.1 t/ha. Variability in potato yield of this magnitude is not unusual in tropical areas as has been shown in the baseline survey of this project and experiments in others (Dawson *et al.* 2004). In some cases very low yield can be attributed to a single main factor as it was with the incidence of PLB in Atlantic crops in West Java. Whilst PLB was likely to have contributed to low yields in these LBDs specific information on pest and disease levels was not available to statistically correlate with yield.

There was no significant difference in average yield from ten sites of crops grown with Local, Indo G4 or Aust G4 seed in 2008/2009 (Fig 6.3 or Annex 1). The quality of Aust seed was adversely affected during a long period of storage (over 5 weeks) in hot and humid ambient conditions from time of arrival in Indonesia to planting. During this period the seed became infested with PTM and it was difficult to supply all farmer groups with good quality seed for the LBD. This has helped to identify the need for improved seed storage knowledge and infrastructure in Indonesia. Despite this some sites such as Warga Mandiri and Mekar Sari reported yields with Aust G4 seed as high as Indo G4 seed. Presumably the seed used on these sites was of better quality or better graded than other sites and good agronomic practices were employed. High potato yield requires both high quality seed and appropriate agronomy as was shown in BMP (best management practice evaluations) in Vietnam (McPharlin *et al.* 2003). On 3 FIL sites where an economic analysis of seed sources was completed yield from Aust G4 seed was on average as high as Indo G4 seed and higher than the Local seed crops. This resulted in better economic return from the use of Aust G4 seed with on average higher income, gross margin and BCA. The better performance of Aust G4 seed in these 3 LBDs compared with the entire 10 sites and is presumably due to a combination of seed selection which ensured better quality seed as well as superior management practices.

In the 2009/2010 LBDs there did not appear to be any significant difference in the physiological state of the seed as expressed in terms of sprout number and length at planting and stems/plant after emergence (Tables 6.12, 6.13, 6.17). Sprout length and number can be used as indicators of the physiological age of seed before planting as seeds with more and longer sprouts are assumed to be physiological older and produce more stems/ plant (Struik and Wiersema 1999). Also the larger size of local and group yield did not appear to influence stem number/plant or yield. The yields in the 2009/10 LBDs were moderate and constraints other than seed probably limited yield. In WA, experiments comparing different quality seed sources did not produce significant differences except at the higher yielding sites over 30 t/ha (Floyd 1986). PLB was monitored as it was the most significant factor limiting yield across all sites. Linear regression showed a significant decline in yield with % incidence of PLB at flowering, but not other crop stages, across all sites. However despite the guaranteed PLB freedom of Aust G4 seed (due to the absence of this disease in Western Australia) exported to Indonesia the % incidence and severity measured in the growing crop from 30 cm height to flowering was not significantly lower than other seed sources. This shows that infection (incidence and severity) from PLB in the growing crop may be extensive enough to mask the effects of PLB status of the seed and that all sources of seed are equally susceptible to attack.

There was no data presented to compare the effect of the different spray regimes, ACIAR and conventional on the LBD plots. Despite this being the case the ACIAR regime was used on all the seed plots and the % incidence did not exceed 4% per plot for any of the seed sources. Similarly the highest severity recorded was 8 that equates to a scale of 50 lesions per plant on the scale used (Results-Table 7 Potato Technical Toolkit, DAFWA 2010). This indicates that the ACIAR regime is successful in maintaining low levels of PLB infection throughout the life of the crop.

The supply of Indonesian Certified G4 seed does not meet farmers' demand (Fuglie *et al.* 2005). This means that inferior quality seed is used instead. This non-certified seed increases the risk of spread of pests and diseases. This has probably already happened in the case of PCN. PCN's wide distribution in central Java and the findings of PCN in other provinces of Indonesia is most likely due to spread through non-certified seed.

These results show that Australian seed can be used to provide an alternative, safe source of high quality seed. Aust G4 seed comes from an area known to be free of PCN (Collins *et al.* 2010) and other important pathogens like bacterial wilt and PLB (Holland and Spencer 2009). The conditions under which Australian seed potatoes are produced are considered to be the best in the world according to the International Potato Center (Dawson *et al.* 2003). The quality of seed from Australia is even further enhanced due to the low number of generations used. The maximum generation used in WA is G5 which makes it equivalent to Class SE (Netherlands), Pre-basic 4 (Scotland) or G5 Elite 4 (Canada) (Dawson 2008). The use of imported seed will help Indonesia protect potato production areas that are currently free of PCN by increasing the availability of high quality seed. These characteristics of potato seed from Western Australia makes it suitable to be the basis for a partial seed scheme for Indonesia to augment its own certified seed (See ACIAR Project AGB/2005/167 Final report Appendix 7 Development of potato seed system – alternative seed supply system).

The response to applied 'limes' either as dolomite or calcium carbonate to LBD plots in 2008/2009 was not significant overall and variable between sites and plots on sites. There was incomplete information of the pH status of plots before planting and after lime application and only a complete set of data on 2 sites. The pH status of the soils prior to planting was therefore not known for all sites. On one acidic site the pH before and after lime application was measured and this showed; an increase in soil pH after lime application, there is an indication that there may have been a positive yield and economic response (BCA) to applied calcium carbonate at 3 t/ha but not 6 t/ha. On other sites the response to the limes were variable and no consistent conclusions could be drawn on the benefits of lime application on yield or BCA. This LBD therefore didn't conclusively clarify findings of the baseline survey that soil acidity was contributing to lower yield in potato crops in Java. Variability in the quality such as the neutralising value (NV) and coarseness of the limes as well as the timing (i.e. interval between lime application and planting) of application (DAFWA 2010) could have contributed to the variable yield response to the applied limes. For example a coarse lime with a low NV applied less than 4 weeks before planting may not the raise the pH much in the life of the crop compared with a finer texture lime of high NV applied much earlier. The variable quality of the seed, especially the Aust seed in 2008/2009 as mentioned, could also have contributed to the variable and sometimes inconsistent responses to the applied limes. The effectiveness of the lime application on most of the sites was not clear as pH information before and after lime application was not available. The importance of soil acidity in potato production still needs to be resolved. Experiments in WJ in showed a yield response to lime in Granola crops in Ciwidey on a soil of similar acidity (pH 4.1) to one used here in West Java. (Subhan and Sumarna 1998). With the now known high concentration of extractable Al in the soils in Indonesia and the sensitivity of potatoes to high soil Al experiments with different sources and more rates of lime on a known site of low pH (< 5.0) is needed.

In Central Java four grower groups from Banjarnegara reported on the 2008 FFS activities. These reports showed similar issues as found with the West java 2008 FFS. The CJ FFS changed more than one variable in comparison plots and used PGPR, a scientifically unproven bio-pesticide, in all or some of the treatment plots. Also site selection and crop management needed improvement as two of the sites were severity affected by PLB and PCN. The Sekartani group's plots which died prematurely after 57 days showed how PLB if not properly managed can be severly affect the development and yield of a crop. The Tunas Harapan Jaya group planted their crop on PCN infested land and as a result had severely reduced yields. The 2009 FIL plots in Central Java were aimed at reducing the errors growers made during the 2008 season whilst also introducing better methodology. Unfortunately as no reports were received from these trials so it is difficult to assess their outcomes. However results from cabbage FIL activities in Central Java showed that the FIL method was applied well in some instances in Central Java. For example the Sekartani farmer group successfully completed a FIL lime investigation in 2008/09 while the Bukit Madu farmer group showed significant improvements in cabbage yield with variety and lime treatments to overcome clubroot disease (Tables 6.2.2f and 6.2.2h in ACIAR Final Report Project ABG/2005/167 Appendix 11 FIL cabbage).

7 Impacts

7.1 Scientific

Yields from Granola crops grown with Aust seed were lower the either Indo or local seed in the first series of seed source x lime LBDs in WJ however Aust seed yielded as well as Indo seed and more than the local seed in the additional LBDs in 2008/2009 and as well as the Indo seed and higher (not statistically significant) than local or group seed in 2009/2010. BCA was higher on average in crops grown from Aust seed than Indo seed which was higher than local seed. Follow up LBDs in 2009/2010 showed yield and economic performance (gross margins and BCA) of crops grown from Aust and Indo seed to be comparable and higher than either crops from group or local seed.

These results show that Australian seed can be used to provide an alternative, safe source of high quality seed as it is free of PCN and other important pathogens like bacterial wilt and potato late blight. The quality of seed from Australia is further enhanced due to the low number of generations used compared to other exporting countries. The use of imported seed will help Indonesia protect potato production areas that are currently free of PCN by increasing the availability of high quality seed. The characteristics of potato seed from Australia allows the idea of an alternative seed supply to be extended even further.

The response to applied ‘limes’ either as dolomite or calcium carbonate to LBD plots in 2008 2009 was not significant overall and variable between sites and plots on sites. On one acidic site there is an indication that there may have been a positive yield and economic response (BCA) to applied calcium carbonate at 3t/ha but not 6t/ha. On other sites the responses to the limes were variable and no consistent conclusions could be drawn on the benefits of lime application on yield or BCA. The interval between lime application and planting and variable quality of the lime could have contributed to the inconsistent responses to the applied limes. The variable quality of the seed, especially the Aust seed in 2008/2009 as mentioned, could have also contributed to the variable responses to the applied limes. The importance of soil acidity in potato production in Indonesia still needs to be resolved. With the now known high concentration of extractable Al in the soils in Indonesia and the sensitivity of potatoes to high soil Al experiments with different sources and more rates of lime on a known site of low pH (<5.0) is needed.

7.2 Capacity

The implementation of the FIL LBDs trained participants in the design, implementation and evaluation of LBDs where a limited number of factors were compared in appropriately designed experiment. Participants improved their knowledge and skills in experimental design and appreciated the need for replication and randomisation of treatments and the use of control plots as comparisons with treatments. They were also involved in the processing and evaluation of data from the seed source comparisons and lime evaluations and report writing. Their skills in PLB monitoring and assessment (incidence and severity) were also improved. This was an improvement in approach to LBDs in previous FILs where often two different management programs were compared. When differences occurred it was not possible to identify the individual factor or factors that caused the change in yield or profit. The FIL methodology also provides the FIL guides with improved information that they require. After the first FFS the guides wanted more information on major pests and diseases and correct control strategies (See “Future ToT Outcomes” in Section 6.2). The FIL methodology provides the information guides require in the Technical Toolkit and provides the guides with suggestions about how their FIL groups can determine improved management strategies through simple but robust experiments.

The accuracy of measurement of soil pH was improved with knowledge of the use of %C and % clay in the soil in determining lime requirements. There was also increased understanding of the important factors in determining lime quality such as neutralising value, fineness and water quality in making accurate rates of lime application as well allowing a sufficient interval between lime application and planting for the lime to react with the soil and increase pH.

7.3 Community

The finding that crops grown with Australian potato seed give yields and returns as high as crops grown with certified Indonesian seed has potential benefits for the farming community. Australian seed is guaranteed free of PCN, PLB and bacterial wilt so the use of it will lower the disease levels in the farms as no extra levels of these pathogens will be introduced with the seed to the farm. This has long term benefits of improved yield and profitability as all these pathogens have severe yield impacts, are costly to control and reduce the profitability of potato production in Indonesia.

Soil acidity is a major issue of agricultural sustainability in Indonesia. Whilst these LBDs did not conclusively show a consistent economic benefit from the application of lime to potatoes in Java management of soil acidity remains an important issue. The issue of high soil and plant Al and Fe and low Ca in potatoes has increased the awareness of soil acidity in potato crop management in the community. As potatoes were considered the crop most tolerant of acid soils in the rotation acidity management is even more important for other crops in the rotation less tolerant of acidity such as the Brassicas. More farmers have improved knowledge and skills in acid soil management from accurate measurement of soil pH and determinations of lime requirements to use of criteria for the selection of the best quality limes.

The accurate recording of LBD activities in properly prepared reports is an important resource for the community.

8 Conclusions and recommendations

1. Skills and knowledge of the management of soil acidity was improved through the implementation of the FIL LBDs where …

2. Imported potato seed from Australia performs as well as Indonesia G4 seed potatoes and provides growers with similar gross margins. Australian seed comes from an area known to be free from PCN and so could safely and economically be used to supplement the Indonesian government certified seed system. The increased availability of PCN free seed will benefit the potato industry of Australia by helping to maintain freedom from this pest in clean areas.

3. Soil acidity remains an important issue for potato production in Indonesia and more work is needed to improve the agronomic and economic efficiency of lime application. These results also show that the FIL method of learning-by-doing demonstration plots is an effective way for farmer groups to determine which management techniques suit their local production system through their own cooperative research.

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10 Annex 1. Yield of seed and lime treatments for West Java FIL (2008/2009).

Pre and post lime treatment soil pH only reported for two sites.

Farmer Group	Seed treatment	Plot size (m^2)	Seeding rate (setts)	Seed yield (t/ha)	Yield of lime treatments (Nominal rates t/ha)					Yield fraction	**Group means**
					Control	$CaCO_3$*3 t/ha	$CaCO_3$* 6 t/ha	Dolomite 3 t/ha	Dolomite 6 t/ha		
Barokah Tani	Local	24	300	23.1	23.5	23.8	22.1	23.5	22.4		
(1)	Indo	24	300	25.3	27.1	29.6	24.8	23.8	21.3	total	**20.5**
	Aust	24	300	13.1	11.3	20.0	13.1	11.5	9.8		
Mukti Tani	Local	24	300	19.2 (19.5)	15.8	23.6	19.2	20.2	17.1		
(2)	Indo	24	300	25.9 (23.40	24.2	19.6	25.4	29.4	31.0	total	**20.6**
	Aust	24	300	16.79(14.2)	21.7	14.6	13.3	19.6	14.4		
Karya Mandiri	Local	24	516	12.7	9.6	13.8	10.0	8.3	5.0		
(3)	Indo	24	415	12.9	10.0	13.3	8.8	6.7	8.3	total	**10.3**
	Aust	24	415	5.4	5.0	4.6	4.6	2.9	2.5		
Suka Haji	Local	24	648	20.1	20.0	13.3	20.8	15.4	30.8		
	Indo	24	591	27.8	28.3	23.8	24.2	25.4	37.5	total	**19.7**
(4)	Aust	24	588	11.2	12.5	9.2	7.9	11.3	15.0		
Muda Tani	Local	24	300	13.4	13.8	10.4	16.3	13.3	13.1		
(5)	Indo	24	300	15.3	10.8	16.3	20.4	17.1	11.7	total	**13.0**
	Aust	24	300	10.3	7.9	12.1	13.8	8.8	8.8		
Perjuangan	Local	24	350	15.0	12.9	13.8	17.1	18.3	22.1		
Tani M	Indo	24	350	27.2	27.5	22.5	23.8	27.1	36.7	total	**20.5**
(6)	Aust	24	350	19.3	23.3	16.7	15.4	19.2	25.4		
Wargi Mandiri	Local	25		16.4 (16.4)	21.4	19.0	14.4	14.8	12.3		
(7)	Indo	25		25.5 (21.8)	25.6	28.4	20.7	18.4	34.5	total	**22.3**
	Aust	25		25.0 (25.3)	24.4	28.4	24.9	23.4	24.0		
	pH change				4.5 – 5.2	4.6 – 5.5	4.0 – 5.3	4.4 – 5.6	4.4 – 5.5		
Gapura	Local	15		28.7	36.7	29.7	31.0	21.3	24.8		
(8)	Indo	15		10.3	10.0	11.8	12.8	10.2	6.5	total	**16.6**
	Aust	15		11.0	7.3	22.8	7.2	7.2	10.3		
	pH change				6.4 – 6.3	6.4 – 6.3	6.5 – 6.7	6.5 – 6.7	6.5 – 6.8		
Tunas Tani	Local	24		14.3	12.9	16.7	14.6	14.2	13.3	not	
(9)	Indo	24		16.7	15.8	18.8	16.7	16.3	15.8	specified	**16.2**
	Aust	24		17.7	16.7	20.8	17.5	16.7	16.7		
Mekar Sari	Local			46.3							
(10)	Indo			50.3							**52.2**
	Aust			60.1							
Seed	Local			**20.9 (20.9)**							
& lime	Indo			**23.7 (23.1)**	**17.6**	**18.4**	**17.1**	**16.5**	**18.2**		
means	Aust			**19.0 (18.8)**							
Significance				(ns LSD = 5.7, P = 0.30)			(ns LSD = 3.2, P =0.72)				

* Reported as CaO

Australian Government
Australian Centre for
International Agricultural Research

Final report appendix 9

title

AGB/2005/167 Farmer initiated learning - potatoes South Sulawesi

prepared by

Muh Asaad

co-authors/ contributors/ collaborators

Baso Aliem, Warda, Nasrullah, Hilda Tahir and Peter Dawson.

1 Executive summary

The overall aim of the project was to assist farmers of the four provinces to increase their returns from the potato and Brassica production systems by adapting proven Australian, Indonesian and CIP technologies to develop best local farming practices.

First an analysis of the current production system was undertaken in a baseline survey.

Adaptation of technologies was done through a participatory approach using the Farmer Field School model. This approach included Training of the Trainer (TOT), adaptive field experiments to test agronomic practices suggested by the baseline survey with farmers.

2 Background

Potato is one of the important horticulture commodities in South Sulawesi because of as alternative food source in food security program. South Sulawesi has high potency for development of potatoes because of supporting suitable agro-climate, available land and market and high supporting of national and regional government. The land potency for development potato in South Sulawesi was about 11,455 ha consisting of 2,720 ha of planted area and 8,734 ha of land for development (Dinas Pertanian Tanaman Pangan dan Hortikultura Prov. Sulawesi Selatan 2003). That land was distributed in seven districts that have different agro-climates and planting times. The yield of potatoes in South Sulawesi during 1988 - 2002 was 7.0 t/ha. This is low compared with its potential yield that has reached 30 t/ha. The low yield is caused by some factors such as unsuitable variety, poor quality seed, sub-optimal agronomic management and pests and diseases. Studies on agronomic and pest management practices of potato farmer have not been conducted in South Sulawesi province especially in the production areas such as Malino, Enrekang and Tator.

The project work in South Sulawesi was added to the original project in 2008 as a variation and the project renamed to be CP/2005/167 Optimising the productivity of the potato/Brassica cropping system in Central and West Java and potato/Brassica/Allium system in South Sulawesi and Nusa Tenggara Barat. This meant that less time was available for the work in Sulsel and NTB compared to Java.

The overall purpose of this project variation is to assist farmers in Sulsel to increase their returns from the potato production system by adapting proven Australian, Indonesian and CIP technologies to conditions in South Sulawesi to develop best local farming practices. Adaptation of technologies was to be through a participatory approach using the Farmer Field School model. This approach included Training of the Trainer (TOT), adaptive field experiments to test agronomic practices suggested by the baseline survey with farmers.

3 Objectives

The aims were to:

- Adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potatoes developed in West and Central Java and adapted to Sulsel.
- Develop the capacity of project partners in Sulsel to support an adaptive research and development strategy to improve the potato and cabbage production systems in Sulsel.

4 Methodology

4.1 Training of the Trainer (TOT)

4.1.1 Planning Workshop May 2008.

A planning workshop was held at AIAT South Sulawesi in 19 May 2008. The meeting was attended by Dr. Peter Dawson (DAFWA), Dr. Mieke Ameriana (IVEGRI) and AIAT researchers and Dinas Pertanian staff involved in the project. The objective of meeting is to decide time and venue of the workshop, TOT curricula and facilitator candidates.

Workshop of TOT and Baseline survey was conducted in 24 - 28 August 2008 at Bukit Indah Hotel, Malino. Workshop was attended by seven of participants from AIAT, five from Dinas Pertanian and facilitated by Mr. Peter Dawson, Mr. Stewart Learmonth (DAFWA), Dr Elske van de Fliert (ACIAR) and Dr Mieke Ameriana (IVEGRI) (Fig 1).

Main activities were TOT preparation, baseline survey, economic survey, soil and petiole sampling and implementation of FFS-ICM. Beside that, it was discussed about TOT curricula and participants, methods of baseline survey and other special topic (pest and disease sampling, TOT facilitators, methods to present subjects or curricula).

The workshop also defined time and venue of TOT, the number of participants, number and name of farmers involved and to be interviewed in the baseline agronomic and economic survey, and the number of Integrated Crop Management Farmer Field School groups that would be established.

Figure 1. Group discussion, one of activities in workshop.

4.1.2 Integrated crop management farmer field schools 2009

The main activities that will be conducted as TOT follow-up are FFS-Potato ICM. FFS-ICM will be facilitated by farmer trainers and supervised by AIAT South Sulawesi, Dinas Pertanian, IVEGRI and ACIAR.

FFS-ICM will conducted in seven potato farmer group consisting of four farmer group at Tinggimoncong sub-district and three Farmer group at Tombolopao sub-district. Each FFS shall facilitated by two farmer trainers (one extension officer and one farmer) with number of FFS participants of 20 farmers. FFS was conducted throughout the planting season with 16 meeting times per group. The FFS started in late of February 2009 based on potato planting calendar of each location.

4.1.3 Farmer initiated learning, learning-by-doing plots 2010

The schedules for implementing potato farmer initiated learning (FIL) activities were adjusted to local cropping schedules, and conducted for one cropping season with 12 weekly meetings starting from 25 May 2010.

FIL were organised with the Ta'calla and Lemo-lemo farmer groups in Pattapang Ward, Tinggimoncong Subdistrict, Gowa District, South Sulawesi Province.

Potential potato FIL participants had to be selected through deliberations between group members, and had to be able to read and write. FIL groups had to involve 20 participants at an ideal ratio of 30% women and 70% men. Participants in potato FIL were land-owning farmers who were members of farmer groups, highly dedicated and serious about taking part in the FIL.

Three farmer study plots were established; each 8 metres wide and 10 metres long (Fig 2). Each plot was used for a different variety of different generation or class:

- Plot I: Atlantic G 4 from Australia,
- Plot II: Local Granola G 4 Setempat, and
- Plot III: Granola sapuan of unknown generation and origin.

The three plots were located close to the weekly meeting site. Farmers' ICM-FFS study plots were on land belonging to the farmers.

FIL materials were as follows:

1. Agro-ecosystem observations
2. Describing agro-ecosystem observations, group decisions for decision making
3. Agro-ecosystem analysis percentages
4. Group dynamics and special topics
5. Ballot box (pre-test and post-test)
6. Collecting harvest yield (ubinan) and doing farming enterprise economic analyses for the study plots
7. Field days
8. Group follow-up plans

The potato FIL were conducted using adult participatory learning from experience.

Potato FIL were held in fields belonging to groups of farmers and applied local farmers' habitual growing techniques in farmer study plots using potato seed of the sapuan variety of unknown generation and origin, whereas in special farmer plots, participating farmers used potato varieties: Atlantic G4 from Australia and local Granola L G4 produced in Buluballea.

The stages involved in potato FIL activities were as follows:

1. Preparatory meetings at the farmer group level. The preparatory meetings involved 20 FIL participants, 2 facilitators, officials from the ward as well as KCD staff. Facilitators provided participants with the following materials:
    - Introductions

- Explaining what FIL is as well as the basic principles involved in their implementation
- Ascertaining participating farmers' experiences in growing potato crops
- Determining special topics based on problems in the local region
- Making study contracts covering participants' expectations and needs, meeting place and study field locations, study times, etc.

Efforts to improved potato farming began with selecting healthy seed, proper soil preparation, crop maintenance and marketing production.

Groups agreed on farmer study plots to look at farmers' usual methods, and ICM technologies writing down on pieces of newspaper as guides for the treatments that would be applied in the practice fields.

2. Potato FIL implementation. Potato FIL activities took place during 12 weekly meetings throughout one cropping season. FIL participants were divided into three small groups, each comprising seven members.

Field activities

1. Materials presented in the first week were as follows:
    - Pre-test ballot box
    - Opening / introductions between participants and facilitators
    - Agro-ecosystem observations and analyses

2. Special topics, group dynamics, reflections/ evaluations of FIL materials

3. From the second to twelfth weeks, materials were as follows. Each small group conducted agro-ecosystem observations, looking at the following things:
    - Plant growth
    - Symptoms of infestation and populations of potato pests and diseases (leafminers, late blight, viruses etc.) as well as natural enemies and their environments.
    - Descriptions of the outcomes of observations on the agro-ecosystems in each of the potato crop study plots.
    - Percentages of agro-ecosystem analysis outcomes, plenary discussions between participants of potato ICM-FFS groups in accordance with the potato crop plots.

4. A field day was held for the meeting on the 12th week to introduce potato FIL activities to farmer groups outside the potato FIL, to the broader farming community using the results achieved in the FIL by the farmer group members. Further FIL activities were also planned.

    Harvest yield was collected for farmer enterprise economic analyses comparing the capacities and skills of farmers with the yield from each plot using varied seed sources. In addition, participants also carried out evaluations using a post-test ballot box.

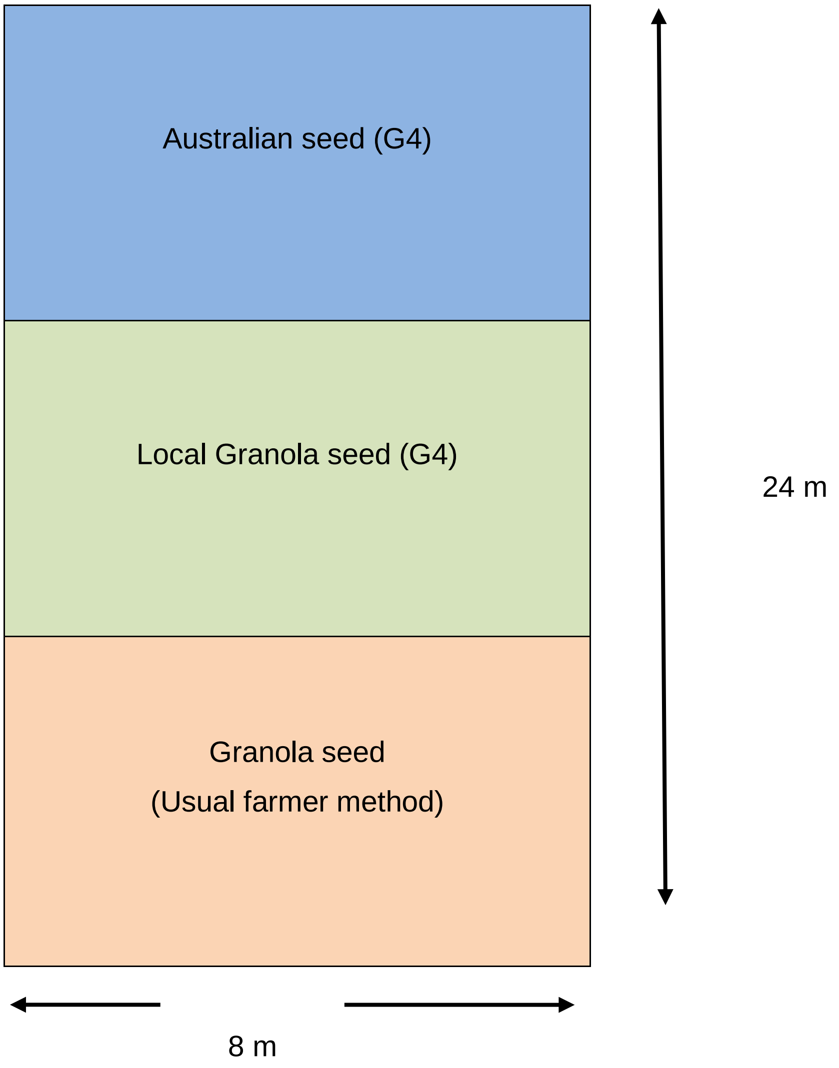

Figure 2. FIL plot layout 2010.

5 Achievements against activities and outputs/milestones

Objective 1: To Adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas/Alliums suited to NTB and Sulsel conditions.

no.	activity	outputs/ milestones	completion date	comments
1.6	Implementation of multiple cycle FFSs that engage farmer groups in season-long learning and adaptive research throughout consecutive potato cropping seasons	At least 12 groups of 25 farmers graduated from multiple cycle potato ICM FFS	2010	12 FIL completed in SS

PC = partner country, A = Australia

6 Key results and discussion

6.1 Training of the trainer (TOT)

The TOT was conducted at P4S (Pusat Pelatihan Pertanian dan Pedesaan Swadaya / Training Centre for Rural Agriculture) at Pattapang Village, Tinggimoncong Sub-district, Gowa district from 15 – 24 December 2008. TOT was attended by 12 participants consisting of six extension officers / pest observers and six farmers (Table 1) and facilitated by eight researcher/senior extension officer from AIAT, one from provincial pest crop protection center (FFS specialist), one from provincial seed certification center (FFS specialist) and two facilitators from Dinas Pertanian. On the sixth to eight day, TOT was supervised by Mrs Julie Warren (DAFWA) and Dr Mieke Ameriana (IVEGRI).

Table 1. List of name, job and address of participants.

No.	Name	Job/Role	Address
1.	Syahruddin, STP.	Extension officer	Malino
2.	Hamka	Extension officer	Malino
3.	Syahrir	Pest observer	Malino
4.	Hakim, STP.	Pest observer	Tombolopao
5.	Imbar Jaya	Pest observer	Tombolopao
6.	Mansyur, S.Hut.	Extension officer	Tombolopao
7.	M.Zaid Karim	Farmer	Buluballea
8.	Halik Hasbi	Farmer	Buluballea
9.	Abd. Jalil	Farmer	Buluballea
10.	Muh. Yahya	Farmer	Kanreapia
11.	Syuaib	Farmer	Kanreapia
12.	Nasir	Farmer	Erelembang

Lot of subjects based on curricula defined during workshop were presented in the TOT such as implementation of GAP on potato, land preparation, seed selection, planting, pest and disease control, harvest and post-harvest handling. In addition technical subjects were also presented such as making insect zoo, introduction and making of organic fertilizer, vector and viral diseases, late blight disease and its control, leafminer and its control, potato cyst nematode and its control, introduction of botanical pesticide, and chemical pesticide and its negative impact. Beside that, also presented some of non-technical subjects such as farming analysis, marketing, agricultural organization, and some of subjects in game type (communication, collaboration, creativity and leadership)

Besides classroom learning (Fig 3), field exercises were also conducted such as introduction of agro-ecosystem, introduction of pests and their natural enemies, introduction of diseases, the making of organic fertilizer, planting practice, soil and petiole sampling, and pest and disease sampling (Fig 4).

Fig 3. Presenting subject in the class

Fig 4. Evaluation of subjects in the field

Preparations by field facilitators (farmer facilitators and officers) prior to field school activities involved field orientation and several considerations as to farmers or farmer groups that would become potato ICM-FFS participants. Considerations during the field orientation included:

a. Coordination meetings between local government and related offices to ensure ICM-FFSs secured support and assistance from various stakeholders.

b. Looking at how ready the fields belonging to planned farmers/farmer group potato crop participants were in terms of becoming study plots.

c. Selecting the more active farmer groups in villages/wards in potato growing centres.

6.2 ICM –FFS 2009

Six SLPTTs were conducted as shown in are shown in Figure 5 planned activities for the life of the project in Sulsel.

1. Kelompok Tani Veteran

Dusun (Kampong):	Buluballea,	Desa:	Patapang,
Kecamatan;	Tinggi Moncong, Kab Gowa,		

Trainers: M Zaid Karim (Petani) and Syahrir (Petugas)

Meeting day: Tuesday

FFS ICM plot was 10 m x 40 m. Conventional plot planted adjacent (also 10 m x 40 m) but planting date was 2 weeks prior.

Spraying for potato late blight (PLB) with ACIAR v conventional. Conventional includes nabati but instead of Areca nut (betel) which is now expensive, they are using pagar hidup & kunyit (tumeric) extract. 1 L extract added to 200 L water. Measurements will include yield by grade of entire plot.

The different planting time however adds a complicating variable. There needs to be training in how to do a basic comparison by keeping as many factors the same as possible. The idea of having a plot set up by the provincial partners would allow the farmer groups to see how FFS can become more scientific.

2. Kelompok Tani Kayu Putih

Dusun (Kampong): Buluballea, Desa: Patapang,

Kecamatan: Tinggi Moncong, Kabupatan; Gowa,

Trainers: Halik Hasbi (Petani) and Hamka (Petugas)

Meeting day: Sunday

Again comparing systemic – contact – systemic against conventional. It seemed they had the idea that mixing contacts with systemics was not a good idea. We must be careful that the message of "systemic – contact – systemic…" means Systemic with contact (if not already in formulation) (S + C) – contact only – (S +C) …

Action threshold used for leafminer fly (LMF) was two mines (gorokan) per leaf from a 24 leaf sample. Four groups each observe 6 plants. Plants are staked so the same plant is monitored through the crop.

3. Kelompok Tani Lemo-lemo

Desa: Patapang,

Kecamatan: Tinggi Moncong, Kabupatan: Gowa,

Trainers: Abdul Jalil (Petani) Sahruddin STP (Petugas)

Meeting day: Sunday

The FFS ICM plot was testing contour planting with silt traps (roak). Once again more than one factor was being compared with no way of isolating responses of individual factors. Methods of measuring soil loss that had been used in WA were discussed so that an objective assessment of soil loss could be made.

Need instruction about buffers and smaller measurement plots. Scientist should attend farmer's meeting to ensure some rigour is applied in planning. More time needs to be invested in planning by the trainers and farmers.

4. Kelompok Ta'Ca'La

Desa: Patapang

Kecamatan: Tinggi Moncong, Kabupaten Gowa,

Trainers: Yahya (petani) Imbar Jaya (Petugas)

This group postponed potato crop after the planted tomatoes.

5. Kelompok Silanggayya

Desa: Kanreapia,

Kecamatan: Tombolo Pao, Kabupaten Gowa,

Trainers: Syuaib (petani) Hakim STP (Petugas)

6. Kelompok Bonto Kanjeng

Desa: Erelembang

Kecamatan: Tombolo Pao, Kabupaten Gowa,

Trainers: Nasir (Petani) Mansyur (S Hut = extension staff)(Petugas).

6.3 FIL 2010

A number of problems and constraints were encountered during potato FIL activities in the 2010 cropping season. These included:

- High rainfall throughout the field schools affected crop growth and pest and disease attacks. The plantings were delayed into the wet season due to the late arrival of the seed from Australia. The seed was late as there were delays in both obtaining the import permit and getting clearance from quarantine.
- The wet season was wetter than usual.
- Collaboration between related institutions (agricultural extensions officers, pest observers and agriculture office branches) with village/ward administrations and field facilitators did not run optimally and affected implementation of the field schools.
- Unavailability of local Atlantic seed to compare with imported Atlantic G4.

Nevertheless the FIL plots grew and were harvested (Figs 5 – 7). Pooled results from the groups showed that the imported Atlantic seed produced a higher yield than Granola G4 or farmer's seed of Granola (Table 2). Atlantic is usually much lower yielding than Granola especially in the wet season due to its susceptibility to PLB. The results also showed the low yield of farmer's seed which produced only about half the yield of Granola G4. These results show the benefits of using high quality seed.

Table 2. Potato yield from various seed sources

No	Seed treatment	No. of tubers planted	Tubers produced (kg)				Yield (t/ha)
			Large	Medium	Small	Total	
1	Atlantic G4	235	75	40	20	135	16.9
2	Granola G4	275	63	39	21	123	15.4
3	Farmers' Granola*	255	20	27	17	64	8.0

* many generations.

Figure 5. Young potato plants

Figure 6. Potato crop (Granola G4)

Figure 7. Pest and disease monitoring

7 Impacts

7.1 Scientific impacts – now and in 5 years

Potato farmer groups at Malino can now verify whether new management techniques are beneficial through using the FIL method of simple, replicated experiments. Previously they have had little access to objective scientific data and have had to rely on information provided by agricultural suppliers.

7.2 Capacity impacts – now and in 5 years

Potato FIL participants can:

- identify quality seed, plant biology, and various pests and diseases and natural enemies and their environments,
- demonstrate and apply basic integrated crop management concepts and make them the basis for conducting weekly observations of their potato crops.
- take action and make decisions independently and in groups relating to their farming enterprises.

7.3 Community impacts – now and in 5 years

Farming communities, farmers and farmer groups that apply the basic principles and concepts of integrated potato crop management technologies in their own fields will increase incomes from their farming enterprises.

7.4 Communication and dissemination activities

Table 7.1. Potato FIL communication and dissemination activities, South Sulawesi.

Date	Personnel	Organisation & Position	Location	Activities
March 08	Terry Hill, Julie Warren, Mieke Ameriana, Peter Dawson	Project Leader Economists, Potato Seed Specialist	Makassar & Malino	Briefing on project using experience from Java. Agreement on training and incorporation into economic survey in NTB and SS
May 08	Mieke Ameriana, Peter Dawson	Economist, Potato Seed Specialist	Makassar & Malino	Economic baseline planing MA PD Curriculum development and Needs Analysis for TOT in South Sulawesi.
Aug 08	Elske van de Fliert, Mieke Ameriana, Peter Dawson, Stewart Learmonth	Extension specialist, Economist, Potato Seed Specialist, Entomologist	Malino	TOT planning, Baseline training PD SL
Dec 08	Julie Warren, Mieke Ameriana	Economists	Malino	TOT
Apr 09	Peter Dawson	Potato Seed Specialist	Malino	Review FFS ICM
Dec 09	Julie Warren Terry Hill	Economist Project Leader	Makassar & Malino	Communication methods established with farmer groups. Prefer DVD's, posters, booklets, website
Sep 10	Julie Warren Terry Hill	Economist Project Leader	Makassar	Project review & evaluation

8 Conclusions and recommendations

8.1 Conclusions

Potato FIL were implemented according to plan, but were delayed due to the late arrival of seed from Australia.

Potato FIL participants were very serious and managed to take part in 12 weekly meetings from beginning to end.

Potato FIL participants can identify quality seed, plant biology, and various pests and diseases and natural enemies and their environments.

FIL participants can demonstrate and apply basic integrated crop management concepts and make them the basis for conducting weekly observations of their potato crops.

Potato FIL participants are able to take action and make decisions independently and in groups relating to their farming enterprises.

8.2 Recommendations

Hopefully coordinators and those responsible can continue potato and Brassica FIL as farmers still very much need proper vegetable/potato crop growing technologies appropriate to standard operational procedures (SOPs).

Farming communities, farmers and farmer groups really need to apply the basic principles and concepts of integrated potato crop management technologies in their own fields to increase incomes from their farming enterprises.

9 Reference

Dinas Pertanian Tanaman Pangan dan Hortikultura Prov. Sulawesi Selatan (2003) Potensi Hortikultura Sulawesi Selatan. Dinas Pertanian Tanaman Pangan Prov. Sulawesi Selatan.

Australian Government

Australian Centre for International Agricultural Research

Final report appendix 10

title	AGB/2005/167 Farmer initiated learning - potatoes NTB
prepared by	Peter Dawson
co-authors/ contributors/ collaborators	Kunto Kumoro, Sudjudi Achmed, Baiq Nurul Hidayah, Lia Hadiawati, Putu Cakra Putra Adnyana, Ian McPharlin, Terry Hill, Julie Warren, Dr Eri Sofiari, Mieke Ameriana (deceased), Kelompok Horsela (Sembalun Lawang Horticulturists Farmer Group)

1 Executive summary

The project aimed to increase the production and profitability of the potato and Allium system in Nusa Tenggara Barat (NTB) through participatory technology transfer of appropriate market focussed crop management techniques. The main objectives were to:

1. Adapt and apply robust integrated crop management (ICM) systems for potato.
2. Develop and implement low-cost schemes that significantly improve the access of smallholder vegetable producers to quality potato seed.
3. Develop the capacity of project partners to use adaptive research and development strategies.
4. Assess the potential to develop a potato seed producing area in eastern Indonesia.

A series of Farmer Field Schools (FFS) were run as the platform for participatory field investigations to overcome potato and cabbage production constraints. Initial methodology compared an ICM plot against a conventional plot but this resulted in many concurrent management changes, the outcome of which was difficult to interpret.

The second and third cycles of potato FFS focussed on the constraints identified by the baseline surveys. Potato constraints investigated were; improved PLB management and seed. A modification was made to the FFS methodology to allow the impact of a single management change to be measured by farmers. We called the new methodology Farmer Initiated Learning (FIL). FIL activities were supported by a Potato Technical Toolkit that described how farmers can undertake rigorous but simple experiments to test these constraints to production. The Technical Toolkits contained supporting information about how simple experiments can be set up, standard operation procedures for managing potato and cabbage crops, background information on cropping constraints and tally sheets for the collection of essential data. A companion field pocket booklet facilitated the recording of treatment inputs and costs so the profitability of treatments investigated could be determined. The standardisation of simple experiments as detailed in the Technical Toolkits meant that collaborating farmer groups could add rigor to their results by pooling data to allow statistical analysis of their results.

The FIL methodology introduced was found to be successful for the groups whose LBD plots produced commercially acceptable yields. The FIL method enables farmer groups to objectively assess the effect of new crop management techniques on profitability. This is an important outcome as there are probably fewer than 10 potato extension specialists in the Indonesian Agricultural Service meaning that farmers need an alternative source of objective information if their crop management is to advance. The FIL method achieves this by successfully getting farmer groups to do simple scientific assessment of new crop management techniques. Specifically in NTB the FIL methodology allowed the farmer groups with help from their guides to show that:

- Super phosphate rates for potatoes grown on paddy soils at Sembalun can be halved from 600 kg/ha to 300 kg/ha.
- Compost rates for potatoes grown on paddy soils at Sembalun can be reduced from 5,000 kg/ha to 3,000 kg/ha.
- PLB control can be improved at reduced cost using the ACIAR systemic-contact-systemic spray program. This result was achieved from two independent farmer groups using a standardised LBD experimental plan during an exceptionally wet cropping season where it rained every day of the crops' life.
- Once-grown Atlantic seed from Australia can be produced with lower levels of virus than is achieved in other areas of Indonesia.

2 Background

Vegetable production is an important component of the rural economy in the highland areas of NTB, although they are only minor producers on a national scale. In 2005 NTB produced just 307 tonnes of potatoes, mainly in East Lombok, or 0.03% of Indonesian production. However there are opportunities to increase potato production significantly.

Downstream supply chain partners, primarily from the processing sector, will play an important role in contributing to the project, with companies such as PT Indofood Frito Lay Makmur, being a project partner, contributing to activities and planning on producing 3,000 tonnes of Atlantic potatoes from Lombok for delivery to the factory in Semarang, Central Java, during October, November and December 2007.

The long term sustainability of a potato industry in Indonesia would be enhanced through the ability to produce seed potatoes. It has been identified through initial scoping studies that the island of Lombok has the potential to be a seed producing area, as it is likely to be free of potato cyst nematode (PCN). However first there is a need to ensure that management of potato crops is efficient and profitable.

The project work in NTB was added to the original project in 2008 as a variation and the project renamed to be CP/2005/167 Optimising the productivity of the potato/Brassica cropping system in Central and West Java and potato/Brassica/Allium system in South Sulawesi and Nusa Tenggara Barat. This meant that less time was available for the work in Sulsel and NTB compared to Java.

The overall purpose of this project variation is to assist farmers in NTB to increase their returns from the potato production system by adapting proven Australian, Indonesian and CIP technologies to conditions in NTB to develop best local farming practices. Adaptation of technologies was to be through a participatory approach using the Farmer Field School model. This approach included Training of the Trainer (ToT), adaptive field experiments to test agronomic practices suggested by the baseline survey with farmers.

3 Objectives

The overall purpose of this project variation is to assist farmers in NTB to increase their returns from the potato and Brassica/Allium production systems by adapting proven Australian, Indonesian and CIP technologies to conditions in NTB and to develop best local farming practices.

The project variation aimed to:

- Adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas/Alliums, developed in West and Central Java and adapted to NTB.
- Develop and implement low-cost schemes that significantly improve the access of smallholder vegetable producers in NTB to quality potato seed.
- Develop the capacity of project partners NTB to support an adaptive research and development strategy to improve the potato and Brassica/Allium production systems NTB.
- Assess the potential to develop a potato seed producing area in eastern Indonesia and therefore creating a viable agribusiness alternative for smallholders.

4 Methodology

4.1 Training of the Trainer (ToT)

4.1.1 Planning Workshop May 2008.

Management of ToT was planned at a workshop held on 22 – 23 May 2008 at Senggigi. Participants were from DAFWA, the two NTB partner organisations; BPTP (Assessment Institute for Agricultural Technology of NTB) and Dinas Pertanian (Department of Agriculture NTB), IVEGRI and the Sembalun farmers group, Kelompok Horsela (**Hor**ticulture **Se**mbalun **La**wang Farmers' Group).

Pak Kunto BPTP NTB was the ToT coordinator. ToT training was needed to produce trained guides for 7 farmer groups. The ToT was to be held in late June and run for 10 – 14 days. The training would take place at Mataram and Sembalun. Seven experienced farmers were nominated to be guides and participate in the training. They were; Haji Moh Kartip, Murtadi, Risdun, Musnaeli, Rupnih, Muhajir, Haji Moh Idris. The ToT guides were to be Asdiwarta and Masrohin.

Subjects planned for ToT curriculum were discussed and ranked in importance. These are shown in Table 4.1.

Table 4.1. Subjects for ToT curriculum and master trainers available in NTB.

No	Subject matter	Facilitator
1.	Potential to develop potatoes in NTB	BPTP
2.	GAP and SOP	Dinas Pertanian
3.	Potato seed Certification System	BPSB TPH
4.	Health and husbandry of seed potatoes	Balai Benih Induk TPH
5.	Main pests of potatoes	BPTP/Balitsa
6.	Main diseases of potatoes	BPTP/Balitsa
7.	PCN	Unram
8.	Late blight & leafminer	BPTP
9.	Soil and fertilisers	BPTP
10.	Potato cultivation for seed production	Dinas Pertanian
11.	Botanical pesticides	BPTPH/BPTP
12.	Capacity building	
13.	Farming business	Dinas Pertanian
14.	Field exercises	

4.1.2 ToT 2008

The workshop was held from 24 – 27 June at BPTP NTB. Participants were from:

- Dinas Pertanian (2 people) ,
- BPTP (4 people),
- Officials (7 people) and
- Sembalun Farmers' Group (7 people)
- BPBK (Office of Potato Seed Development, Pangalengan, West Java)

4.1.3 Farmer Field School 2008

The aims were to :

- To train farmers in solving farming problem in groups.
- To give quick solutions for problems that appear in the field.

4.1.4 Farmer initiated learning, learning-by-doing plots 2009

The aims of this Farmer Initiated Learning activity was to test management techniques in a simple experiment according to the guidelines of the Potato technical Toolkit which was developed by the project. This included the development of a method of cooperative learning between farmers and guides using farmer method of group exercises to solve farming production problems so that solutions can be quickly applied to problems in the field.

Superphosphate & compost

The farmer groups compared the rate of superphosphate. The standard method is as shown in the "Farmer method" of column of Table 4.2 while the new methods being tested were different superphosphate rates ("LBD plot 1" column) and different compost rates ("LBD plot 2" column).

Table 4.2. Fertilising treatments with local compost for Groups I - III

No	Fertiliser	Fertilising treatment (kg/ha)		
		Farmer method	LBD plot 1	LBD plot 2
		Farmer Groups I - III		
1	Local compost	3000	3000	5000
2	NPK Ponska	600	600	600
3	Sulphate of ammonia	300	300	300
4	Superphosphate	600	300	300
		Farmer Groups IV - IV		
1	Manufactured compost	3000	3000	5000
2	NPK Ponska	600	600	600
3	Sulphate of ammonia	300	300	300
4	Superphosphate	600	300	300

Potassium

Potassium treatments are presented in Table 4.3 and repeated as many as 3 times by 3 co-operating farmers of two groups according to baseline soil analysis data base showing low status of exchangeable potassium content as presented in the following Table 4.3.

Table 4.3. Sulphate of potash treatment for Group III and Group IV.

Treatment	Base fertilizer rate					Side-dressing fertilizer rate		
	Compost	Dolomite	Sulphate of ammonia	Fertipos	Sulphate of potash	Sulphate of ammonia	Urea	Sulphate of potash
K1	10000	400	609	960	0	0	156	0
K2	10000	400	609	960	61	0	156	61
K3	10000	400	609	960	122	0	156	122
K4	10000	400	609	960	244	0	156	244
K5	10000	400	609	960	488	0	156	488

4.1.5 Farmer initiated learning plots 2010

The aims of this FIL activity was to test management techniques in a simple experiment according to the guidelines of the Potato technical Toolkit. The learning-by-doing (LBD) plots were to investigate potato late blight (PLB) management (Potato Technical Toolkit, Chapter 3.1 LBD plot, comparing controls of PLB) and seed sources (Potato Technical Toolkit, Chapter 3.2 LBD plot, comparing seed sources).

5 Achievements against activities and outputs/milestones

Objective 1: To Adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas/Alliums suited to NTB and Sulsel conditions.

no.	activity	outputs/ milestones	completion date	comments
1.6	Implementation of multiple cycle FFS that engage farmer groups in season long learning and adaptive research throughout consecutive potato and rotation crop production seasons.	14 groups of 25 farmers graduated from multiple cycle potato ICM FFS	Jun 2010	20 FIL competed in NTB.

PC = partner country, A = Australia

Objective 2: To develop and implement low-cost schemes that significantly improve the access of Indonesian farmers to quality potato seed

no.	activity	outputs/ milestones	completion date	comments
2.6	Development, training and implementation of improved practices for producing clean low-generation seed with and by lead farmers and/or commercial seed producing companies	Trial report [Seed comparison tests]	Jun 2010	Seed comparison between fresh imported seed and once grown seed completed

PC = partner country, A = Australia

6 Key results and discussion

6.1 ToT

6.1.1 Potato seed training

Ir Wawan Wintarasa, MM from BPBK (Balai Pengembangan Benih Kentang/Office of Potato Seed Development) Pengalengan, presented information about potato seed production.

6.2 FFS 2008

The Farmer Field School was opened by the Sembalun Sub-district leader (Camat) on 13 September 2008. Farmers listening to presentation are shown n Figure 6.2a. The aims of the FFS were explained. An explanation of the characteristics of compound chemical fertilisers and how this can be determined by examining the analysis which is printed on the bag. Practical aspects of potato production were demonstrated and practised in the field as shown in Figures 6.2b to d. There were eight groups which studied their own plots which were 1,000 m^2. Activities included monitoring and identifying common insects, both pests and their natural enemies as well as assessing for disease levels. Results of the harvest can be seen in Figure 6.2e. Potato processing exercise was also included with the production of keripik (crisps, Figure 6.2f). Packing and transportation was also a focus of the Farmer Field School. Inputs and production of pairs of sites were recorded and presented as an average gross margin for the plot. These are shown in Tables 6.2.1 to 6.2.4. Yields ranged from 20 to 26 t/ha with gross margins of 19.4 to 33.5 million Rp per ha. These gross margin budgets

As in West Java farmers reported that the FFS meetings improved their knowledge and skills of potato production through observations and conclusions based on joint decisions and through direct practice. The farmers reported that they had;

- Learnt to observe and analyse problems of potato production,
- Learnt about improved land preparation,
- Learn to work with nature when producing potatoes, and
- Used pesticides in a wiser manner.

Figure 6.1. Farmer guides and officials during ToT training

Figure 6.2a. Farmer participants at the opening of the Farmer Field School.

Figure 6.2b. Placing seed

Figure 6.2c. Hilling up the rows

Figure 6.2d. Guides organizing practical field learning activities.

Figure 6.2e. Results of the harvest is transit store.

Figure 6.2f. Farmers processing potatoes.

Figure 6.2g. Potatoes leaving Sembalun for processing in Java

Table 6.2.1. Summary report – field school activity for farmer groups Orong Teniong and Orong Paok in Sembalun 2008.

Demonstration plot topic	**Amount and frequency of inorganic fertiliser**			
Farmer groups	1. Orong Tenjong		2. Orong Paok	
Group's leader	A. Leo		A Rupni	
Field guide	Halidi			
Planting date	22-Jul-08		Harvest date	30 Oct 08
Variety	Atlantic			
Demonstration plot area	1,000 m			
Fertiliser frequency	3 times	1. 1/3 dose at planting		
		2. 1/3 dose 25 days after planting		
		3. 1/3 dose 45 dap		

ECONOMIC ANALYSIS

DESRIPTION	AMOUNT	UNITS	UNIT PRICE (Rp)	TOTAL (Rp/plot)
COSTS				
Soil preparation & planting	11	days	30,000	330,000
Fertilising & hilling	8	days	30,000	240,000
Pest & disease control	12	days	15,000	180,000
Harvest & transport	2.12	t	100,000	212,000
Seed	200	kg	10,500	2,100,000
NPK fertiliser	60	kg	2,000	120,000
Super phosphate fertiliser	40	kg	1,800	72,000
Sulphate of ammonia	30	kg	1,500	45,000
Insecticide Promectin 50 ml	1	bottle	60,000	60,000
Insecticide Cyrotex 25 gr	2	packet	65,000	130,000
Fungicide Starmil	3	packet	50,000	150,000
Fungicide Victory 80 WP	3	packet	55,000	165,000
TOTAL INPUT COST				3,804,000
INCOME				
Total Production	2050	kg	2,800	5,740,000
GROSS MARGIN (Rp/plot)				1,936,000
GROSS MARGIN (Rp/ha)				19,360,000
B/C RATIO				1.51

Table 6.2.2. Summary report – field school activity for farmer groups Orong Buatan and Orong Dayan Desa in Sembalun 2008.

Demonstration plot topic	**Amount and use of a combination of inorganic and organic fertiliser.**			
Farmer group	1. Orong Buatan		2. Orong Dayan Desa	
Group leader	Muhajir		A Resdun	
Field guide	Samirih			
Planting date	22-Jul-08		Harvest date	25-Oct-08
Variety	Atlantic			
Demonstration plot area	1,000 m			
Fertiliser frequency		I. 1/2 dose at planting 2. 1/2 dose 25 days after planting		

ECONOMIC ANALYSIS

DESRIPTION	AMOUNT	UNITS	UNIT PRICE (Rp)	TOTAL (Rp/plot)
COSTS				
Soil preparation & planting	11	days	30,000	330,000
Fertilising & hilling	8	days	30,000	240,000
Pest & disease control	13	days	15,000	195,000
Harvest & transport	30	days	10,000	300,000
Seed	200	kg	10,500	2,100,000
NPK fertiliser	60	kg	2,000	120,000
Super phosphate fertiliser	40	kg	1,800	72,000
Sulphate of ammonia	30	kg	1,500	45,000
Compost/organic fertiliser	35	kg	600	21,000
Insecticide Cyrotex 25 gr	2	packet	65,000	130,000
Insecticide Promectin 50 ml	1	packet	60,000	60,000
Fungicide Victory 80 WP	3	packet	55,000	165,000
Fungisida Starmil 100 gr	3	packet	50,000	150,000
TOTAL INPUT COST				3,928,000
INCOME				
Total Production	2600	kg	2,800	7,280,000
GROSS MARGIN (Rp/plot)				3,352,000
GROSS MARGIN (Rp/ha)				33,520,000
B/C RATIO				0.85

Table 6.2.3. Summary report – field school activity for farmer groups Orong Telega and Orong Ronggak in Sembalun 2008.

Demonstration plot topic	**Chemical pesticide observation**			
Farmer group	1. Orong Telaga		2. Orong Ronggak	
Group leader	Suhilwadi		H.M. Idris	
Field guide	Minardi			
Planting date	22-Jul-08		Harvest date	
Variety	Atlantic			
Demonstration plot area	1,000 m			
Fertiliser frequency	Twice	I. 1/2 dose at planting		
		2. 1/2 dose 25 days after planting		

ECONOMIC ANALYSIS

DESRIPTION	AMOUNT	UNITS	UNIT PRICE (Rp)	TOTAL (Rp/plot)
COSTS				
Soil preparation & planting	10	days	30,000	300,000
Fertilising & hilling	6	days	30,000	180,000
Pest & disease control	9	days	15,000	135,000
Harvest & transport	20	days	10,000	200,000
Seed	200	kg	10,500	2,100,000
NPK fertiliser	60	kg	2,000	120,000
Super phosphate fertiliser	40	kg	1,800	72,000
Sulphate of ammonia	30	kg	1,500	45,000
Insecticide Promectin 50 ml	1	packet	60,000	60,000
Insecticide Cyrotex 25 gr	1	packet	65,000	65,000
Fungicide Victory & Manzate	4	packet	60,000	240,000
Fungicide Starmil 100gr	2	packet	50,000	100,000
TOTAL INPUT COST				3,617,000
INCOME				
Total Production	2000	kg	2,800	5,600,000
GROSS MARGIN (Rp/plot)				1,983,000
GROSS MARGIN (Rp/ha)				19,830,000
B/C RATIO				0.55

Table 6.2.4. Summary report – field school activity for farmer groups Orong Dayan Pangsor and Orong Serut in Sembalun 2008.

Demonstration plot topic	**Observation of a combination of chemical and botanical pesticides**			
Farmer group	1. Orong Dayan Pangsor		2. Orong Serut	
Group leader	Musnaeli		Darwinti	
Field guide	Indriarti			
Planting date	22-Jul-08		Harvest date	30-Oct-08
Variety	Atlantic			
Demonstration plot area	1,000 m			
Fertiliser frequency	I. 1/2 dose at planting 2. 1/2 dose 25 dap*			
ECONOMIC ANALYSIS				

DESRIPTION	AMOUNT	UNITS	UNIT PRICE (Rp)	TOTAL (Rp/plot)
COSTS				
Soil preparation & planting	11	days	30,000	330,000
Fertilising & hilling	8	days	30,000	240,000
Pest & disease control	12	days	15,000	180,000
Harvest & transport	21.1	days	10,000	211,000
Seed	200	kg	10,500	2,100,000
NPK fertiliser	60	kg	2,000	120,000
Super phosphate fertiliser	40	kg	1,800	72,000
Sulphate of ammonia	30	kg	1,500	45,000
Pupuk Nabati Nuzuur	0.5	bottle	50,000	25,000
Insecticide Promectin 50 ml	1	bottle	60,000	60,000
Insecticide Cyrotex 25 gr	2	packet	65,000	130,000
Fungicide Victory 80 WP	3	packet	55,000	165,000
Fungicide Starmil 100gr	3	packet	50,000	150,000
TOTAL INPUT COST				3,828,000
INCOME				
Total Production	2120	kg	2,800	5,936,000
GROSS MARGIN (Rp/plot)				2,108,000
GROSS MARGIN (Rp/ha)				21,080,000
B/C RATIO				0.55

6.3 Farmer initiated learning activities 2009

The Economic Baseline Survey showed that inputs for potato production at Sembalun were the highest of four provinces assessed (ACIAR Project AGB/2005/167 Appendix 2 Baseline economic survey of potatoes). Farmers in NTB spent more on seed, fertilisers and agro chemicals than farmers in the other provinces.

In order to assess whether inputs are appropriate the farmers needed a method that would allow them to focus on one management input at a time. In the Farmer Field School (FFS) system for potatoes in Indonesia the paradigm has been to compare an integrated crop management (ICM) plot with a conventionally managed plot (DAFWA 2009). This results in comparing two plots which have very different management. If one plot performs better than the other it is difficult to determine what factor was responsible for the difference. Individual LBD demonstration plots which were essentially simple experiments to test five important factors identified by the baseline survey (McPharlin 2010) were designed and published in the Potato Technical Toolkit developed by the project (DAFWA 2010). Collaboration between groups by pooling results was also planned to ensure rigorous comparisons are made. Adoption of this simple experimental methodology was aimed at increasing the capacity of farmers to assess the value of management changes.

For NTB in 2009 the concept of simple comparative experiments to test one variable was included in the FFSs which we renamed Farmer Initiated Learning (FIL) to identify the changed methodology.

The Potato Technical Toolkit was not aimed at farmers but at their guides who were either official of the Department of Agriculture or else very experienced farmers. The Technical Toolkit included a Standard Operational Procedure for management of factors not under investigation. This SOP was to ensure that other management factors were not limiting the performance of the LBD plots. The Technical Toolkit also included comprehensive background information about the factors being investigated as well as tally sheets to assist the farmer groups collect accurate and important information.

At Sembalun six farmer groups compared rates of superphosphate and rates of compost. The results from their LBD plots are presented in Table 6.3. The results from each farmer group were used as replicates with the combined results being analysed using analysis of variance.

For superphosphate there was no significant difference between rates of 300 and 600 kg/ha. Superphosphate costs 2000 Rp/kg (BPTP NTB 2009a) and the average farmer uses 433 kg/ha. The finding that 300 kg of superphosphate is sufficient for potato production in the paddy areas of Sembalun means that there can be a saving of 133 kg of superphosphate or 266,000 Rp/ha which will improve farmer income because of reduced input costs.

For compost there was no significant difference between rates of 5,000 and 3,000 kg/ha. Manure costs 497 Rp/kg (BPTP NTB 2009a) and the average farmer uses 3,192 kg/ha. The finding that 3,000 kg of compost is sufficient for potato production in the paddy areas of Sembalun means that there can be a saving of 192 kg of compost or 95,425 Rp/ha for the average farmer which will also reduce input costs. For farmers who use above average organic manure the savings will be greater; if a farmer who previously used 5,000 kg/ha of compost reduces this input to 3,000 kg/ha the savings would be 994,000 Rp/ha.

Table 6.3.1. Results of Farmer Initiated Learning LBD plots investigating superphosphate and compost rates – NTB 2009.

Treatment	Yield (t/ha)
Super phosphate	
300 kg/ha	33.0
600 kg/ha	33.1
P	ns
LSD	1.4
n	6
Compost	
3,000 kg/ha	33.0
5,000 kg/ha	32.7
Significance	ns
LSD	2.8
n	6

A complete report of the activities was prepared by BPTP NTB (2009b) and a translation can be found in Annex 1. In this report it was noted that the Farmer treatment plots above produced an average yield of 33.1 t/ha. The Farmer treatment here refers to the rate of phosphate applied. All other management was according to the Standard Operational Procedure developed for the Potato Technical Toolkit. Farmers and BPTP staff were surprised to see that the 33.1 t/ha yield in the Farmers treatment plot was much higher than the 20 t/ha that farmers usually produce in this area.

The agronomic baseline survey of potatoes in NTB indicated that potassium may be a limiting factor for potato production. This was tested in LBD demonstration plot which looked at 6 rates of potassium. This was repeated at 3 sites. Yield from this potassium demonstration shows no difference between potassium rates (Table 6.3.2). At two sites yields were far lower than the first site and this was caused by these sites being planted late which coincided with foggy, cloudy weather 40 days after planting. This weather increased humidity and caused a *Phytophthora* sp. infection that reached 20-30 % of the plant population despite control measure being applied. This intervention of the weather means that this potassium activity should be repeated ensuring that the sites are planted during the main growing season.

Tabel 6.3.2. Yield produced by the potassium fertilisation plots.

Treatment				Yield
#	Amount K_2SO_4 applied (kg/ha)			
	Basal	Side dressing	Total	(tonnes/ha)
K1	0	0	0	21.5
K2	61	61	122	21.2
K3	122	122	244	21.8
K4	244	244	488	24.1
K5	488	488	976	23.5
n				3
Significance				ns
LSD $P < 0.05$				4.2

6.4 FIL 2010

The LBD plots were planted in the wet season of 2010. It rained almost every day when the crops were growing. The high rainfall even damaged the local paddy rice crop.

6.4.1 ACIAR PLB treatments

Five farmer groups planted LBD plots; two groups planted in paddy fields and these LBD plots were severely affected by the wet weather, the third was damaged by herbicide. Results from the two remaining sites, Koang Londe and Mentagi., where crops grew well, are examined below.

Yields for both late blight treatments were similar with the farmers' management producing 17.97 t/ha while the ACIAR recommended treatment yielded significantly higher with 19.47 t/ha (Table 6.4.1). This shows that the new ACIAR PLB control method may have had better efficacy than the farmers' usual method. PLB infection data backs this up with the farmers' management plot recording 17% of plants infected at flowering while the ACIAR recommended treatment only had 10% of plants infected. This was significant at $P < 0.10$ but not at $P < 0.05$ (Table 6.4.1).

The PLB also differed in profitability as shown by gross margin. The farmers' management included average pesticide costs of Rp 10.95 million per ha while the ACIAR method was slightly lower at Rp 10.56 million per ha. This is a 39% higher than found in the economic baseline survey where average pesticide expenditure was Rp 7.9 million per ha (ACIAR Project AGB/2005/167 Appendix 2 Table 6.1). The fungicide component of costs under farmers' management was Rp 8.9 million per ha while the ACIAR method was slightly lower at Rp 8.5 million per ha. Farmers' management fungicide costs were 59% higher than shown in the baseline survey probably because of the very wet season. The ACIAR treatment produced a gross margin of 10.83 million Rp/ha which was significantly greater, by 4.04 million Rp/ha than the farmers' treatment gross margin.

These results show that the FIL methodology of LBD demonstration plots is an effective way for farmer groups to do their own research on crop management. The results also show that the ACIAR recommendations for PLB management are effective and produce greater profits than the farmers' usual disease management.

Table 6.4.1. PLB infection, yield, income and costs from two PLB management techniques tested by two farmer groups at Koang Londe and Mentagi in Lombok during the wet season of 2010.

Potato late blight		Yield	Income	Costs		Gross
Treatment	Infection (% plants infected at flowering)			Total	Fungicide	margin /ha
		(t/ha)	(Rp 000 000/ha)			
Farmers'	16.9	18.0	48.5	41.7	8.9	6.8
ACIAR	10.0	19.4	52.4	41.6	8.5	10.8
n	2	2				2
Significance (P = 0.05)	ns	*				*
LSD (P=0.05)	9.8	0.4				1.0
Significance (P = 0.1)	*					
LSD (P=0.10)	4.9					

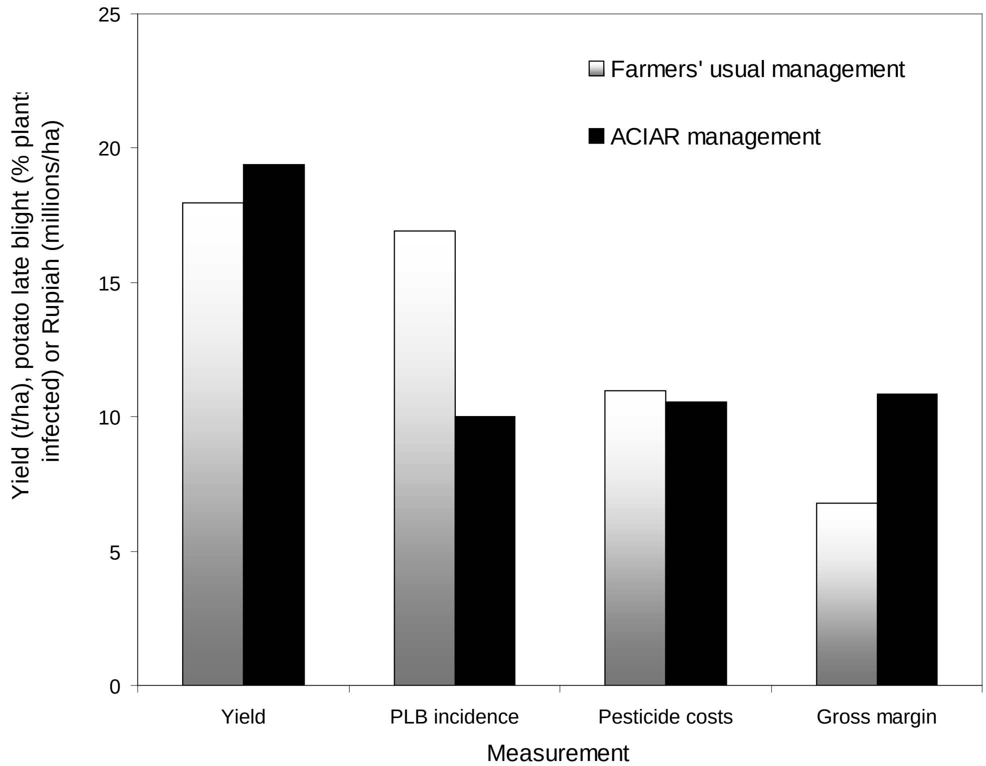

Figure 6.4. Effects of improved potato late blight management at Sembalun, Lombok. Yield was significantly higher (LSD P < 0.05 = 0.4 t/ha)

6.4.2 ACIAR seed source treatments

One farmer group planted an LBD seed source plot at Lendang Luar in the wet season of 2010.

Both seed sources grew vigorously, the newly imported WA seed had 64 stems from 40 plants/row compared with the 69 stems of the once-grown seed. This indicates that the two seed sources probably had similar physiological age.

The newly imported seed produced more than double the number of tubers compared with the once-grown seed (Table 6.4.2). The tubers filled out which meant that yield of the newly imported Australian seed was 18.3 t/ha while for the once-grown dry season bulked Australian seed was 9.1 t/ha (Table 6.4.2).

Table 6.4.2. Yield, income and costs from two potato seed sources tested by a FIL group at Lendang Luar in East Lombok in the wet season of 2010.

Atlantic seed source	Tuber number by grade (tubers/50 m^2)				
	< 30 mm	30 - 50 mm	> 50 mm	Reject	Marketable (No rejects)
Australian import	160	685	590	13	1,435
Once-grown Australian seed	95	324	241	54	660
	Yield by grade (t/ha)				
	< 30 mm	30 - 50 mm	> 50 mm	Reject	Marketable (No rejects)
Australian import	2.5	10.2	5.6	0.1	18.3
Once-grown Australian seed	1.2	4.9	3.0	0.8	9.1

The once-grown seed had about 12% of plants with visible secondary (seed-borne) virus symptoms (14/120 plants). This level is probably not high enough to affect yield but it could have affected tuber set. In WA, experiments comparing different quality seed sources showed lower generation seed set more tubers than older generation seed (Floyd 1986).

The virus levels of 12% in once-grown seed is a good finding in an Indonesian context. In Java farmers report that it is difficult to grow Atlantic seed because of virus problems. The first generation of plants show 0.5% symptoms of “mosaic” virus, while the next generation consistently shows 60% (See ACIAR Project AGB/2005/167 Appendix 11 Post-harvest, section 6.2.6). This may indicate that the degeneration rates of Atlantic at Sembalun are less than in Java.

The 12% virus level found would not have affected yield greatly because even severe PVY strains which may cause 50% yield loss in a plant only cause about 4% crop loss when 12% of plants are infected (Struik & Wiersema 1999, appendix 2).

This 12% virus level could also be reduced with the following interventions:

- farmers are trained in seed potato virus management, e.g. roguing,
- Granola is grown instead of Atlantic (reported to be less susceptible to virus degradation),
- aphid management appropriate for seed crops is introduced.

The results of this FIL plot should provide evidence that once-grown WA seed from Sembalun can be used to complement the existing Indonesian seed supply system. This evidence will help to gain entry of WA Granola seed potatoes to Indonesia.

7 Impacts

7.1 Scientific impacts – now and in 5 years

Potato farmer groups at Sembalun can now verify whether new management techniques are beneficial through simple, replicated experiments. Previously they have had little access to objective scientific data and have had to rely on information provided by agricultural suppliers. See next section for more details.

7.2 Capacity impacts – now and in 5 years

There are at least 20,000 potato enterprises in Indonesia based on a production area of 71,238 ha (Badan Pusat Statistik 2009) with the assumption that average farm size is 2 ha (Johnson *et al.* 2008) and the cropping frequency is 1.8 crops per year (Scholz 1983 cited in Adiyoga *et al.* 2001). There are probably fewer than 10 potato extension specialists in the Indonesian Agricultural Service and so farmers need an alternative source of objective information if their crop management is to advance. The FIL method achieves this by successfully getting farmer groups to do simple scientific assessment of new crop management techniques. Over two years the farmer FIL groups at Sembalun tested:

- the effect of superphosphate rates,
- compost rates,
- potassium rates,
- a new PLB management program, and
- two seed sources.

Kelompok Horsela, with the help of BPTP NTB and Dinas Pertanian NTB, showed that they were able to organise groups to repeat these simple experiments in a standardised manner. Of these five simple experiments discussed above, four were able to be replicated. This meant that the results from several groups can be used as replicates and combined to allow statistical analysis which improves confidence to the results.

7.3 Community impacts – now and in 5 years

20 farmers who participated in the FIL activities at Sembalun were surveyed about impacts in their village (BPTP 2009b).

Economic impacts

Table 7.1. Farmers perceived economic impacts from FIL activities.

Change as a result of FIL activities	Respondents agreeing (%)
Cultivation technology improved	65
Yield increased	30
Reduced cost of production	10
Technical problems were easily overcome	10
Pesticide use more thrifty	60
Improved crop management	25
Confidence in importance of organic fertiliser	10
Fungicide use efficiency increased	60

Social impacts

Table 7.2. Farmers perceived social impacts from FIL activities.

Change as a result of FIL activities	Respondents agreeing (%)
Cooperation within the group improved	30
Knowledge and skills improved	60
Increased income/community economic matters	30
Farmer behaviour to agricultural system improved	25
Farmers aware of importance of collective marketing	5

Environmental impacts

Of the farmers involved with the FIL activities 25% though that crop management had improved, cultivation technology had improved (65%), use of pesticides was more thrifty.

Table 7.3. Farmers perceived environmental impacts from FIL activities.

Change as a result of FIL activities	Respondents agreeing (%)
Pesticide use is more accurately targetted	30
Knowledge and skills improved	30

7.4 Communication and dissemination activities

Table 7.4. Communication and dissemination activities.

Date	Personnel	Organisation & Position	Location	Activities
Jun 07	Peter Dawson Dr Eri Sofiari Eko Istiyanto	Potato seed specialist Project Leader – Indonesian Rural development specialist	South Sulawesi and NTB	Scoping study to determine value of extending project to NTB and South Sulawesi.
Mar 08	Terry Hill Julie Warren Mieke Ameriana Peter Dawson	Project Leader, DAFWA Economists Seed specialist	South Sulawesi and NTB	Planning meeting NTB
Mar 08	Peter Dawson John Marshall	Seed specialist DAFWA Consultant nematologist	NTB/Central Java	Planning meeting NTB partners, Prof Mulyadi Gadjah Mada University, commence soil survey Sembalun with Kelompok Horsela

Table 7.4. continued. Potato economic survey communication and dissemination activities.

Date	Personnel	Organisation & Position	Location	Activities
May 08	Peter Dawson	Seed specialist	NTB/Sembalun	ToT & baseline survey training
May 08	John Marshall	Consultant nematologist	NTB/Central Java	PCN survey Sembalun and training Baiq Nurul Hidayah.
May 08	Peter Dawson	Seed specialist DAFWA		TOT for FFS fFacilitators in the four critical constraints of potato cyst nematode (PCN), leafminer, soil acidity and seed. GAP development.
Oct 08	John Marshall	Consultant nematologist	NTB/Central Java	PCN survey Sembalun and training Baiq Nurul Hidayah.
Nov 08	Kunto Kumoro Nurul Hidayah	BPTP NTB Coordinator & Plant Pathologist	Western Australia	Study Tour on seed potato production
Feb 09	Ian McPharlin	Potato agronomist DAFWA	Sembalun	Inspection of WA seed plots planted Nov 2008 & FIL planning
Feb 09	Prof Mulyadi Ir Nana Ranu Laksana Aris Munandar	Nematologist, Gadjah Mada Uni Director of Hort Seed Prod, Dinas Head Potato Seed Production, Kledung	Western Australia	Study Tour on seed potato production and PCN management
Apr 09	Peter Dawson	Seed specialist DAFWA	Sembalun	Review of FIL and planning for 2nd cycle cycle
Jul 09	Stewart Learmonth	Entomologist DAFWA	Sembalun	FIL IPM activity planning
Nov 09	Julie Warren Terry Hill	Economist Project Leader	NTB & South Sulawesi	Project review. Prefer DVD's, posters, booklets, website. Potential for NTB seed production. Study tour to WA organization.
Feb 10	Minardi Risdun, Ir M Samsul Hedar Ir Usman Fauzi MSi Sudjudi BSc.SP	Head, Sembalun Farmers' group Treasurer, Sembalun Farmers' group Head Quarantine Office NTB Head Production Sector Laboratory Head, BPTP NTB	Western Australia	Study Tour on seed potato production and PCN management. Production of DVD about seed production techniques appropriate for Indonesia and how Sembalun aras of NTB can be kept free from PCN.
Jun 10	Peter Dawson Asep Abdie	Seed specialist DAFWA Project Reviewer	Pangandaran & Sembalun	Project review at Sembalun FIL activities 2010
Sep 10	Julie Warren Terry Hill	Economist Project Leader	NTB	Project review

8 Conclusions and recommendations

8.1 Conclusions

The FIL methodology introduced was found to be successful for the groups whose LBD plots produced commercially acceptable yields. The FIL method enables farmer groups to objectively assess the effect of new crop management techniques on profitability. This is an important outcome as there are probably fewer than 10 potato extension specialists in the Indonesian Agricultural Service meaning that farmers need an alternative source of objective information if their crop management is to advance. The FIL method achieves this by successfully getting farmer groups to do simple scientific assessment of new crop management techniques. Specifically in NTB the FIL methodology allowed the farmer groups with help from their guides to show that:

- Super phosphate rates for potatoes grown on paddy soils at Sembalun can be halved from 600 kg/ha to 300 kg/ha.
- Compost rates for potatoes grown on paddy soils at Sembalun can be reduced from 5,000 kg/ha to 3,000 kg/ha.
- PLB control can be improved at reduced cost using the ACIAR systemic-contact-systemic spray program. This result was achieved from two independent farmer groups using a standardised LBD experimental plan during an exceptionally wet cropping season where it rained every day of the crops' life.
- Once-grown Atlantic seed from Australia can be produced with lower levels of virus than is achieved in other areas of Indonesia.

8.2 Recommendation

The FIL method should be pursued as a way of adding value to FFS activities.

9 References

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10 Annex 1. Activity report

FIELD SCHOOL
INTEGRATED CROP MANAGEMENT
OPTIMALISING POTATO PRODUCTIVITY
IN THE SEMBALUN HIGHLANDS

Compiled by:

ORGANISING TEAM ACIAR CP/2005/167 NUSA TENGGARA BARAT

ASSESSMENT INSTITUTE FOR AGRICULTURAL TECHNOLOGY

WEST NUSA TENGGARA

CENTRE FOR AGRICULTURAL TECHNOLOGY ASSESSMENT AND DEVELOPMENT

INDONESIAN AGENCY FOR AGRICULTURAL RESEARCH AND DEVELOPMENT

DEPARTMENT OF AGRICULTURE

2009

PREFACE

Praise, thanks and prayers to Allah the Almighty, because of His grace and favour, this Activity Report of the Integrated Crop Management Farmer Field School (ICM-FFS) for potatoes in Sembalun has been completed well.

This activity potato ICM-FFS forms cooperation between the Indonesian and Australian Governments through the ACIAR project CP/2005/167 that is being undertaken by Assessment Institute For Agricultural Technology NTB in the highlands of Sembalun in East Lombok.

Appreciation and thanks are given to all parties for carrying out this activity. Hopefully this good coooperation can continue to devevelop for into the future.

Mataram, 26 December 2009

Head AIAT NTB

Dr. Ir. Dwi Praptomo S., MS.

NIP. 19591226 198303 1 002

CONTENTS

LIST OF TABLES

LIST OF ATTACHMENTS

SUMMARY

Potato forms one of the important vegetable commodities with good market prospects, both as a vegetable as well as processed food. Because of this position the potato in the future is hoped to become a choice for diversifying carbohydrate sources that can be a means to increase the reliability of food supply and overcome world poverty. The fast growth of *fast food* restaurants, has already produced a opportunity for a new agribiiness. One of the favourite in these restaurants is *french fries* (fried potato). Productivity of Granola is fairly good. Under optimal conditions our farmers can average yields of 30 ton per hectare per growing season. But Granola cannot be turned into french fries. Because its water content and sugars are high, while its starch is low. So when it is fried it will be dark and soggy. Atlantic is different, when it is fried it will be golden, hard and crisp. The main constraint making our potato farmers reluctant to grow Atlantic is that its productivity per hectare per crop is only around 20 ton. Because of this, in the scheme to optimise potato yield in Sembalun, BPTP NTB undertook Integrated Crop Management (ICM) Farmer Initiated Learning activities (FIL) through ACIAR Project No : CP/2005/167 which is a cooperative project between the Indonesia and Australian governments. This activity had the aim for develop a joint learning method between farmers with guides and to train farmer groups in solving farming production problems; so that solutions can be quickly given regarding field problems by comparing pembandingan farmer potato crop management with inroduced teknology from ACIAR and BPTP NTB ICM, pest and disese control along with specifc local fertiliser recommendations. The way the Potato Field school was undertaken was greatly appreciated by farmers as group learning vehicle to increase increase farmers' knowledge in potato ICM. The results are clear, that introduced fertiliser and pest and disease control technology that was undertaken in the Potato FIL Demplot can improve the use of phosphate efficiency up to 50% [more] than existing farmer teknology and can give an average increase in production up to 13 tonnes/ha (65 %) above the average yield of farmers around the FIL Demplot of only 20 tonnes/ha. This is a really fantastic increase. With well targetted sosialisation of this technology productivity constraints can be overcome.

I. INTRODUCTION

I.1. Background Information

Potato (*Solanum tuberosum*) forms one of the important vegetable commodities that have good market prospects, both as vegetables as well as processed food. Because of this position the potato in the future is hoped to become a choice for diversifying carbohydrate sources that can be a means to increase the reliability of food supply and overcome world poverty.

The rapid growth of *fast food* (cepat saji) restaurants, has already produced a opportunity for a new agribiiness. One of the favourite in these restaurants is *french fries* (fried potato). In addition snack food processing factories, like PT Indofood Fritolay Makmur, process potato into crisps. Characteristics of potatoes that are intended for consumption as fried potatoes and for crisp processors are: a. have to be high in starch, b. low in sugar and water. Karakteristik kentang tersebut diperlukan agar produk akhir yang dapat dinikmati konsumen menunjukkan kualitas terbaiknya. Potato varieties that have such characteristics (like Atlantic) are mostly used by the potato crisp processing industry. Whereas the potato that is commonly grown by our farmers is Granola, mostly recognised as a table potato. Productivity of Granola is fairly good. Under optimal conditions our farmers can harvest on average 30 tonne per hectare per growing season. Granola cannot be processed as *french fries* or potato crisps, as its water content and sugars are high, while its starch content is low. Potatoes like this if processed produce dark, limp crisps. Atlantic is different, when it is fried it will be golden, hard and crisp. Pengembangan kentang masih terkendala oleh keterbatasan ketersediaan kentang bibit yang berkualitas dan tingginya tingkat serangan organisme pengganggu tanaman.

Potato development in Nusa Tenggara Barat is occuring in the Sembalun sub-district where there are slopes of Mt Rinjani with elevation of around 1,050 meter up to 1,250 m asl. The development of potatoes in this area has been through a cooperative partnership of potato farmers with PT Indofood Fritolay Makmur. In the agreement of this cooperation the PT Indofood partner supplies a loan for allocating potato seed and other production inputs in the form of pesticides and fertiliser; erpayment of the loan occurs after harvest.

This partnership has been going since 2007 until now with total production already sent to PT Indofood experiencing annual growth as shown in the following Table :

Table. 1. Total Atlantic production from Sembalun (NTB) that have been sent Indofood.

No	Year	Crop Area (ha)	Total Production (tonnes)	Yield (tonne/ha)
1.	2007	18	378	21.1
2.	2008	152	2,840	18.7
3.	2009	158	2,868	18.2

Source : Data primer, 2009.

Komoditas hortikultura/sayuran yang menjadi primadona masyarakat Sembalun saat ini adalah kentang Atlantik. Petani Sembalun bisa menanam kentang di musim kemarau maupun di musim hujan. Di musim hujan kentang ditanam di lahan kering atau tegalan yang potensi arealnya mencapai 1.500 ha lebih dan pada musim kemarau ditanam di lahan sawah setelah panen padi lokal pada bulan Juni-Juli dengan potensi areal mencapai 1,105 ha. From Table I above shows that the area so far used to produce potatoes in the rice paddy fields is only just less than 15 %.

Consider that the PT Indofood factory production capacity for processing potato crisps is more than 100 tonnes/day has not yet beeen reached from [potatotes] within the country and still need to import 20-30% of its production capacity; of course this issue only forms one large marketing opportunity both for development area and also potato production in Sembalun. Atlantic yield at Sembalun is still relatively low, just reaching 15-20 tonnes/ha, in fact several beberapa potato studies in Indonsia show the yield can reach 35 tonnes per hectarer per cropping season. The main constraint to Atlantic potato development in Sembalun among other problems is the availability of seed potatoes, and an ICM system that is not yet been applied in a proper manner.

Because of this, in the scheme to optimise potato yield in Sembalun, BPTP NTB undertook ICM FFS through ACIAR Project No : CP/2005/167 which is a cooperative project between the Indonesia and Australian governments.

FFSs that were held formed one method of disseminating results of research/theories for speeding up transfer of technology innovations in order that users can understand these innovations can all the applied eresults be at once appreciated.

Feld school participants were divided into 6 spread out groups (orong) and every orong was guided by one official (PPL) and 2 field guides (farmers).

1.2. Aims

The aims of this ICM FFS is:

1. To develop a method of cooperative learning between farmers and guides using farmer method of group exercises to solve farming production problems so that solutions can be quickly applied to problems in the field.
2. To compare farmers potato management technology with technology introduced from the results of the research of ACIAR, CIP and IVEGRI through an integrated crops/pest and disease management approach along with specific local fertilisation redommendations.

1.3. Outputs

Outputs that are hoped from implementing this FFS will include the following:

1. The ability of farmers to learn together in groups to find solutions in a quick way to field problems.
2. To improve the efficiency of potato production.

1.4. Benefits.

Kegiatan Sekolah Lapang petani yang dipraktekkan expected will give the following benefits:

1. Improving pengetahuan dan keterampilan petani kentang di Sembalun.
2. Improved cost efficiency and means of production
3. Raise the farm enterprise income.

II. LITERATURE REVIEW

Potato (*Solanum tuberosum*), is one of the tuber crops fromCentral/South America. This commodity was cultivated by the Aztec Indians, Mayas and Incas for several thousnd years before Christ. For the Indian people in Central and South America, potato formed a basic foodstuff along with corn, cassava dan ubi-jalar. Potatoes were brought to Europe by Spain in 1794, and in a short period of time it spread to all of Europe, then to all the world. In a short period of time Europeans also enjoyed potato as their basic foodstuff after grain. The Netherlands took the potato to Java in 1794. The first potato producton was at Cimahi, West Java. Then the Netherlands also introduced potato to Brastagi, North Sumatra in 1811. Afterwards centres of potato developed in Brastagi (Sumut), Kerinci (Jambi), Pangalengan (Jabar), Dieng (Jateng), Tengger (Jatim) and Toraja (Sulsel). In a brief time Indonesians became fond of potato. Namun beda dengan di kalangan masyarakat Indian dan Eropa yang menjadikan kentang sebagai makanan pokok, maka di negeri ini kentang difungsikan sebagai sayuran.

Pengembangan kentang *French fries* sangat mendesak, karena saat ini Indonesia masih sangat tergantung pada produk impor serta permintaan dalam negeri sangat banyak. Karena itu dalam tahap awal yang akan dikembangkan adalah masalah perbenihan, melalui pengembangan benih lokal ataupun inroduksi benih dari luar untuk dikembangkan di sentra-sentra produksi yang cocok.

Demand for table and processing potatoes shows growth. The value of potatoes imported to Indonesia in 2007 was US$ 40 million from 43,477 tonnes. For the year 2008 up to September potato imports reached 29,187 tonnes valued at US$ 28 million. The value of potatoes exported from Indonesia in 2007 was US$ 5 million for 43,872 tones. In 2008 up to September potato exports were 6,575 tonnes with a value of US$ 2.1 million. In 2009 Indonesia still imported 48,000 tonnes with a value of US$ 33 million, even though there was an expecation that at this time Indonesia would export 139,960 tonnes of potatoes with a value of $US 164 million ((Konferensi Pers oleh Dirjen Hortikultura Dr. Ir. Ahmad Dimyati, MS).

Sebagai gambaran bahwa pada tahun 2007 ekspor kentang segar sebesar 9.652 ton dan impor sebesar 5.557 ton. Impor kentang *frenc fries* sebesar 10.581 ton dan impor tepung kentang sebesar 11.196 ton. Produksi dan produktivitas di sentra produksi masih mungkin ditingkatkan menjadi 30 ton/ha melalui penggunaan benih bermutu varietas unggul, penerapan budidaya yang baik (GAP/SOP) dan penguatan kelembagaan dan kemitraan usaha.

To answer all the above challenges a new breakthrough through participatory approach with farmers in increasing produktivitas yang masih dibawah standart tersebut dengan pola Sekolah Lapang Petani. Implementasi proses belajar bersama sambil praktek langsung diharapkan mampu merubah paradigma petani selama ini yang cenderung konsumtif dalam pengelolaan tanaman yang tidak ramah lingkungan sebagai-mana divisualisasikan dengan input tinggi dalam penggunaan bahan kimia baik untuk pupuk maupun pestisida.

The execution of the field school invloved the farmers in an active learning process that compared exiting farmer crop management against new amanagement techniques. Farmers were actively invloved starting from soil preparation, planting, pest and disease control up to harvest. Consequently the treatments can be compared and it is hoped to be make the avaluation themselves from the yield that is produced.

III. METHODS

III.1. Time and Place

This FFS activity was undertaken in the farmer's rice paddy fields in the village of Sembalun Lawang, Sub-district Sembalun, EastLombok Regency, Nusa Tenggara Barat; from July until November 2009.

III.2. Materials and Equipment

Materials that were used in this FFS activity:

1. Atlantic potato seed
2. Inorganic and organic fertiliser {ZA (sulphate of ammonia), Superphos, NPK, Dolomit, Kompos, Fertiphos, ZK (sulphate of potash)}
3. Pesticides (Recomended by ACIAR and existing practice)

Equipment that was used in this FFS activity:

1. Tractor, hoe, sickle
2. Handsprayer
3. Measuring tape, sacks, scales

III.3. Activity Plan

This FFS activity:invloved 6 sub-groups (orong) of the Hortikultura Sembalun Lawang (Horsela) farmer's group, namely:

Tabel 2. Field School Group Participants

No	Group	Guide	Members
1	Orong Lendang Luar	Minardi, Supardin	16 people
2	Orong Tenjong	A Leo, Mahkub	16 people
3	Orong Paok + Kekoro	Rupnih, Mustiaji, Halidi	16 people
4	Orong Ronggak +Telaga	H. M. Idris, Suhilwadi, Samirih	16 people
5	Orong Dayan Pangsor + Serut	Musnaeli, Darwinti, Indriati	16 people
6	Orong Dayan Desa + Buatan	Risdun, Muhajir, Masruhin	16 people

The plan undertaken in these FFS are as follows:

1. Inorganic phosphate fertiliser rates, were repeated by 6 groups and application of local and manufactured compost fertiliser were repeated by 3 of the 6 groups mentioned, as presented in the following tables 3 and 4:

Table 3. Fertilising treatments with local compost for Groups I - III

No	Fertiliser	Fertilising treatment (kg/ha)		
		Farmer method	FIL 1	FIL 2
1	Local compost	3000	3000	5000
2	NPK Ponska	600	600	600
3	ZA	300	300	300
4	Superphos	600	300	300

Table 4. Fertilising treatments with manufactured compost for Groups IV – VI

No	Fertiliser	Fertilising treatment (kg/ha)		
		Farmer method	FIL 1	FIL 2
1	Manufactured compost	3000	3000	5000
2	NPK Ponska	600	600	600
3	Sulphate of ammonia	300	300	300
4	Superphosphate	600	300	300

2. Potassium fertilising treatment, presented in table 5 and repeated as many as 3 times by 3 co-operating farmers of two groups according to baseline soil analysis data base showing low status of exchangeable potassium content (Kdd) as presented in the following Table 5:

Table 5. Sulphate of potash treatment for Group III and Group IV

Treat-ment	Base fertilizer rate					Side dressing fertilizer rate		
	(kg/ha)							
	Compos	Dolomit	ZA	Fertipos	ZK	ZA	Urea	ZK
K1	10000	400	609	960	0	0	156	0
K2	10000	400	609	960	61	0	156	61
K3	10000	400	609	960	122	0	156	122
K4	10000	400	609	960	244	0	156	244
K5	10000	400	609	960	488	0	156	488

3. Pest and disease control treatments

- Farmer Method: Systemic and contact mixed with base control from farmer threshold levels
- IPM Method: Alternate applications of systemic and contact pesticides with base control from IPM threshold levels for pests

For more details see the following plot plan:

Table 6. Aplikasi Perlakuan Untuk Demplot SL I – VI.

No	Pengelolaan Tanaman	Plot Number		
		1	2	3
1	Variety		Atlantis	
2	Seed source		Sertifikat	
3	Planting density		80 x 30 cm	
4	Pemupukan	Rek Petani	Rek FIL. 1	Rek FIL. 2
5	Pengendalian OPT	Cara Petani		PHT/IPM
6	Pengamatan Agronomi		Every week	
7	Pengamatan OPT		Every week	
8	Pengamatan hasil panen		At harvest	

Table 7. Aplikasi Perlakuan Untuk Demplot ZK

No	Pengelolaan Tanaman	Plot Number				
		5	1	4	2	3
1	Pengambilan contoh tanah			Semua plot sebelum tanam		
2	Varietas			Atlantis		
3	Sumber Bibit			Sertifikat		
4	Jarak tanam			80 x 30 cm		
5	Pemupukan			Sesuai rancangan perlakuan		
6	Pengendalian OPT			Cara Petani		
7	Pengamatan Agronomi			Setiap minggu		
8	Pengamatan OPT			Setiap minggu		
9	Pengambilan sample petiole			Setelah umur 1 bln setiap 2 minggu sekali		
10	Pengamatan hasil panen			At harvest		

III.4. Procedure

III.4.1. Determining location

- Choosing one field cooperator member of the group with agreement all members, with consideration of factors of ease of visiting the field.
- A representative potato field which avoided shade.
- Used a natural field.

III.4.2. Field management

- The field was cleared of weeds and crops remains beforehand
- The first soil preparation was undertaken was ploughing and left for a ± 2 weeks to have the opportunity to aerate the soil.
- The second soil preparation was with a hand tractor to reduce clods of the first ploughing and to smooth the soil so that the soil was ready for planting.

III.4.3. Setting up FIL demplots

- Plots were prepared by dividing 3 petaks in an east west direction with the installation of semi permanent patoks in the farmers natural petak.
- Plot buffers of 0.5 meter width were made as a border between treatments.
- Each plot size was measured.
- Plot area was needed to determine the appropriate fertilser dose for the recommended treatment

Farmer Treatment	border 0,5 m	Treatment FIL .1	border 0,5m	Treatment FIL .2

- After plots were established soil pH was measured for determine dolomite rates.

III.4.4. Setting up potassium demplots

- Ploting dilakukan pada petak alami dengan membagi 5 (lima) petak in an east west direction with memasang patok semi permanen.
- Diukur luasan masing-masing plot
- Luas plot diperlukan untuk menentukan dosis pupuk sesuai perlakuan rekomendasi

III.4.5. Fertilisation application

III.4.5.1. Demplot FIL treatment

- First basal fertiliser including all the rate of compost, superphos and half the treatment rate of inorganic fertiliser (NPK Phonska dan ZA) was spread in an even way when planting the seed potatoes.
- Secondly side-dressings at half the treatment rates of inorganic fertilser (NPK Phonska dan ZA) were applied at a crop age of 25 days after planting.

III.4.5.2. Potassium demplot treatmnents

- First basal fertiliser was spread evenly all treatment rates of compost, Dolomite, Fertiphos and ZA along with half the treatment dose of potassium sulphate in the planting row as seed was planted.

- Secondly side-dressings were applied at 25 days after planting with all the treatment dose of urea along with half the treatment dose of potassium sulphate.

III.4.6. Pest and disease control

III.4.6.1. Perlakuan Petani Untuk Demplot Petani dan SL1 Dan Demplot ZK

- Praktek pengendalian yang dilaksanakan adalah dengan menggunakan cara yang biasa dilakukan petani mulai dari jenis pestisida, dosis, frekwensi penyemprotan dan batas ambang aplikasi penyemprotan.

III.4.6.2. IPM treatment for Demplot SL2

- Pest and disease control used the IPM concept as recommended by ACIAR for example not using METALAXYL or MEFENOXAM (msl. Ridomil Gold MZ).

- For applying pesticides threshold already established for IPM were used [batas ambang toleransi = threshold].

- The first spray used was a Curzate Victory mix or Equation at 80% emergence if emergence was even or at 50% emergence if it was uneven.

- After the first spray, a repeated progam was followed as follows:
  contact ---- systemic --- contact ---- systemic ---etc.

- Jika turun hujan, semprotlah pada setiap 3 hari sekali atau selang 2 hari

- Jika tidak ada hujan, semprotlah pada setiap 5 - 7 hari sekali

- Aplikasikan fungisida minimal 4 jam sebelum turun hujan.

III.5. Data type and collection procedure

Data that was gathered consisted of :

- Soil data analysis before and after Field School activity

- Data analisi petiole every fortnight aftercrop was one month old and undetaken four times

- Control thresholds for IPM for Plot SL.2.

- List of pesticides used

- Monitoring of pest caught in the sticky trap
- Yield data

The data that was collected was then processed and complied in a descriptive way to show the difference between treatments.

IV. RESULTS AND DISCUSSION

IV.1. Charcteristics of the Field School location

The location of the FFS LBD plots were the paddy fields on the Sembalun valley with an area of 1,105 ha that's located on the slopes of Mt Rinjani with an altitude of 1.150 to 1.250 mabove seas level, with climate type C and D4, temperature around 17 – 26 ^{o}C with average humidity of 91%, rainfall of 2,000 – 3,000 mm/year occurring from November to May with 100 - 132 total rainy days per year.

This valley is very fertile with top soil depth between 30 – 40 cm having a sandy clay texture of inceptisol soil type formed from young decayed volcanic soil and accumulations of organic material from the surrounding slopes of Mt Rinjani. The hills that encircle the lembah Sembalun valley form a protective buffer that isolates it from several pests or disease important to potato.

Based on the soil survey that was undertaken by John Marshall Sembalun valley sampai saat ini not yet been found potato cyst nematode (PCN) that potato farmers fear a lot because it damages potato tubers and results in harvest failure as has happened in Java.

IV.2. Laboratory analysis results

Based on the analysis results from before and after the FFS activity as shown in the following table indicates that soil pH is colse to 5.5 which is an optimum pH for producing potatoes as was the case for P nutrition which also still shows the status of this nutrient is high. However the element potassium has a low status namely less than 0.3 cmol/kg. This situation is caused by potato crop production main macro element that is influential in potato cultivation is the element potassium (K), where based on the results of crop tissue *petiole* analysis the most dominant element is K which reaches 10 % then following succession Nitrogen 2% and another element phosphate less than 1 %. This situation is believed meanwhile the cause of the low status of exchangeable potassium (Kex) at the location of the FFS especially and in the main potato growing areas.

To supply an explanation of the above there follows prepared soil analysis results data at the begining and end of the Field School activity along with petiole analysis results from the potassium plot in the following tables:

Table 8. Soil analysis at the beginning of the activity.

#	Sender	pH H_2O	N Total (%)	P_2O_5 Bray (ppm)	NH_4 acetate 1 N pH 7 K-ex	Na-ex	Ca-ex	Mg-ex
					(cmol(+)/kg)			
1	Aldi K1	5.40	0.07	25.33	0.23	0.43	6.74	1.55
2	Aldi K2	5.59	0.13	26.25	0.25	0.43	6.18	1.75
3	Aldi K3	5.69	0.12	26.06	0.29	0.28	2.71	1.02
4	Aldi K4	5.76	0.08	27.16	0.22	0.35	3.25	1.00
5	Aldi K5	5.53	0.06	27.72	0.25	0.28	2.02	0.72
6	Mujanip K1	5.40	0.07	76.05	0.15	0.02	0.37	0.22
7	Mujanip K2	5.50	0.05	65.03	0.15	0.06	0.91	0.28
8	Mujanip K3	5.40	0.07	58.78	0.21	0.22	2.01	0.48
9	Mujanip K4	5.55	0.07	74.03	0.25	0.61	5.35	1.02
10	Mujanip K5	5.50	0.06	49.96	0.27	0.44	5.99	1.12
11	Athar K1	5.88	0.19	43.72	0.08	0.02	0.02	0.08
12	Athar K2	5.75	0.08	55.29	0.14	0.06	1.28	0.27
13	Athar K3	5.65	0.13	85.05	0.08	0.02	0.31	0.13
14	Athar K4	5.64	0.16	84.68	0.14	0.05	0.01	0.13
15	Athar K5	5.75	0.06	37.84	0.23	0.20	2.31	0.60

Table 9. Soil analysis at the end of the activity.

#	Sender	pH H_2O	N Total (%)	P_2O_5 Bray (ppm)	NH_4 acetate 1 N pH 7 K-ex	Na-ex	Ca-ex	Mg-ex
					(cmol(+)/kg)			
1	Aldi K1	5.52	0.30	23.83	0.12	0.33	2.96	1.04
2	Aldi K2	5.60	0.31	21.64	0.17	0.5	7.36	1.11
3	Aldi K3	6.22	0.38	21.27	0.28	0.4	6.11	1.05
4	Aldi K4	5.32	0.36	22.19	0.18	0.53	6.27	1.00
5	Aldi K5	5.37	0.33	21.82	0.32	0.39	4.55	0.88
6	Mujanip K1	5.92	0.27	23.86	0.40	0.57	4.35	1.01
7	Mujanip K2	5.94	0.23	22.01	0.21	0.84	5.07	0.87
8	Mujanip K3	5.71	0.23	24.60	0.27	0.62	4.01	0.67
9	Mujanip K4	5.50	0.23	25.15	0.29	0.73	4.36	0.76
10	Mujanip K5	5.73	0.14	25.34	0.31	0.69	5.29	0.82
11	Athar K1	5.56	0.13	41.43	0.38	0.79	3.95	1.05
12	Athar K2	5.50	0.18	44.39	0.28	0.43	6.46	0.90
13	Athar K3	5.78	0.18	39.95	0.26	0.71	4.87	0.81
14	Athar K4	5.84	0.22	46.24	0.33	0.59	2.9	0.67
15	Athar K5	5.66	0.20	43.28	0.35	0.9	6.49	0.62

Table 10. Crop petiole analysis at 5 weeks after planting.

#	Dry wt	N Total (%)	Total extract ($HClO_4$ & HNO_3) P	K	Na	Ca	Mg	Fe	Mn	Zn	Cu	S
								(ppm)				(%)
1.		2.64	0.33	8.00	0.05	0.63	0.92	134	174	19	4	0.02
2.		3.00	0.24	7.78	0.05	0.54	0.73	168	174	12	8	0.02
3.		2.84	0.29	8.06	0.06	0.44	0.64	176	166	14	18	0.02
4.		2.96	0.26	8.46	0.05	0.46	0.91	196	196	12	tt	0.02
5.		3.13	0.22	8.18	0.08	0.38	0.80	244	212	10	tt	0.02
6.		4.26	0.34	7.86	0.08	0.42	0.44	152	76	22	tt	0.05
7.		4.12	0.27	7.74	0.09	0.66	0.66	192	126	28	tt	0.06
8		4.13	0.36	7.86	0.09	0.58	0.50	212	128	24	tt	0.02
9		4.62	0.29	7.70	0.10	0.76	0.70	160	140	28	tt	0.02
10		3.42	0.28	7.90	0.14	0.70	0.63	176	124	12	tt	0.08
11		4.28	0.36	7.10	0.10	0.85	0.72	208	144	18	tt	0.04
12		4.32	0.41	7.34	0.11	0.74	0.69	188	130	32	tt	0.02
13		4.14	0.41	7.86	0.12	0.97	0.71	208	98	50	tt	0.08
14		4.40	0.39	7.42	0.12	0.84	0.68	224	98	32	tt	0.06
15		4.05	0.45	7.90	0.12	0.72	0.64	232	82	20	4	0.03

Table 11. Crop petiole analysis at 7 weeks after planting.

#	Dry wt	N Total (%)	Total extract ($HClO_4$ & HNO_3) P	K	Na	Ca	Mg	Fe	Mn	Zn	Cu	S
								(ppm)				(%)
1.	7.2	1.71	0.23	8.20	0.02	0.46	0.57	448	368	84	2	0.11
2.	6.9	1.57	0.13	9.30	0.05	0.59	0.45	294	366	100	2	0.13
3.	7.1	2.05	0.10	10.1	0.06	0.54	0.45	214	318	96	tt	0.13
4.	5.9	2.37	0.09	12.8	0.06	0.53	0.55	216	380	112	tt	0.10
5.	6.8	2.23	0.09	12.0	0.05	0.40	0.37	260	410	114	tt	0.15
6.	4.7	2.45	0.14	11.8	0.06	0.50	0.33	166	206	136	tt	0.19
7.	6.7	1.86	0.14	10.6	0.06	0.52	0.31	180	194	154	tt	0.20
8	6.4	2.94	0.14	9.80	0.05	0.57	0.35	190	192	138	2	0.12
9	9.0	2.59	0.11	12.2	0.05	0.55	0.36	206	200	142	4	0.10
10	8.8	2.00	0.12	12.0	0.05	0.69	0.34	148	208	140	6	0.17
11	7.5	2.17	0.13	9.20	0.08	0.75	0.37	208	464	254	4	0.14
12	4.8	1.98	0.17	9.90	0.09	0.54	0.38	172	416	222	8	0.19
13	4.0	2.48	0.11	7.89	0.05	0.70	0.35	158	768	244	8	0.12
14	6.9	2.41	0.16	9.40	0.10	0.49	0.29	134	758	194	10	0.18
15	9.2	1.91	0.13	10.4	0.10	0.71	0.26	230	805	315	13	0.19

Table 12. Crop petiole analysis at 9 weeks after planting.

#	Dry wt	N Total (%)	Total extract ($HClO_4$ & HNO_3) P	K	Na	Ca	Mg	Fe	Mn	Zn	Cu	S
								(ppm)				(%)
1.	7.64	2.02	0.16	8.41	0.02	0.37	0.78	1335	441	85	39	0.11
2.	5.54	1.96	0.14	9.1	0.01	0.32	0.86	554	520	106	24	0.13
3.	6.86	2.09	0.15	9.12	0.02	0.34	0.76	610	490	122	20	0.13
4.	6.86	2.28	0.15	9.66	0.01	0.39	0.72	500	364	88	16	0.13
5.	7.80	2.03	0.18	11.96	0.00	0.54	0.53	220	292	206	16	0.11
6.	7.82	1.53	0.13	13.76	0.01	0.31	0.52	314	434	126	22	0.12
7.	7.66	1.73	0.13	13.36	0.00	0.49	0.49	322	276	222	22	0.12
8	8.17	1.52	0.15	12.56	0.01	0.51	0.36	310	252	220	30	0.13
9	7.63	0.70	0.15	10.76	0.01	0.61	0.53	494	262	212	28	0.12
10	7.94	1.64	0.14	13.26	0.01	0.48	0.34	458	262	208	28	0.13
11	6.79	2.33	0.16	13.26	0.01	0.45	0.58	786	504	304	28	0.14
12	6.27	1.60	0.16	13.56	0.02	0.50	0.66	478	552	358	28	0.13
13	7.13	1.78	0.14	12.66	0.00	0.47	0.55	318	372	252	28	0.14
14	7.18	2.21	0.12	12.76	0.01	0.50	0.47	282	448	276	30	0.15
15	7.96	1.53	0.13	12.36	0.01	0.48	0.30	186	358	332	26	0.18

Table 13. Crop petiole analysis at 11 weeks after planting.

#	Dry wt	N Total (%)	Total extract ($HClO_4$ & HNO_3) P	K	Na	Ca	Mg	Fe	Mn	Zn	Cu	S
								(ppm)				(%)
1.	6.56	2.03	0.17	5.58	0.05	0.39	1.04	1411	488	82	24	0.08
2.	7.04	1.83	0.16	6.29	0.06	0.68	1.11	1270	322	106	20	0.16
3.	6.59	1.71	0.22	7.29	0.05	0.52	1.05	1160	462	114	tt	0.25
4.	7.44	2.51	0.23	8.18	0.05	0.57	1	872	216	86	tt	0.17
5.	7.68	1.27	0.19	8.52	0.06	0.46	0.88	816	316	122	16	0.16
6.	6.99	2.03	0.25	9.21	0.05	1.16	1.01	756	282	218	6	0.09
7.	7.51	1.76	0.23	9.14	0.04	1.15	0.87	782	194	144	0	0.10
8	8.54	1.1	0.18	9.17	0.05	0.97	0.67	504	244	166	16	0.12
9	8.18	1.32	0.15	9.10	0.04	0.82	0.76	554	188	110	tt	0.10
10	7.34	1.9	0.24	8.75	0.04	0.87	0.82	668	274	122	14	0.20
11	6.42	2.17	0.24	5.92	0.07	0.82	1.05	206	728	214	22	0.34
12	6.05	2.12	0.18	8.91	0.04	0.92	0.9	814	648	154	tt	0.13
13	6.02	2.08	0.19	5.94	0.02	1.13	0.81	776	414	164	16	0.11
14	7.29	2.05	0.14	5.35	0.01	1.16	0.67	742	486	160	4	0.17
15	5.49	2.05	0.15	9.07	0.03	1.2	0.62	214	466	254	2	0.16

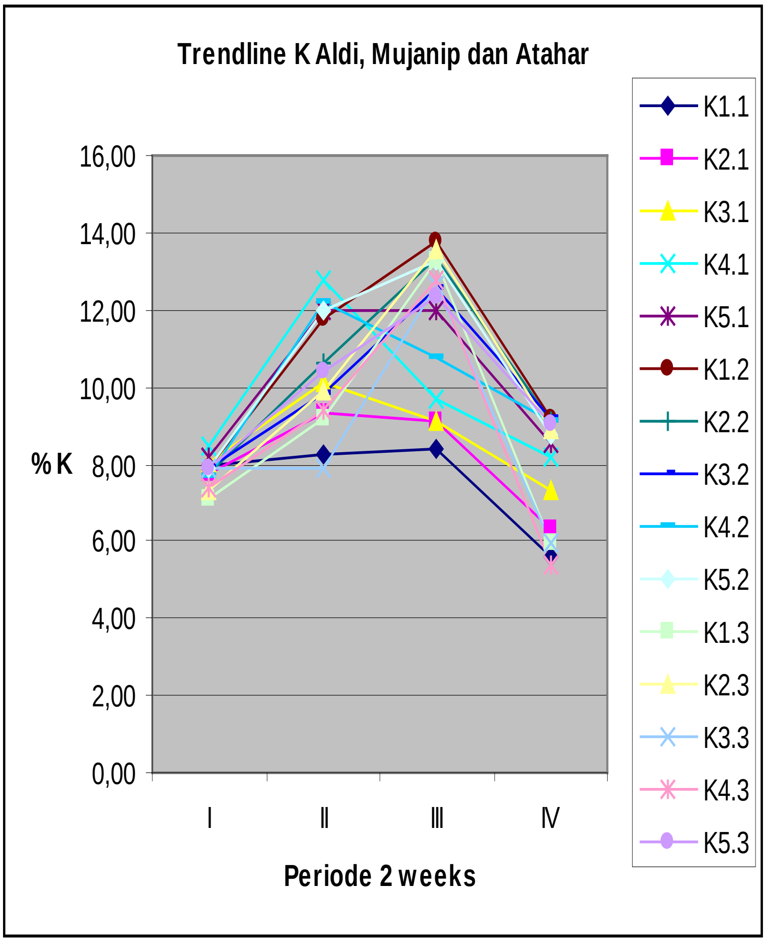

Table 14. Fortnightly petiole K absorption trendline from petiole analysis tables.

IV.3. Pest and disease control

The use of pesticides, based on monitoring, that were applied to control pests and diseases is shown in Table 15 following;

Table15. Type of pesticide used in controlling pests and diseases in the Farmer Intitated Learning plots.

No	Existing Petani		PHT/IPM ACIAR	
	Pestisida	Bahan Aktif	Pestisida	Bahan Aktif
1.	Apsa	Alkil aril alkoksilat asam oleat	Apsa	Alkil aril alkoksilat asam oleat
2.	Besmor	Poli Oksietilen Alki Aril Eter	Besmor	Poli Oksietilen Alki Aril Eter
3.	Cozene	Mankozeb & Karbendazim	Cylotex	Siromazin
4.	Cyrotex	Siromazin	Dhytane	Mankozep
5.	Dhytane	Mankozep	Equation	Simoksanil & Pamoksadon
6.	Equation	Simoksanil & Pamoksadon	Jose	Sipermetrin
7.	Indostik	Tendensat Nonil Tenol Etilen Oksida	Industik	Tendensat Nonil Tenol Etilen Oksida
8.	Jose	Sipermetrin	Revus	Mandipropamid
9.	Klopindo	Imidacloprid	Satgas	Propineb
10.	Metindo	Metamil	Sidamec	Abamectin
11.	Nemispor	Mankozeb	Tracer	Spinosad
12.	Pentacron			
13.	Pentacur			
14.	Revus	Mandipropamid		
15.	Rovral	Iprodion		
16.	Sidamec	Abamectin		
17.	Satgas	Propineb		
18.	Topsindo	Tiofanat Metil		
19.	Winder	Imidacloprid		
20	Victory	Mankozeb		

Regarding results of dominant pest population observations from Yellow Sticky Trap that were installed 45 days after planting in every plot aer shown in Table 16 :

Table 16. Average observed population of dominant pests in *Yellow Sticky Trap.*

No	Farmer Group	Total Population	
		Leafminer fly	Thrips
1.	Lendang Luar	152	671
2.	Dayan Desa + Buatan	854	477
3.	Tenjong	646	432
4.	Paok + Kekoro	598	604
5.	Ronggak + Telaga	230	695
6.	Pangsor + Serut	1086	494

IV.4. Yield

After maturity was reached harvest was undertaken for each treatment plot for each FFS group or the experimental potassium fertiliser plots and from the the yield results of each plot were converted per hectare as shown in the following Table:

Table 17. Yield of conventional farmer management and SL treatment.

NO	GROUP	Treatment Plot (ton/ha)			Rank by
		Farmer	FIL 1	FIL 2	yield
1	ORONG TENJONG	29.9	28.9	33.0	5
2	ORONG LENDANG LUAR	35.4	36.7	33.1	2
3	O DAYAN DESA + BUATAN	48.8	50.2	48.2	1
4	O DAYAN PANGSOR + SERUT	30.7	30.4	30.4	4
5	O RONGGAK + TELAGA	34.8	32. 9	31.9	3
6	O PAOK + KEKORO	18.7	19,1	19.8	6
	AVERAGE	33.1	33.0	32.8	

According to the average yield data that is shown in Tabel 17 above it shows that between Farmer Plot and Plot SL1 and Plot SL 2 there isn't a clear difference in yield namely 33 ton/ha; whereas in Plot SL1 and SL2 where phosphate fertilisation of 50% namely 6 kwintal [kwintal = 100 kg]/ha of the farmers' and only 3 kwintal per plot SL1 and SL2. Therefore there is [improved] efficiency of phosphate inputs so that there will be an impact on the improving farmer income because of reduced input costs.

Normally the average yield of Atlantic in Sembalun is 20 ton/ha; the average yield of the demplots both the Farmer plot as well as the SL1 and SL2 was 33 ton/ha. This means that optimal ICM if the FFS treatment contributes to an increase in production of 13 tonnes more per hectare, or about 65%, this is a really fantastic increase.

Table 18. Yield produced by the potassium fertilisation plots:

Site	Yield (tonnes/ha)				
	K1	K2	K3	K4	K5
I (A. Aldi)	30.3	31.1	32.2	32.1	31.1
II ((Mujanip)	21.4	18.0	19.6	22.9	18.8
III (Atahar)	12.9	14.6	13.7	17.3	20.8
Average	21.5	21.2	21.8	24.1	23.5

The experimental yield from the potassium demonstration plot as shown in Table 18 doesn't show a difference between treatments except in replicate III. Generally in replicate II & III gave yeilds far lower than the average, this issue is caused at 40 days after planting when the weather was less that good as evidenced by foggy cloud which consequently increased humidity and caused a *Phytophthora sp.* Infection that reached 20-30 % of the plant population. Although control action of applying fungicide had already been undertaken but the crop growth was too late so it caused lower yield that the average of the replicates.

Based on the average treatment dose potassium has not yet given optimium yield between treatments, namely treatment K1, K2 and K3 there wasn't a clear difference with respective yields of 21.5 ton /ha, 21.2 ton/ha and 21.8 ton/ha; except for K4 and K5 which gave yields of 24.1 ton/ha and 23.5 ton/ha indicating and increase of 10-12 % compared with the control K1.

IV.5. Preferensi Petani Terhadap Pelaksanaan Sekolah Lapang

Based on a survey that was distributed to 20 cooperating farmers, farmers preference regarding the execution of this FFS can be shown as follows:

1. Extreme change that occurred in the village

From 20 respondents that completed the survey/questionnaire about assessing the FIL activity in NTB in November 2009 several statements were given as follows:

Table 19. Changes occuring in the village reported by farmers involved in FIL.

No	Farmer expressions / statements	Respondents agreeing	
		(Number)	(%)
1	Increase in income/community economic matters	6	30
2	Improved crop management	5	25
3	Farmer stance/behaviour petani to agricultural system improved.	5	25
4	Awareness for the need of animal stable system.	1	5
5	Confidence in the importance of organic fertiliser	2	10
6	Increase in the number of potato farmers	1	5
7	Farmers ware of the importance of collective marketing of yield.	1	5

The table above shows there are various farmer opinions / expressions. Most farmers stated that the extreme change that occurred in the village was the increase in community income, improved crop management and farmer attitude / behaviour regarding the agricultural system also improved.

The data above shows that 6 respondents (30%) stated that in Sembalun village there has already extreme change namely an increase in farmer income / community economic matters. There also 5 farmer respondents (25%) that stated that 3 years before this appeared: agricultural crop management improved and 5 people (25%) stated that Sembalun farmer attitude / behaviour Sembalun in farming was additionally better. After carrying out several demplots using organic fertiliser, and yield that was obtained showed the use of organic fertilizer was better, so 2 farmer respondents (10%) stated that organic fertilizer is fairly important in vegetable production. Besides that there was also one farmer respondent (5%) that said that a. the amount of potato farmers increases every year; b. the need for a system of [collecting] cattle manure for [use] as the main ingredient of organic fertiliser; and c. the importance of a market that can accommodate the increasing production of the vegetable farmers in Sembalun.

2. Benefit to the agricultural system

20 farmer respondents produced several statements as follows:

Table 20. Benefits to the agricultural system following FIL activities according to farmers involved in FIL.

No	Farmer statement	Respondents agreeing (Number)	(%)
1	Improved cultivation technology	13	65
2	Increased yield	6	30
3	Improved cost of production	2	10
4	Price of agricultural produce relatively stable	1	5

The above Table shows that there were 13 farmer respondents (65%) stated that cultivation technology that developed in the rural areas improved; 6 farmer respondents (30%) stated that Sembalun achieved increased production; 2 farmer respondents stated that efficiency of cost of production occurred and one farmer respondent (5%) stated that there was stability in the agricultural produce in the rural areas.

3. Benefit for the farmer group

20 farmer respondents stated the following:

Table 21. Benefits to the farmer group following FIL activities according to farmers involved in FIL.

No	Farmer statement	Respondents agreeing (Number)	(%)
1	Cooperation in the group improved	6	30
2	Technical problems were easily overcome	2	10
3	Increasing knowledge & skill	12	60

The above table shows that 6 farmer respondents (30%) stated that the ACIAR program that was undertaken had an impact by bettering the feeling of togetherness of the group, 2 people (10%) stated that all technical problems were easier to overcome and 12 farmer respondents (60%) stated that they increased their knowledge and skill in farm business.

4. Changes in pesticide use

20 farmer respondents felt that several changes occurred in the use of pesticides, consequently farmers mentioned more than one issue. All statements from farmer respondents are as follows:

Table 22. Changes in pesticide use following FIL activities as reported by farmers involved in FIL.

No	Farmer statement	Respondents agreeing	
		(Number)	(%)
1	The use of pesticides is more thrifty	12	60
2	Pesticide use is more accurately targetted	6	30
3	Mixes are no longer used	8	40

12 farmer respondents (60%) stated that the use of pesicides had become more thriftly; 6 farmers (30%) stated pesticide use was more accurately targetted; and 8 farmer respondents (40%) stated that the use of mixed pesticides no longer occurred.

5. Change in fungicide use

20 farmer respondents stated that there was a change i the use of fungicides, as printed in the Table:

Table 23. Changes in fungicide use following FIL activities as reported by farmers involved in FIL.

No	Farmer statement	Respondents agreeing	
		(Number)	(%)
1	Use of mixed fungicides no longer used	8	40
2	Fungicide use efficiency	12	60

Eight (8) farmer respondents (40%) stated that now fungicides are no longer mixed; on whereas 12 other farmer respondents (60%) stated that introduced technology caused the efficient use of fungicides.

6. Comment about future ACIAR developments

Table 24. Comments about future ACIAR project activity according to farmers involved in FIL.

No	Farmer statement	Respondents agreeing	
		(Number)	(%)
1	Continued development of other technology	8	40
2	Continued development of Sembalun	5	25
3	Continued, other commodities	4	20
4	Continued, *Phytophthora* FIL plots	2	10
5	Continued, seed potato program	1	5

The above table shows that potato farmers in Sembalun hope that ACIAR activity will still be continued, especially in farmer attempts in this place to develop a potato seed system for the future. 8 people (40%) hoped that there will be other technology that will be very beneficial for potato development in Sembalun, 5 other farmers (25%) hope that Sembalun can be further developed and be known all over Indonesia, 4 people (20%) hope that ACIAR activity in the yes to come will also touch on other highland commodities that are produced in Sembalun. Similarly another respondent hoped that continued ACIAR activity in Sembalun would be planned to support the development of the potato seed industry.

V. CONCLUSIONS AND RECOMMENDATIONS

V.1. CONCLUSIONS

On the basis of the outcomes and discussions that we have analysed in the previous chapters, we can draw the following conclusions:

1 Given its topography, the physical and chemical composition of its soil, its climate and the potato cyst nematode survey which was conducted jointly by BTTP and ACIAR, the Sembalun valley presents sufficiently suitable characteristics for the development of potato cultivation.

2 The Potato Farmers' Field School is much appreciated by the farmers as a channel of community education whose aim is to increase their knowledge of ICM.

3 The technology which we worked out of blending manure, pesticides and fungicides into the soil in the potato demonstration plot at the Field School was able to increase the efficiency of phosphate fertilizers by up to 50% compared to the technology which is currently being used by farmers. The average production can thus be increased by up to 65% over and above the average production obtained by neighbouring farmers.

4 Where treatment with doses of potassium was applied, the average production outcomes have not been ideal in-between applications; there was no obvious difference in-between the successive treatments K1, K2 and K3 which yielded 21.5 tons/ha, 21.2 ton/ha and 21.8 ton /ha respectively; it was only with treatments K4 and K5 that the production rose to 24.1 and 23.5 ton /ha thus showing an increase of 10 to 12% compared to the post-K1 control.

V2. RECOMMENDATIONS

On the basis of the outcomes and discussions that we have analysed in the previous chapters, we can make the following recommendations:

1. As concerns the program of the Potato Farmers’ Field School, there is still a need to develop the technology of blending other elements into the soil in order to raise the benchmark of what is a high average production for vegetable horticulturists and in order to obtain an efficient input together with a type of agriculture which is environmentally friendly and sustainable.

2. As concerns the verification of the potassium demplot K, we need to conduct further and more thorough experiments in order to obtain data which are more accurate.

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Final report appendix 11

title	AGB/2005/167 Farmer initiated learning - cabbage
prepared by	Andrew Taylor
co-authors/ contributors/ collaborators	Peter Dawson, Ian McPharlin, Mr Mufrodin, Mr Akhmad Arifudin, Mr Frans Silva, Mr Mohammed Assad

1 Executive summary

A total of 16 Farmer Field Schools (FFS) or Farmer Initiated Learning (FIL) cabbage plots were undertaken across Central Java and South Sulawesi from 2008 until 2010 with participation of approximately 320 farmers. The aims of the FFS and FILs were to improve the knowledge and understanding of the three key constraints to cabbage production in Indonesia being clubroot, soil acidity and IPM of pests. By empowering farmers to become technical experts in the management of these constraints improved yields, profitability and sustainability will lead to improved social and developmental impacts in the community.

Initially eleven FFS were undertaken in Central Java during the 2008/09 cabbage growing season. The treatments tested were chosen by farmers with the aid of Training of Trainer (ToT) trained facilitators and indicated that improvements to the FFS methodology were needed in order to achieve the objectives. These areas included;

- testing of fewer treatments,
- the standardisation of LBD plot activities so replication could be carried out by other groups.
- replication within a farmer group.
- Using better rigour for the control plot. Although some farmer groups had their conventional practices as a control they often modified these on-the-run.
- Improved data gathering to overcome the missing information from earlier FFS which analysis of records of learning-by-doing plots difficult.

The improved FFS method as called FIL and was based on a carefully planned learning-by-doing (LBD) activity. This new method was tested by the Sekar Tani farmer group in 2008/09. This LBD plot served three purposes; first to determine the amount and type of lime required to increase pH in the acidic soils of Indonesia, second to determine the effect liming has on the level of clubroot seen on crops and third to introduce farmers to a more detailed scientific method through hands on training. It was discovered that applications of $Ca(OH)_2$ were more efficient than dolomite in increasing cabbage yields but not in reducing clubroot incidence.

A review of the 2008 cabbage LBDs lead the project team to develop a Cabbage Technical Toolkit (CTT) aimed at the facilitators (ACIAR 2010). The CTT was designed to improve on the areas identified in the previous cabbage LBDs by containing:

- Information on designing simple farmer experiments that compared new management techniques against conventional practices.
- Standard operating procedures for cabbage production.
- Example experiments including managing clubroot through liming and resistant varieties and improved pest management through IPM.
- A comprehensive set of tally sheets for capturing important data.

The new round of the cabbage FIL LBD plots conducted in 2010 were the first to include the experiments from the CTT. Two farmer groups, Madu (Central Java) and Pemuda Tani Vetran (South Sulawesi), compared a local variety against the clubroot resistant variety Maxfield with and without liming of the soil. Both FIL LBD plots shows Maxfield produced higher yields with lower clubroot infection than the local varieties. Further demonstration plots are required in Indonesia to confirm the results of the ability of Maxfield to produce higher yields and remain resistant to clubroot. Liming has been shown to be a cost effective clubroot control measure in South Sulawesi with the application of lime producing higher gross margins than that of not liming.

2 Background

The Learning By Doing (LBD) approach to farmer education and extension has been employed in several developing countries including China (Mangan & Mangan 1998), Africa (Anandajayasekeram *et al.* 2007), Vietnam, Cambodia, Peru, Sri Lanka and Indonesia (van den Berg 2004) for a variety of agricultural commodities. The concept of LBD plots originated in Indonesia as a way to educate farmers to reduce their reliance on pesticides in rice paddies (van den Berg 2004). The approach is to use Farmer Field Schools (FFS), where a group of 25-30 vegetable farmers meet weekly at a field and study a crop from sowing to harvest whilst monitoring key stages and recording data on their observations (Ketelaar & Kumar 2002). After the data is collected it is analysed by a group of farmers and a decision is made on the implementation of management options. The FFS are facilitated by an expert farmer who is either a government or NGO extension officers or farmers who have undertaken training through a Training of Trainers course (Ketelaar & Kumar 2002). The approach of the FFS is designed to be an interactive and practical method of training that empowers farmers to be their own technical experts on major aspects of their farming system (Anandajayasekeram *et al.* 2007) and less reliant on external measures and advisors (van den Berg & Lestari 2001).

The baseline survey of cabbage production in Indonesia which was done by this project (See Appendix 3 Baseline Agronomic Survey of cabbages) identified three key limiting areas of production; clubroot, IPM of pests and soil acidity. These three areas were subsequently chosen to be the basis of the cabbage LBD plots. In an evaluation of Indonesian LBD case studies the benefits of LBD plots have been to successfully reduce the number of insecticides in rice up to 61% and increase yields by 21% (van den Berg 2004). LBD plots also lead to social benefits with their use in the Philippines aiding the introduction and establishment of the diamond back moth parasitoid *Diadegma semiclausum* in cabbage production systems and therefore reducing the reliance on chemicals (Ketelaar & Kumar 2002).

Clubroot disease (*Plasmodiophora brassicae*) is a significant problem for Indonesian cabbage farmers and an integrated management program is the best option for control. The interaction between soil conditions is widely known. Raising soil pH is one of the oldest methods in managing clubroot with incidence and severity generally reduced when pH is higher than 7.2 (Donald *et al.* 2006). Given the acidic nature of Indonesian soils raising pH represents a suitable LBD option for farmers as it has the potential to improve two key constraints to cabbage production. However it has been noted that several variables are present in the effectiveness of applying lime to soils including soil moisture, particle size, the incubation period between application and planting and the soils responsiveness to the liming (Donald *et al.* 2006, Donald & Porter 2009). Furthermore liming is known to control the pathogen when spore loads are low but even heavy applications are ineffective when the soil is heavily infested (Rimmer *et al.* 2007).

The FFS system is also not without its problems, one of which is the difficulties in assessing and measuring their impacts (van den Berg 2004). Impact evaluation is complex because of methodological obstacles, the range of intermediate and developmental impacts and a difference in the perspective of stakeholders (van den Berg 2004). Therefore it is possible that the impact reported by participants in FFS may not actually translate into improved agricultural sustainability and community benefits.

3 Objectives

The three major constraints to cabbage production as identified by the cabbage baseline survey were soil acidity, clubroot and IPM of pests. Improving farmer's knowledge and management of these constraints were objectives of the cabbage LBD's. Through empowering farmers to become their own technical experts on cabbage production it is aimed that an improvement in overall yields, profitability and sustainability will occur. This will lead to social and development impacts in the surrounding agricultural communities.

Another aim of the LBDs was to 'road test' the new Technical Toolkits for cabbages that were designed to develop a better understanding of the concepts of small scale on farm scientific experiments.

4 Methodology

The cabbage LBDs in Central Java followed a similar pattern to FFS previously held in Indonesia with a Training of Trainer session occurring in August of 2008 just prior to planting of the first plots. At the ToT the facilitators of the farmer groups were presented information about clubroot, soil acidity, IPM and other diseases. After the ToT the facilitators meet with the farmer group and decide on the experiment they wanted to conduct as part of the LBD including the outcomes, targets and objectives.

The method of the LBD would involve 25% of studies being undertaken in class whilst the remainder would be outside. The group would meet once a week for approximately 16 weeks. Tasks would be divided into subgroups generally made up of 5 farmers. These subgroups would then monitor 10 plants from the conventional and experimental plot every week throughout the life of the crop and discuss their observations with the whole group.

After the crop was completed harvest would occur and the yield results for each plot would be recorded. Each farmer group would then report their financial situation of each plot along with their conclusions in a final report. A two day review of the 2008 FFS was conducted in January of 2009 where all the farmer groups met and discussed with the facilitators what they had learnt and achieved in the current FFS plots.

The Cabbage Technical Toolkit (CTT) was developed in 2009 and passed onto the growers to implement in the 2010 LBD uptake. Farmers and facilitators chose a variable to study from the CTT and this was then studied by the farming group. It was encouraged that several of the farming groups study the same variable so that results could be collated and analysed across groups not only within a single farming group. Upon deciding on a variable to study each farmer group grew their crops in the 2010 season.

4.1 Farmer groups and their treatments

Tempelsari 2008

The Tempelsari group compared two different pesticide regimes in their LBD plots. The experimental plot included the use of 3 litres of insecticide and 1kg of fungicide per 3,000 plants. The conventional plot on the other hand included 4 litres of insecticides and 6 kg of fungicide per 3,000 plants.

Sri Rejeki 2008

The Sri Rejeki farmer group compared a non-replicated experimental pest and disease control plot versus conventional farming practices plot for their LBD trial. The experimental plot involved the use of two applications of *Trichoderma*, one frangipani extract spray, and 4 sprays of Dipel (active ingredient *Bacillus thuringiensis*). Dipel is registered in Indonesia for the use against diamond back moth and cabbage cluster caterpillar, *Trichoderma* is used for plant disease control and the purpose of frangipani extract was not explained. All other conventional practices remained the same. The conventional plot involved two applications of Matador (*lambda sihalotrin*), one application of Decis (*deltamethrin*), one spray of Curacron (*profenofos*) and 7 unidentified sprays.

Manunggal 2008

The Manunggal farmer group performed a simple experimental plot versus a conventional plot during their LBD. The experimental plot consisted of *Trichoderma* applications to control cabbage diseases and 4 times application of chemical pesticides. The conventional plot consisted of no *Trichoderma* application and 8 times chemical applications.

Klakah Sarimulyo 2008

Klakah Sarimulyo used plant growth promoting Rhizobacteria (PGPR) and *Trichoderma* in addition to 4 sprays of Matador and Curacron as part of their experimental Farmer Field School plot. For their conventional plot they included 8 sprays of Matador and Curacron only.

Ngudi Luhur 2008

The Ngudi Luhur farmer group compared 5 different treatments during their LBD plots. Treatment 2:conventional plot with a total of 6 insecticide sprays and an additional fungicide applied. Treatment 1: based on critical pest thresholds and sprayed a total of 4 times with insecticides during the crop. Treatment 3;used 1 t/ha of dolomite applied 3 weeks prior to planting with 6 insecticide sprays applied in the crop. Treatment 4 involved a total of 7 insecticide sprays and treatment 5 was 5 applications of PGPR.

Bukit Madu 2008

Bukit Madu farmer school compared three treatment plots. Treatment 1 cow manure and PGPR applications, treatment 2 cow manure and 400kg of lime and treatment 3 cow manure only (the control). Each plot had 4 sprays of Tracer (*spinosad*) and Curacron. Buldok (*betasiflutrin*) was sprayed at planting time in each plot.

Sekar Tani 2008

The Sekar Tani farmer group compared 6 treatments with conventional management. Soil pH of the site was 4-4.5. Treatment 1 involved applying 400 grams of *Trichoderma* and 500 grams of manure per plot. Treatment 2 involved PGPR, treatment 3 involved the biological agent M-Bio, Treatment 4 involved synthetic chemicals applied to the roots of the seedling before being dipped in water. Treatment 5 involved the use of lime applied in each seedling hole, Treatment 6 involved an application of garlic juice and the conventional farmer practices acted as a control. Each treatment had 200 plants.

Trubus 2008

The farmer group Trubus compared a farmer school plot with their conventional practices. The farmer plot involved fermented fertilisers, garlic, *Trichoderma*, PGPR and 6 pesticide sprays. The conventional plot techniques were not listed.

Sumber Rejeki 2008

The Sumber Rejeki group compared conventional practices with farmer treatments. The conventional plot included 10 kg of manure, Ponska and 2 applications of urea (50 kg per treatment). Four applications of the insecticides Matador, Terplain and Curacron were applied. The farmer treatment involved using M-bio at 5, 10 and 15 cc applications with no lime. Cow manure was added with additional applications of urea and 1 pesticide spray

Tunas Harapan 2008

The Tunas Harapan farmer group compared their conventional practices with Farmer School practices. The Farmer School practices include PGPR (Treatment 1), cow manure (Treatment 2), tobacco extract with soursop leaves (Treatment 3), and with no fertiliser (Treatment 4). No details of conventional practices were given.

Sekar Tani 2008/09 Lime plot

The site chosen was a known clubroot infested site and the standard, susceptible Green Coronet variety was used. The LBD plot included two different formulations of lime, $Ca(OH)_2$ and Dolomite. These were applied at two rates of lime, one being conventional recommendations based on soil texture and initial pH (DAFWA 2010a) (5.2 t/ha dolomite and 4.2 t/ha $Ca(OH)_2$) and the 'ACIAR' recommendation being based on soil organic carbon (SOC) and % clay (DAFWA 2010b) (8.5 t/ha dolomite and 6.8 t/ha $Ca(OH)_2$). A hot water treatment against seed borne blackrot was also included in the experiment where seeds were placed in water heated to 50 °C for 30 minutes prior to planting. A control with no lime or hot water seed treatment was included for analysis.

Ngudi Luhur 2010

Adopting the FIL technique in the 2010 LBD plots of the Ngudi Luhur farmer group compared the use of the varieties Grand 11 and Green coronet with and without lime applications. This was virtually a repeat of the comparison used by the Sekar Tani group in 2008/09. In total there were four treatments with two replications per treatment. A total area of 144 m^2 was planted with each plot consisting of 18 m^2.

Bukit Madu 2010

The Bukit Madu group used FIL method to test two cabbage varieties, Maxfield a variety resistant to clubroot in Australia and Greenfrosh a commonly grown variety, with and without lime application in their study. The amount of lime or type added was not detailed.

Sekar Tani 2010

The Sekar Tani FIL LBD compared different types of lime, hot water treatment of seed and different pest and disease control regimes. The two types of lime applied include $Ca(OH)_2$ and Dolomite, both applied 27 days before planting. The hot water treatment involves taking the seed and placing it in 50°C water for 30 minutes before cooling down. This technique destroys the bacteria that causes black rot. The pest and disease regimes were considered either the ACIAR program based on the technical toolkits or regular farmer practices. A control plot was also used that included standard farmer practice and no liming.

Sumber Rejeki 2010

The Sumber Rejeki LBD group compared the use of Grand 11 and Sito varieties, with and without liming. There were two replications per treatment for a total of eight plots. Plot size and type or amount of lime was not detailed.

Pemuda Tani Vetran 2010

The Pemuda Tani Vetran FIL group tested a local variety with Maxfield and the effect of liming on yield and clubroot incidence. Soil pH prior to liming was 4.5. The liming of the plots was performed with 3 t/ha of an unnamed lime source.

5 Achievements against activities and outputs/milestones

Objective 1: To Adapt and apply robust integrated crop production, pest management and postharvest handling systems for potato and Brassicas/Alliums suited to Java, NTB and Sulsel conditions.

no.	activity	outputs/ milestones	completion date	comments
1.5	Updating ToT/FFS curricula and training manuals, and develop extension materials	Technical toolkit	2009	Cabbage Technical Toolkit developed.
1.6	Implementation of multiple cycle FFSs that engage farmer groups in season-long learning and adaptive research throughout consecutive Brassica cropping seasons	Cabbage FIL LBD reports	2010	Cabbage FFS & FIL activities completed and reported in this document.

PC = partner country, A = Australia

6 Key results and discussion

6.1 Locations

A total of 16 cabbage LBD or FIL plots were conducted from Central Java and South Sulawesi from 2008 until 2010 (Table 6.1). This represents the participation of about 320 farmers.

Table 6.1: The cabbage LBD or FIL plots conducted in Central Java and South Sulawesi indicating start and end times and the number of participants.

Location	Farmer Group	Village	Start & end dates	No. Participants
Banjarnegara sub-district, Central Java				
Batur	Trubus	Sumber	Aug - Nov 2008	20
	Tunas Harapan Jaya	Bakal	Oct – Dec 2008	19
Pejawaran	Sekar Tani	Gembol	Aug – Nov 2008	22
	Sumber Rejeki	Beji	Oct – Dec 2008	20
Wanayasa	Bukit Madu	Kasimpar	Aug – Nov 2008	20
	Ngudi Luhur	Wanaraja	Aug 2008 - Nov	20
	Bukit Madu	Kasimpar	Jan 2010 - ?	
	Ngudi Luhur	Wanaraja	Jan – Mar 2010	
Pejawaran	Sekar Tani	Gembol	Nov 08 – Mar 09	
	Sekar Tani	Gembol	Jan 2010 - ?	
	Sumber Rejeki	Beji	Dec 09 – Mar 10	
Wonosobo sub-district, Central Java				
Kejajar	Manunggal	Tieng	Sep – Dec 2008	25
	Klakah Sarimulyo	Tambi	Sep – Dec 2008	24
Garung	Sri Rejeki	Mlandi	Sep – Dec 2008	20
	Tempelsari	Kayugiyang	Sep - Dec 2008	20
Gowa sub-district, South Sulawesi				
Tinggi Moncong	Pemuda Tani Vetran	Bulu Ballea	Apr – Sep 2010	20

6.2 Farmer groups and their findings

6.2.1 Wonosobo 2008:

Tempelsari 2008

The farmer school plot yielded almost 5.5 t/ha more than the conventional plot and had less inputs and therefore had a gross margin almost Rp 600,000 per ha higher than the conventional plot (Table 6.2.1a). It is difficult to explain why there is yield difference between the plots except the possibility that the conventional plot, with its use of pesticides, has a phytotoxic effect on the plants and therefore reducing yields.

Table 6.2.1a. Yield, income, costs and gross margin from conventional and Farmer Field School treatment plots by the Tempelsari farmer group 2008.

Treatment	Total yield* (t/ha)	Income (Rp/ha)	Costs (Rp/ha)	Gross margin (Rp/ha)
Conventional	35.2	2,641,500	767,878	1,873,622
Farmer Field School	42.6	3,181,500	710,156	2,471,344

* Yield based on 2.5m^2 plots.

Sri Rejeki 2008

The yield and income analysis can be seen in Table 6.2.1b that shows a 142% higher yield which gave an almost 15 times increase in gross margin was made from the Farmer Field School experimental plot.

Table 6.2.1b. Yield, income, costs and gross margin from conventional and Farmer Field School pest and disease treatment plots by the Sri Rejeki farmer group 2008.

Treatment	Total* yield (t/ha)	Income (Rp/ha)	Costs (Rp/ha)	Gross margin (Rp/ha)
Conventional insecticides	26	1,950,000	1,867,500	82,500
FFS biological pesticides	37	2,774,500	1,652,500	1,122,000

* Yield based on 2.5m^2 plots.

Manunggal 2008

The experimental plot had only 5% clubroot incidence in comparison with the conventional plot that had 10% and this may explain why the yield was 3t/ha lower in the conventional plots. The increased costs of 4 conventional sprays meant the gross margin of the FFS plot was higher than the conventional plot. The economic analysis of the plots is shown in Table 6.2.1c.

Table 6.2.1c.`Percentage of plants affected by clubroot, yield, income, costs, and gross margin from conventional and Farmer Field School pest and disease treatment plots by the Manunggal farmer group 2008.

Treatment	Plants with clubroot (%)	Total* yield (t/ha)	Income (Rp/ha)	Costs (Rp/ha)	Gross margin (Rp/ha)
Conventional; *Trichoderma,* 4 sprays	10	42	2,100,000	1,122,200	977,800
Farmer Field School; No *Trichoderma*, 8 sprays	5	45	2,250,000	998,200	1,251,800

* Yield based on 2.5m^2 plots.

Klakah Sarimulyo 2008

Total yield was 3t/ha higher in the conventional plot than the FFS plot but costs were Rp 124,000 more per hectare and therefore the gross margins were similar despite the income from the FFS being lower (Table 6.2.1d).

Table 6.2.1d. Yield, income, costs and gross margin from conventional and Farmer Field School PGPR treatment plots by the Klakah Sarimulyo farmer group 2008.

Treatment	Total yield*	Income	Costs	Gross margin
	(t/ha)		(Rp/ha)	
Conventional	37.2	1,860,000	1,122,200	737,800
Farmer Field School; *Trichoderma* & PGPR	34.2	1,712,000	998,200	713,800

* Yield based on 2.5 m^2 plots.

6.2.2 Banjarnegara 2008

Ngudi Luhur 2008

Clubroot percentage was not recorded in all treatment plots but was 5% in the insecticide sprayed 6 times plot and 10.15% in the 7 times sprayed insecticide plot.

Treatment 3 with the lime application had the highest yield at 28.8t/ha followed by the treatment that involved controlling pests based on threshold levels. The application of PGPR resulted in no yield and the conventional insect control produced 16t/ha, the second lowest yield.

Table 6.2.2a. Percentage of plants affected by clubroot and yield from conventional and Farmer Field School treatment plots by the Ngudi Luhur farmer group 2008.

Treatment #	Treatment Description	Plants with clubroot (%)	Total* yield (t/ha)
2	Conventional insect control (6 sprays)	5	17.6
1	Insect control based on thresholds		24.0
3	Conventional insect control with lime		28.0
4	Conventional insect control with extra spray (7 sprays)	10	16.0
5	Application of PGPR		0

* Yield based on 2.5 m^2 plots.

Bukit Madu 2008

Cow manure and PGPR had the highest yields and the highest percentage of clubroot (Table 6.2.2b). This appears contradictory given the negative effect clubroot has on yield so therefore it would be expected that the higher the percentage of clubroot the lower the yield. Similarly, cow manure with lime had the lowest clubroot incidence and also the lowest yield reported.

Table 6.2.2b. Percentage of plants affected by clubroot and yield from conventional and Farmer Field School PGPR and lime plots by the Bukit Madu farmer group 2008.

Treatment #	Treatment Description	Plants with clubroot (%)	Total yield* (t/ha)
3	Control, cow manure	4.3	43.2
1	Cow manure with PGPR	12.4	52.1
2	Cow manure with lime	2.3	36.8

* Yield based on 2.5m^2 plots.

Sekar Tani 2008

It was discovered that only *Trichoderma* and pesticide applications controlled clubroot and therefore these two treatments are the only plots where yield was measured and economic analysis was performed. Both treatments recorded the same yield at 0.5kg/per head or 100kg overall, the *Trichoderma* plot however cost more to produce and therefore had a smaller profit margin (Table 6.2.2c).

Table 6.2.2c. Yield, income, costs and gross margin from conventional and Farmer Field School treatment plots by the Sekar Tani farmer group 2008.

Treatment	Total* yield (kg/treatment)	Income (Rp/treatment)	Costs (Rp/treatment)	Gross margin (Rp/treatment)
7. Conventional				
1. 400 g *Trichoderma* & 500 g cow manure	100	150,000	136,400	13,600
2. PGPR				
3. M-Bio biological agent				
4. Synthetic root pesticides	100	150,000	109,900	40,100
5. Lime				
6. Garlic juice				

* Yield based on 2.5m^2 plots.

Sumber Rejeki 2008

The size of the plots or treatments was not recorded. No yield results or economic analysis was received from this exercise.

Trubus 2008

Each plot recorded the same yield (Table 6.2.2d) but the conventional plot had less inputs and therefore was had a higher gross margin.

Table 6.2.2d. Yield, income, costs and gross margin from conventional and Farmer Field School PGPR treatment plots by the Trubus farmer group 2008.

Treatment	Total* yield (kg/ha)	Income (Rp/ha)	Costs (Rp/ha)	Gross margin (Rp/ha?)
Conventional	12.8	1,000,000	652,000	348,000
Farmer Field School; fermented fertilisers, garlic, *Trichoderma*, PGPR and 6 pesticide sprays	12.8	1,000,000	725,000	275,000

* Yield based on 2.5m^2 plots.

Tunas Harapan 2008

Yield data was from a total of 10 plants per plot (Table 6.2.2e) with the conventional treatment having the highest yield at 18kg/10 plants, whilst the no fertiliser treatment had the lowest yield at 5kg/10 plants.

Table 6.2.2e. Yield comparison of 10 plants per treatment plots by the Tunas Harapan farmer group in 2008.

Plot Number	Yield (kg/10 plants)
Conventional	18
1. PGPR	9
2. Cow manure	13
3. Tobacco extract with soursop leaves	15
4. No fertiliser	5

Sekar Tani 2008/09 Lime plot

A second LBD plot was performed by the Sekar Tani farmer group in 2008/09 to compare the effect of different agricultural limes on clubroot incidence and severity. The comparisons were more rigorous than their previous exercise above due to the change from FFS to Farmer Initiated Learning (FIL) method introduced by this project. This method plans to test one new management treatment against conventional management using a standardised design. If different farmer groups use the same design then results from different groups can be used as replicates to add rigour to the results.

Initial soil pH was acidic 5.5 and it was aimed to increase this to pH of 6.5 by using conventional recommendations of 5.2 t/ha dolomite and 4.2 t/ha $Ca(OH)_2$ and 'ACIAR' recommendation based on SOC and % clay of 8.5 t/ha dolomite and 6.8 t/ha $Ca(OH)_2$. The use of lime had a significant effect on marketable yield with the $Ca(OH)_2$ having the highest yields. There was no significant effect on percent clubroot individually or in the addition of lime to the field, regardless of type. There was no significant differences between the ACIAR recommendations and the FFS recommendations for both yield and clubroot percentage when the hot water treatment and control were removed from the analysis. Of the plots the hot water treatment and the control plot without lime had a 100% crop loss as a result of clubroot (Table 6.2.2f.). Observations of the plots were taken in February 2009 (Fig 6.2).

Table 6.2.2f. Effect of lime application, hot water treatment of seed and two crop management regimes on yield and clubroot infection of cabbage.

Treatment	Amount (t/ha)	Yield (kg/ plot)	Plants with clubroot (%)
Dolomite conventional	5.2	0.5	92
$Ca(OH)_2$ conventional	4.2	10.0	58
Dolomite ACIAR	8.5	2.5	58
$Ca(OH)_2$ ACIAR	6.8	10.8	65
Hot water		0	100
Un-limed control		0	100
Significance #		**	ns
LSD		5.6	91
Lime			
No lime applied		0.0	100
Lime applied		5.9	68
Significance #		ns	ns
LSD		10.9	34
Lime rate recommendations			
FFS	?	5.2	75
ACIAR	?	6.7	62
Significance #		ns	ns
LSD		27.1	75

ns = not significant or '*' = P < 0.1, '**' = P < 0.05,'***' = P <0.01

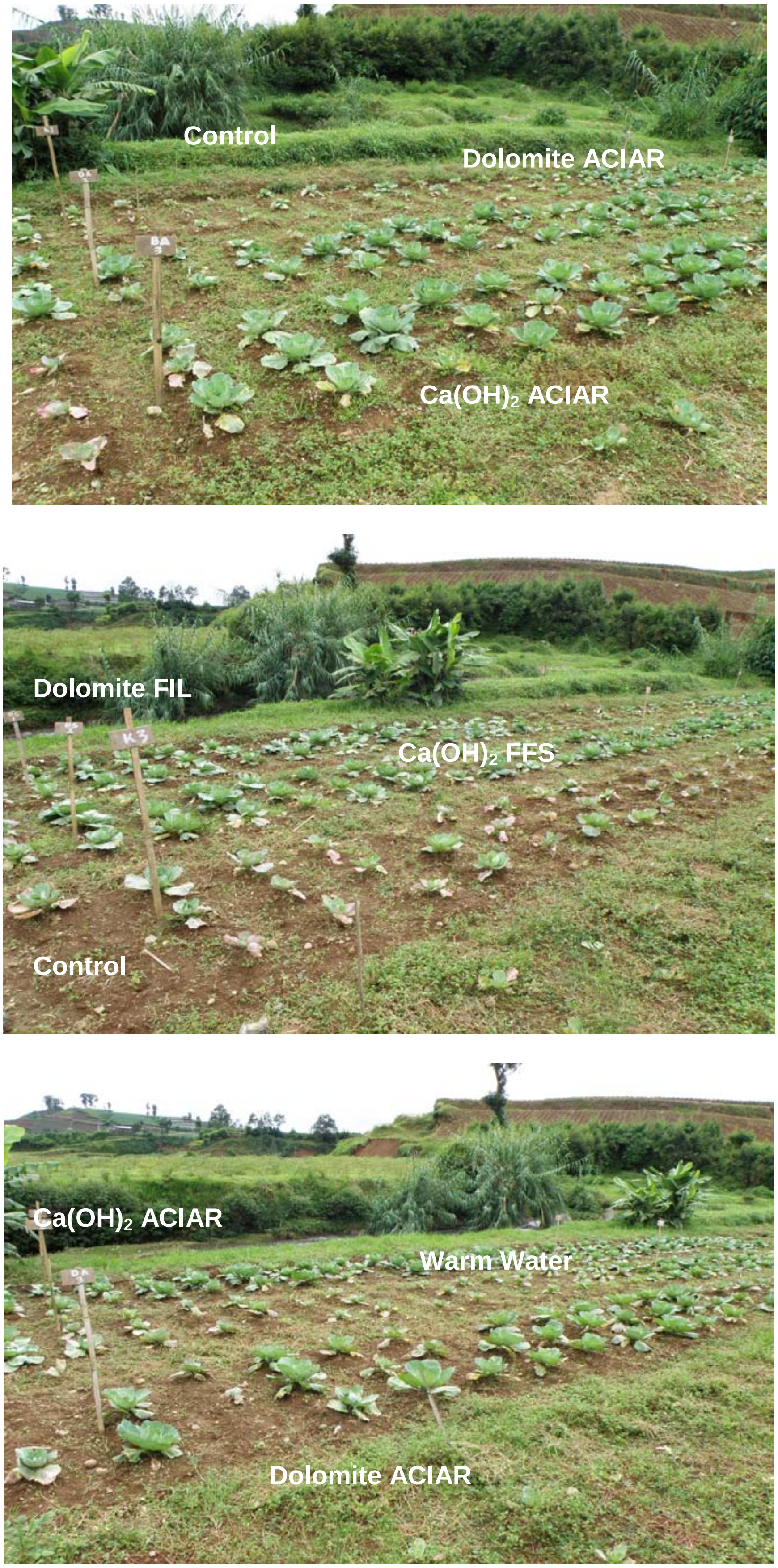

Figure 6.2. The learning-by-doing plots of the Sekar Tani cabbage trial with different lime treatments and rates. Photo taken in Feb 2009.

6.2.3 Banjarnegara 2010

Ngudi Luhur 2010

No yield data was received but percentage of plants infected with was given, from this the average clubroot incidence per variety and with or without lime could be calculated (Table 6.2.2g). There was not enough data to perform any meaningful statistical analysis however.

Table 6.2.2g. Effect of variety and lime on clubroot infection of cabbage in plots set up by the Ngudiluhu Farmer Group 2010.

Treatment			Clubroot (%)
Variety			
	Green 11		17
	Green coronet		19.8
Significance			n/a
LSD			n/a
Lime			
	No		22.3
	Yes		14.5
Significance			n/a
LSD			n/a
Variety x lime			
	Green 11	Lime	13
		No lime	21
	Green coronet	Lime	16
		No lime	23.5
Significance			n/a
LSD			n/a

Bukit Madu 2010

There was a significant difference between the yields and clubroot percentage for the Maxfield and Greenfrosh varieties (Table 6.2.2h). Liming had a significant effect on increasing yield (Table 6.2.2h). Liming did not have a significant effect on % of plants infected with clubroot. The interaction of liming and variety gave a significant effect on yield with the Maxfield and lime having the highest yield. Maxfield and lime yielded significantly higher than Maxfield without lime and the other treatments (Table 6.2.2h). However Greenfrosh and lime yielded significantly lower than Greenfrosh without lime. There was no significant effect on the percentage of clubroot when the influence of variety and liming were combined.

Table 6.2.2h. Effect of variety and lime on clubroot infection of cabbage in plots set up by the Bukit Madu Farmer Group 2010.

Treatment		Yield (t/ha)	Plants with clubroot (%)
Variety			
Greenfrosh		13.6	31.4
Maxfield		28.3	0.0
Significance #		***	**
LSD		1.7	19.5
Lime			
No lime		21.9	13.5
Lime		19.9	17.9
Significance #		*	ns
LSD		1.7	19.5
Variety x lime			
Greenfrosh	No lime	15.8	35.8
	Lime	11.3	27.1
Maxfield	No lime	24.0	0.0
	Lime	32.5	0.0
Significance #		***	ns
LSD		2.4	27.6

ns = not significant or '*' = P < 0.1, '**' = P <0.05,'***' = P < 0.01

Sekar Tani 2010

This trial was a follow up of the 2008 liming LBD but no results were presented.

Sumber Rejeki 2010

There were no records of cabbage yield or incidence and severity of clubroot from the trial but it was noted by participants that the incidence of clubroot was higher in the lime plots than without liming and that the Grand 11 had higher yields than the Sito variety.

6.2.4 Gowa 2010

Pemuda Tani Vetran 2010

A report of this group's activities from BPTP South Sulawesi is attached in Annex 1.

Soil pH increased to 6.0 - 6.5 by the end of the demonstration. There was a significant difference in yield and clubroot incidence between varieties with Maxfield producing higher yields and lower clubroot percentage. Liming had no significant effect on both yield and clubroot incidence. When combined, variety and liming had no significant effect on yield but did have a significant effect on clubroot incidence with Maxfield and liming having significantly lower clubroot incidence.

The cost of liming is considerable with the cost of lime 1,000,000 Rp/tonne and application labour costs of 300,000 Rp per ha. Lime has a residual effect and is thought to last for 5 years in the tropics (Perry Dolling personal communication). Gross margins for the Pemuda Tani Vetran treatments were determined using cabbage gross margins developed in Central Java (See Appendix 4 Baseline Economic survey). The cost of the lime applied was divided by six to apportion this cost over the six consecutive crops which would benefit from the improved soil pH. We believe that this is a conservative estimate of the longevity of the effect of this lime. The costs for the application of the lime were fully costed to this crop where it was applied. Seed costs for Maxfield were assumed to be twice the cost of local seed. The result is that the gross margins for the lime treatments are higher than for the no lime treatments (Table 6.2.2i). This shows that liming is an economical treatment to increase yield and reduce clubroot infection on low pH soils of South Sulawesi. The gross margins for the Maxfield variety treatments averaged about Rp 9 million per ha, about twice the gross margin of the local variety treatments. The gross margin calculations are shown in Table 6.2.2j.

Table 6.2.2i. Effect of variety and lime on clubroot infection of cabbage in plots set up by the Pemuda Tani Vetran Farmer Group 2010.

Treatment		Soil pH		Yield	% plants	Gross
		Before treatment	After harvest	(t/ha)	with clubroot	margin (Rp/ha)
Variety						
Local variety				15.5	28.5	
Maxfield				21.2	2.5	
Significance #				0.06	**	
LSD				6.1	10.8	
Lime						
No lime				17.5	22.5	
Lime				19.2	8.5	
Significance #				ns	*	
LSD				6.1	10.8	
Variety x lime						
Local variety	No lime	4.5	4.5	14.8	40	4,629,051
	Lime	4.5	6.3	16.2	17	5,025,985
Maxfield	No lime	4.5	4.5	20.2	0	9,188,451
	Lime	4.5	6.3	22.2	0	9,507,276
Significance #				ns	0.08	
LSD				8.7	15.3	

ns = not significant or '*' = P < 0.1, '**' = P < 0.05,'***'= P < 0.01

Table 6.2.2j. Gross margin analysis for the four lime by variety treatments for Pemuda Tani Vetran Farmer group, South Sulawesi. The cost of the amount of lime applied was divided by six as the benefit of the lime will be shared by at least 6 consecutive crops. Application costs were fully borne by the current crop. The cost of Maxfield seed was assumed to be twice the cost of local seed.

Local variety no lime

Income	t/ha	Price Rp/ton	Total per ha
Marketed	14.8	874,355	12,940,449
Cow feeding	1.4	109,294	150,000
Waste	0.5	-	-
	16.6		13,090,449
Costs		Rp/t	
Seed			570,000
Seed treatment			2,272,500
Fertiliser			1,240,000
Lime (& transport cost)/6*	0	166667	0
Pesticide			500,000
Herbicide			0
Labour			0
Land preparation			1,240,000
Lime application			0
Planting			300,000
Hand weeding			550,000
Irrigation			120,000
Pesticide application			120,000
Fertiliser application			290,000
Harvest			498,898
Equipment maintenance & depreciation			760,000
Storage		0	
Other			-
Total costs			8,461,398
Gross Margin			4,629,051

Local variety plus lime

Income	t/ha	Price Rp/ton	Total per ha
Marketed	16.2	874,355	14,164,545
Cow feeding	1.4	109,294	150,000
Waste	0.5	-	-
	18.0		14,314,545
Costs		Rp/t	
Seed			570,000
Seed treatment			2,272,500
Fertiliser			1,240,000
Lime (& transport cost)/6*	**3**	166667	**500,000**
Pesticide			500,000
Herbicide			-
Labour			-
Land preparation			1,240,000
Lime application			300,000
Planting			300,000
Hand weeding			550,000
Irrigation			120,000
Pesticide application			120,000
Fertiliser application			290,000
Harvest			526,060
Equipment maintenance & depreciation			760,000
Storage			0
Other			-
Total costs			9,288,560
Gross Margin			5,025,985

* Cost of lime divided by 6 to show cost benefits 6 consecutive crops

Maxfield variety no lime

Income	t/ha	Price Rp/ton	Total per ha
Marketed	20.2	874,355	17,661,964
Cow feeding	1.4	109,294	150,000
Waste	0.5	-	-
	22.0		17,811,964
Costs		Rp/t	Total cost
Seed			**1,140,000**
Seed treatment			2,272,500
Fertiliser			1,240,000
Lime (& transport cost)/6*	0	166667	-
Pesticide			500,000
Herbicide			-
Labour			-
Land preparation			1,240,000
Lime application			-
Planting			300,000
Hand weeding			550,000
Irrigation			120,000
Pesticide application			120,000
Fertiliser application			290,000
Harvest			655,951
Equipment maintenance & depreciation			760,000
Storage			0
Other			-
Total costs			9,188,451
Gross Margin			8,623,512

Maxfield variety plus lime

Income	t/ha	Price Rp/ton	Total per ha
Marketed	22.2	874,355	19,410,673
Cow feeding	1.4	109,294	150,000
Waste	0.5	-	-
	24.0		19,560,673
Costs		Rp/t	Total cost
Seed			**1,140,000**
Seed treatment			2,272,500
Fertiliser			1,240,000
Lime (& transport cost)/6*	**3**	166667	**500,000**
Pesticide			500,000
Herbicide			-
Labour			-
Land preparation			1,240,000
Lime application			300,000
Planting			300,000
Hand weeding			550,000
Irrigation			120,000
Pesticide application			120,000
Fertiliser application			290,000
Harvest			720,897
Equipment maintenance & depreciation			760,000
Storage			0
Other			-
Total costs			10,053,397
Gross Margin			9,507,276

* Cost of lime divided by 6 to show the cost of lime provides benefitsto 6 consecutive crops

6.3 Discussion

A total of eleven LBD plots were undertaken in Central Java during the 2008/09 cabbage growing season with a total participation of 210 farmers. Initially the treatments tested were chosen by the farmers with the aid of ToT trained facilitators. The initial LBD plots included a range of so called "biopesticides" such as *Trichoderma*, frangipani extract, tobacco leaf extract and PGPR. PGPR is a compost tea of microbes known as plant growth promoting rhizobacteria that is manufactured in both universities and by local distributors in Indonesia with the claims of being a general growth promoter and fungicide. Like all the biopesticides used in these early LBD plots, manufacture of these products was not from a controlled facility and therefore the effect the use of these products have on yield is not backed by replicated scientific data.

In combination with the use of biopesticides farmers were also reducing the number of applications of pesticides for their experimental plot. As pesticides account for a significant proportion of input costs this reduction often lead to the increases in profit seen in some farmer groups including Tempelsari, Manunggal and Sri Rejeki.

The early LBD plots indicated that several key areas of simple scientific experiments would need to be re-examined with the farmers. These areas included;

- testing of fewer treatments,
- the standardisation of LBD plot activities so replication could be carried out by other groups.
- replication within a farmer group would also be beneficial, only one farmer group Sekar Tani included replications in their first LBD plot.
- Using better rigour for the control plot. Although some farmer groups had their conventional practices as a control they often modified this as well as the experimental plot.
- Improved data gathering. After the LBD plots were completed all the farmer groups lacked reporting on all or some of their treatments or experiments and inputs and costs making analysis of their data and historical records of trials difficult to achieve.

Despite these short falls each farmer group concluded that these early LBD plots were a success by increasing the knowledge, attitude and skills of the farmers attending whilst also increasing cooperation between farmers, facilitators, government officials and NGO's.

A one-off LBD experimental plot was designed by the ACIAR team and grown by the Sekar Tani farmer group in late 2008. The LBD plot served three purposes; first to determine the amount and type of lime required to increase pH in the acidic soils of Indonesia. Second to determine the effect liming has on the level of clubroot seen on crops and finally to introduce farmers to a more detailed scientific method through hands on training. Applications of Ca $(OH)_2$ were found to significantly increase yields of cabbages in Central Java but were not significant in the reduction of clubroot percentage (Table 6.2.2f). Raising soil pH by using lime is one of the oldest and most widely practised techniques to control clubroot with incidence and severity generally reduced at pH 7.2 (Donald & Porter 2009). It is likely that the liming did have an effect on reducing clubroot severity as shown by the difference in health of plants in Fig 6.2. The clubroot assessment in Table 6.2.2h is incidence, not severity. A severity assessment method is now provided in the CTT (DAFWA 2010b, Results-Table 9) to enable FIL groups to make this improved assessment. Also the lime effect may have been reduced due to the lime being applied within a month of planting which is too late. Poor mixing with the soil and the short interval before planting does not allow enough time for the lime to increase pH to the levels which control clubroot. Poor mixing with the soil and the short interval before planting does not allow enough time for the lime to increase pH to the levels which control clubroot. A number of variables are known to influence the effect of liming and clubroot control including soil preparation, moisture and texture, particle size and quantity of lime and the incubation interval between application and planting (Donald & Porter 2009).

The higher yield when $Ca(OH)_2$ was used to increase pH compared with dolomite ($MgCO_3.CaCO_3$) suggests that the form of the lime is important in clubroot control. Calcium hydroxide has a higher neutralising value and reacts more rapidly with the soil and will change pH more rapidly than dolomite at comparable rates required to change the soil pH the same amount. This is important when it is difficult to allow sufficient time between lime application and planting for pH to change. However it has been suggested that particle size and proper mixing of lime in the root zone of the soil is as or more important than form of lime (Dobson *et al*. 1983). The higher yield when the ACIAR recommendation was used to determine lime requirement compared with the traditional FS method suggested the use of %SOC and %clay (ACIAR 2010, Aitken *et al*. 1990) was more accurate than the use of soil texture assessments alone.

After reviewing the 2008 cabbage LBDs from Central Java the project team developed a Cabbage Technical Toolkit (CTT). This publication was aimed at the facilitators. It contained information on designing simple farmer experiments that compared a new management technique against conventional practice. The CTT contained a standard operating procedure (SOP) for cabbage production to ensure that treatments being tested were not affected by other management constraints. Several example experiments were included as well as a comprehensive set of tally sheets for capturing important data. These experiments included managing clubroot through lime application, managing clubroot through resistant varieties and lime, use of subsoil to manage clubroot in the nursery and improved pest management using IPM. The CTT also included extensive background information on the major constraints to cabbage production for the benefit of the facilitators. This fundamental change in how Farmer Field School activities would be run deserved to be distinguished from previous practice with a new name. We called this new procedure for Farmer Field Schools Farmer Initiated Learning (FIL) or Pembela**jar**an Peta**ni** Pelo**por** or Jarnipor or PP for short in Indonesian.

The new round of the cabbage LBD plots were the first to include these experiments. As with some of the trials conducted in 2008 some of the reporting on the results were lacking from Wonosobo and the Sekar Tani and Sumber Rejeki farmer groups.

As a result of the CTT all LBD plots had at least 2 replications per treatment and a control plot that included either a standard growing variety or standard liming practice.

Statistics could not be performed on the Ngudi Luhur group as individual replicate data was not received, but only the average of the two plots. Interestingly it does appear that the percentage incidence of clubroot is decreased slightly at this site with the application of lime and therefore it is likely that if liming was to continue an increase in soil pH would have a significant effect. The application of lime at Bukit Madu and Pemuda Tani Vetran groups also showed increased yields, with a significant increase at the Bukit Madu site (Table 6.2.2h), and reduced clubroot incidence, significant at Pemuda Tani Vetran (Table 6.2.2i). The Pemuda Tani Vetran group showed that liming was an affordable treatment (Table 6.2.2l). Surprisingly although lime reduced clubroot incidence in several sites, although not always significantly, when the Greenfrosh variety was combined with liming at the Bukit Madu site it produced lower yields than the no liming plots (Table 6.2.2h). It is possible that another factor or variable besides clubroot, such as blackrot disease or an insect pest, reduced the yields of these plots as the clubroot incidence was reduced with liming.

Both the Bukit Madu (Central Java) and Pemuda Tani Vetran (South Sulawesi) farmer groups compared a local variety against that of Maxfield (synonym Tekila). Maxfield is a cabbage variety developed by Syngenta Seeds that has shown high levels of resistance to clubroot in Australia. A large number of virulent combinations of *Plasmodiophora brassicae* are known to exist (Rimmer *et al*. 2007) and it was not certain whether the resistance seen in Australia would be maintained in the high disease pressure environment that Indonesia represents.

The results from both LBD plots indicates that Maxfield produces a higher yield and lower percentage clubroot than the comparison local varieties, with a significant increase when compared to the variety Greenfrosh. As these two LBD plots were planted in two different locations, Central Java and South Sulawesi, and each were known highly infested plots it is encouraging to see that resistance may hold in Indonesia although in Central Java some plants were still lost to clubroot. However when combined with liming Maxfield produced the highest yields and had no loss to clubroot in both trials and therefore a recommendation of liming with the use of Maxfield as part of an integrated disease management program appears to have merit. These results are summarised in Figures 6.3.1 and 6.3.2 below.

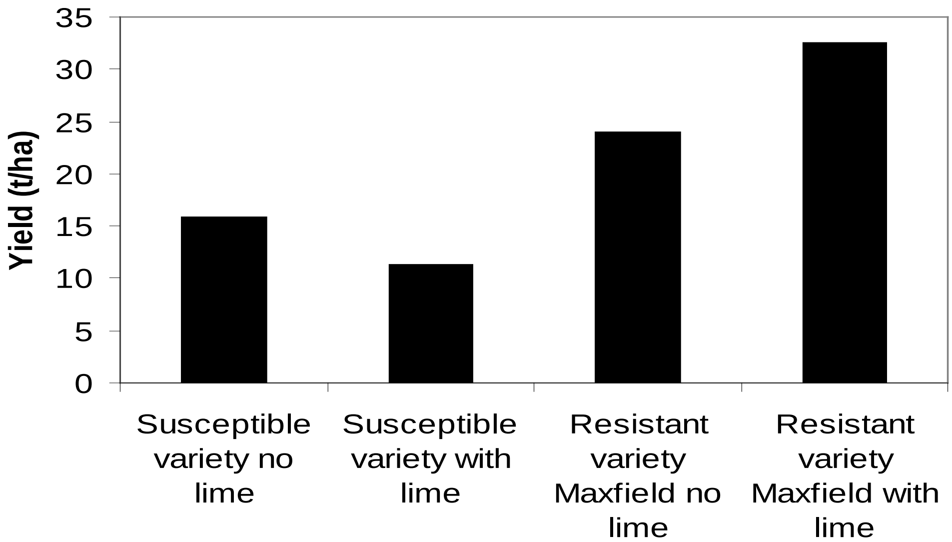

Figure 6.3.1. Yield of cabbage in the Bukit Madu farmer group Farmer Initiated Learning plots on clubroot infected site. The resistant variety (Maxfield) had significantly greater yield than the susceptible variety. The resistant variety with lime also had a significantly higher yield than the resistant variety without lime. LSD 5% = 2.4 t/ha. It is not known why the susceptible variety with lime had a significantly lower yield than the susceptible variety without lime.

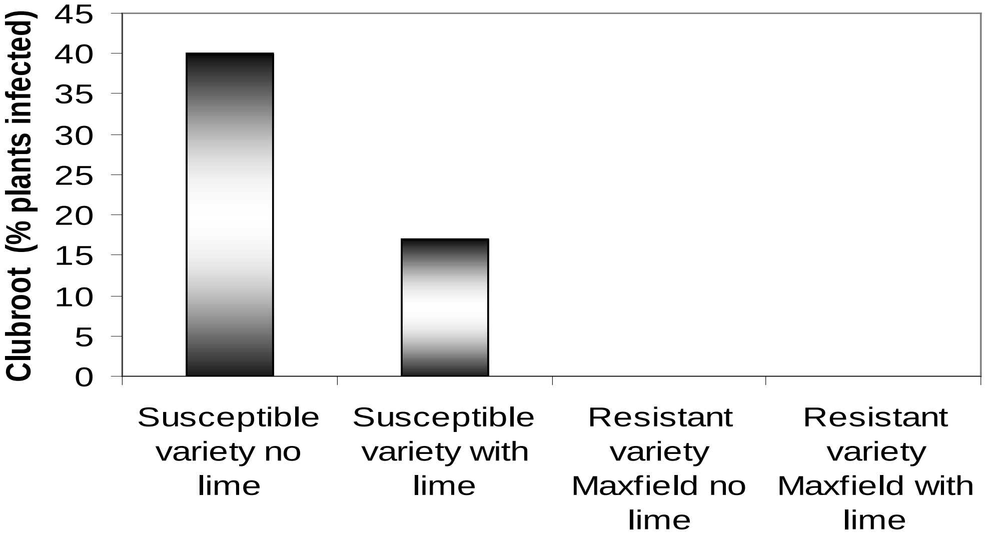

Figure 6.3.2. Percentage of cabbage plants infected with clubroot in the Pemuda Tani Vetran farmer group Farmer Initiated Learning plots on clubroot infected site. Treatments were variety and lime. The LSD is 15.3% which means that the number of plants of the susceptible variety infected with clubroot was significantly lower with lime than without lime. Also no plants of the resistant variety were infected.

Despite the promising results of Maxfield in the LBDs further demonstration plots are required to determine whether resistance holds and to introduce a different variety to the market. The Sumber Rejeki farmer group was to trial Maxfield as part of their LBD but found there was low viability of the seedlings. It is uncertain whether this was a direct result of the seeds, poor seedling production systems used by Sumber Rejeki or another variable. Furthermore, variety development may be needed as farmers noted that Maxfield has a different leaf size and thickness than local varieties and therefore may not be adopted in Indonesia as a result. There are numerous socioeconomic factors limiting the adoption of new potato varieties in developing countries, in particular market forces (Forbes 2009) and the cabbage industry in Indonesia would be no different.

7 Impacts

7.1 Scientific impacts

The cabbage LBD plots in Central Java and South Sulawesi confirmed clubroot is the major constraint to production in Indonesia. A new clubroot resistant variety Maxfield has been tested in FIL demonstration plots at two highly infested clubroot locations and has displayed improved yields and resistance to infection than the local varieties. Further variety development work could see this variety become the main cabbage variety grown in Indonesia.

There were some benefits shown with liming in the later LBD plots despite the lack of significant improvement in yields or clubroot infection. The soils tested as part of the baseline survey indicated that the majority were acidic and therefore conducive to clubroot development. With continued use of the correct source of lime using the correct method these acid soils will gradually increase in pH and become more effective in suppressing clubroot in the future.

Combining Maxfield with lime applications gave the highest yields and lowest incidence of clubroot in the later FIL LBD plots. This indicates that an integrated management program is required in the cabbage production areas to control clubroot. Due to short crop rotations and the use of susceptible varieties the fields in Indonesia are highly infested with clubroot spores and can only be reduced through integrated programs.

7.2 Capacity impacts

Initial LBD plots carried out by the farmer groups in Central Java indicated that simple scientific experiments were not well understood. The farmer plots were generally conceived as plots where farmers could try a range of products or formulas against a conventional plot that was also modified to try and test several variables of cabbage production. Consequently, very little if anything of concrete value could be demonstrated from these plots. Farmers were often convinced that using biopesticides was effective in their fields against clubroot. This may have been due to the severe nature of clubroot and the difficulties with control combined with a willingness to be seen as sustainably producing cabbages. Scientific evidence for the effectiveness of these biopesticides is lacking or not clear. Reporting on their experiments and trials was also found to be inconsistent.

The Cabbage Technical Toolkit that was developed now gives cabbage farmer groups and their facilitators the capacity to successfully carry out and report on simple but rigorous scientific experiments.

The farmers groups in Central Java and South Sulawesi now have the capacity to:

- Conduct simple scientific experiments with the understanding that only one or two factors are changed from standard practices to determine effect. The importance of repetitions in trials to counter any one-off effects is greater understood.
- Understand that bio-pesticides are not an effective silver bullet in controlling diseases and pests especially if there is no scientific evidence backing up the claims of the salesmen.

- Write complete scientific reports that include correct methodology, results and findings. The understanding that these reports can be used at a later date to compare yields and methods or as a historic record of past farming practices.

- Farmers and facilitators have the capacity to develop the understanding of farmers that were not part of these LBD plots.

7.3 Community impacts

The community in the villages surrounding these LBD's will benefit as an integrated approach to clubroot management will produce higher yields and therefore higher profit for the members of the community. The reduction in use of chemicals that do not control clubroot will benefit the environment as well as the safety and health of the farmers using the products. The reduction in use of biopesticides will result in fewer inputs into the cabbage production system and therefore greater profit.

Improved reporting on experiments will act as a historical record for farmers in future generations to gauge improvements in farming practices over time and therefore improve community knowledge.

7.4 Communication and dissemination activities

Table 7.4. Communication and dissemination of LBD's, FIL's and FFS

Date	Personnel	Organisation & Position	Location	Activities
Dec 07	Andrew Taylor	Pathologist	Kledung	Presented information regarding the results of the baseline survey to the Training of Trainers.
Aug 08	Ian McPharlin Andrew Taylor Dolf De Boer Peter Ridland	Agronomist Pathologist Pathologist Entomologist	Kledung	Cabbage baseline presentation and preparation of LBDs for cabbage FFS
Apr 09	Peter Dawson	Potato Seed Specialist	W Java, South Sulawesi and Lombok	Review potato LBD plots in WJ and Sulsel. Provide recommendations for the improvement of scientific method and reporting.
Feb 09	Andrew Taylor	Pathologist	Sulsel, C Java	Observe Sekar Tani cabbage lime plot planted in 2008
Oct 09	Andrew Taylor	Pathologist	W Java	Provide training in potato technical toolkits to farmers and facilitators from all over Java. Scientific method can be interchanged with cabbage LBDs.

8 Conclusions and recommendations

8.1 Conclusions

The LBD plots have been successful in allowing farmers to experience the procedures and benefits of simple scientific experiments. Initial LBD plots in Central Java identified knowledge gaps in the procedure and undertaking of scientific experiments by farmers and facilitators including lack of repetition, changing multiple variables, lack of a control and minimal report writing. The Cabbage Technical Toolkit was developed and introduced to Farmer Group facilitators to assist them in planning and carrying out further successful FIL LBD plots.

The LBD plots undertaken in Central Java and South Sulawesi in 2010 showed a marked improvement in the layout and procedure of the demonstration plots. These plots included replications, changing only one variable between the experimental, control plots and better report writing that enabled analysis of the data.

The LBDs in CJ and Sulsel have demonstrated that the clubroot resistant cabbage variety Maxfield could be suitable for the Indonesian market if further product development takes place. Liming has been shown to increase the pH of the acidic soils in Indonesia and therefore will help manage clubroot if the practice is continued. Liming has also been shown to be an affordable treatment.

Overall growers that participated in the cabbage LBDs felt that they increased productivity and production of quality cabbages, increased the capacity of the farmers in managing their crops and increased income and prosperity.

8.2 Recommendations

It is recommended that LBD's or similar farmer initiated learning concepts continue to be undertaken with respects to cabbages so that the concepts of simple scientific experiments are reinforced and become common practice.

Improvement in the knowledge and skill of the facilitator or expert farmer is required. Training of trainer programs appear not to have been successful in CJ in regards to educating the facilitators in conducting experiments and new procedures for training are recommended.

Syngenta international to investigate further trials and demonstrations of Maxfield (syn. Tekila) in Indonesia. There is large market potential for a clubroot resistant cabbage variety in Indonesia and Maxfield appears to remain resistant under Indonesian conditions.

9 References

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10 Annex 1. Outcome report from Brassica integrated crop management farmer field schools in Gowa district, South Sulawesi

Managing clubroot with resistant varieties and liming

Australian Government

Australian Centre for International Agricultural Research

SOUTH SULAWESI AGRICULTURE TECHNOLOGY RESEARCH INSTITUTE,

SOUTH SULAWESI PROVINCIAL FOOD CROPS AND HORTICULTURE OFFICE AND

AUSTRALIAN CENTRE FOR INTERNATIONAL AGRICULTURAL RESEARCH (ACIAR)

2010

10.1 INTRODUCTION

10.1.1 Background

The Agriculture Research and Development Institute together with other farming institutions and communities have played an important role in developing farming through technology innovations, institutions and policies. However, since food self-sufficiency there has been a tendency for the adoption of innovations to slow down in increasing production, as is apparent from the stagnation of productivity in various farming commodities and income and prosperity among rural farming communities. This malaise was due, in part, to ineffective dissemination of technological innovations with information on technologies not reaching farmers, but also to existing technologies being inappropriate to local conditions.

Brassicas constitute one important vegetable commodity that has experienced reduced productivity resulting from many problems with farming, from inappropriate cultivation techniques and pest and disease infestations, particularly clubroot. Brassica productivity in South Sulawesi for 2009 was 14.65 t/ha, while the region has the potential to produce 40 t/ha. Though many research institutions have generated technologies for increasing productivity, the problem is down to farmers not applying technological innovations.

Along with this, the government has programmed and implemented Integrated Crop Management Farmer Field Schools (ICM-FFS) for various commodities. **Integrated Crop Management Farmer Field Schools** are places of non formal education for farmers to increase knowledge and skills through an Integrated Crop Management (ICM) approach conducted directly in the field. ICM-FFS constitutes an agricultural extensions model.

Experience shows that direct technology transfer to farmers in the field will be more successful than in the classroom, for that reason, in these ICM-FFS activities, every ICM-FFS region has a field laboratory as a show area and place for farmers to practice, adjusted to local conditions by understanding problems and opportunities through collaborative needs and opportunity assessments. Thus, the technology the farmers would secure is location specific.

10.1.2 Objectives

1. Accelerate technology transfer in Brassica crop management, particularly clubroot control

2. Increase production, productivity and yield quality

3. Increase farmer income and production to ensure greater prosperity

4. Nurture farmer capacity and innovation and motivate farmer groups to optimise production in their Brassica cropping system

5. Secure and ideal model for the application of Brassica ICM-FFS

6. Manage clubroot through the use of resistant varieties and liming

10.1.3 Targets

1. The adoption of innovative technologies for the integrated management of Brassica crops

2. The provision of Brassica production that meets needs with guaranteed quality

3. Increased farmer income and prosperity

4. The development of farmer capacity and capability in optimising the management of fields in their farming enterprises

5. The application of an ideal ICM-FFS model

6. Clubroot control through the use of resistant varieties and liming

10.1.4 Input

1. Brassica farmers in Kampung Baru (Bulu Ballea), Tinggi Moncong Subdistrict, Gowa District
2. Field facilitators (Field II facilitators and trained officers)
3. Fields/ Brassica growing
4. Funding from ACIAR project CP/2005/ 167 (Part of SMAR)

10.1.5 Output

1. Increased knowledge, insight and skills among farmers in the integrated management of Brassica growing
2. Increased productivity and quality of Brassica yield

10.1.6 Benefits

1. Added value so farmers can increase their income and prosperity
2. Accelerated dissemination of Brassica ICM technologies
3. Farmers trained to formulate ideas, plans, establish farmer groups and motivate them in technology transfer as well as decision making for their enterprises.

10.1.7 Impacts

1. Increased productivity, production and quality of Brassicas

2. Increased human resources capacity in managing Brassica crops

3. Increased farmer income and prosperity.

10.2 FIELD SCHOOL IMPLEMENTATION

10.2.1 Time and place

Activities took place between April until September 2010 in the Veteran Farmer Group site in Bulu Ballea, Pattapang Ward, Tinggi Moncong Subdistrict, Gowa District.

10.2.2 Materials and equipment

Materials used were Brassica seeds (Maxfield and local), organic and inorganic fertilisers, pesticides, agricultural lime, etc.

Equipment used included mattocks, scythes, buckets, stake markers, plastic string, tape measures, plastic bags, stationery, etc.

10.2.3 Implementation methods

Learning processes were participatory, with participants playing an active role in the learning processes, finding what was in the field for themselves, and conducting:

- Ecosystem observations
- Drawings
- Group discussions
- Presentations and finally making decisions on actions to take

The learning approach involved adult education by developing participatory principles. Participants were active in the learning processes and undertook all activities included in the training materials themselves. This method helped facilitate ore focused learning for participants based on their own experiences, so the conclusions they drew were accurate data. Officers and guides were only facilitators to create a climate of learning. The study process in the ICM-FFSs followed an experience study cycle: experiencing directly, expressing, analysing, drawing conclusions and applying them.

- The means for learning were Brassica cropping fields and farmers' own fields.
- Training facilitators. Each Brassica ICM-FFS was led by 2 facilitators
- 20 participants took part in training
- Training schedules: Brassica ICM-FFS took place throughout one cropping season. The twelve meetings took place once a week. Training began around 07:00 and finished at 13:00, meaning effective training time of around 6 hours.
- Methods and techniques for discussing materials: As field school participants were adults with plenty of experience, the participatory approach was presented through group discussions, brainstorming, case studies, demonstrations/practicals in the field as well as combinations of several techniques that allowed the development of participation in the learning process.

10.3 OUTCOMES

10.3.1 Preparations

Preparatory meetings covered efforts to coordinate between stakeholders to choose facilitators, determine location, select farmer groups, establish participants, place, time and study fields.

Preparatory meetings took place in two stages:

a. Village level meetings

   Brassica ICM-FFS preparatory meetings held at the village level involving village heads, Agriculture KCD, PHP officers, extensions officers, community figures and farmer group heads.

b. Farmer group level meetings

   Meetings at the farmer group level determined locations, farmer groups and FFS participants, established organisational structure, study days and times and set up sub groups. The 20 participants were divided into 4 (four) five-person sub groups. To facilitate recognition of the sub groups, each was given the name of a pest or disease.

10.3.2 Weekly meetings

In the weekly meetings, Brassica crop ecosystems, special topics and group dynamics were discussed.

Brassica ecosystem analyses

This is one of the main activities in ICM-FFSs, and must be undertaken by every participant. Each sub group conducted observations on 20 plants in each Brassica crop: 10 in conventional plots and 10 in ICM-FFS plots, all marked with stake markers. However, for several weeks before cropping, other activities took place during the preparation to planting stages. Ecosystem observations began in the fourth week. Components observed included crop condition (vegetative growth: plant height, canopy width and number of leaves), pest/disease population/condition, natural enemies, weather conditions, water, weeds, soil and other factors.

During observations, when participants found pests, diseases or natural enemies they could not identify, or symptoms affecting crop growth, they were placed in containers for discussions during meetings in the classroom. Following observations in the field, each participant analysed the data and laid it down pictures of the agro-ecosystem analyses.

Special topics

Special topics given to participants at each weekly meeting were adapted to the main problems facing local farmers and adjusted to conditions in the growth phase.

Group dynamism

To nurture participants' enthusiasm and willingness to continue to take part in every series of activities, group dynamism was part of every meeting.

10.4 EVALUATIONS

10.4.1 Ballot boxes

In the first days of the ICM-FFS a pre-test was held to ascertain participants' capabilities and skills and other things relating to Brassica crop management.

At the end of the ICM-FFS a post-test was held to ascertain participants' capacity and understanding after following the series of ICM-FFS activities. Post-test results were expected to show improvements, and were indicators of how much farmer participants' knowledge and skills had improved.

10.4.2 Evaluations

Participants were generally enthusiastic about Brassica ICM-FFSs, and attendance rates were suitably high as shown by the registers for each meeting.

The results from the three FFSs generally showed increased Brassica productivity and knowledge about clubroot management. In addition, farmers understood many aspects such as comprehending Brassica agro-ecosystems and Brassica biology, pests and diseases and their natural enemies, clubroot, collecting samples of plants and pests/diseases, as well as understanding critical thresholds for pests and diseases, as well as the effects of excessive pesticide use.

Yield from the MX + lime seed plot was equivalent to 22.20 t/ha; MX without lime equivalent to 20.20 t/ha; local seed + lime was 16.16 t/ha and local seed without lime was 14.77 t/ha. The different yields were due mainly to the use of clubroot resistant seed and applying lime as a means for managing disease.

10.5 PROBLEMS AND RESOLUTION EFFORTS

10.5.1 Problems

High rainfall and humidity affected crop growth

10.5.2 Resolution efforts

Schedules and planting patterns are determining factors in Brassica growth and production.

10.6 CONCLUSIONS AND RECOMMENDATIONS

10.6.1 Conclusions

- Brassica ICM-FFS activities went well thanks to the support of all the participants and facilitators involved
- Farmers/FFS participants' knowledge increased in relation to the optimisation of the integrated management of Brassica crops including recognising and managing clubroot, and technology transfer after the activities.
- Brassica productivity was higher in the FFS than conventional fields.

10.6.2 Recommendations

- Activities like this need to be continued and extended to other farmer groups

10.6.3 ANNEX

Table 1. Plot layout for Brassica ICM-FFS (management of clubroot with resistant varieties and liming)

6 m

MX + **lime**	**MX** **without lime**	**Local +** **lime**	**Local** **Without lime**
MX + **lime**	**MX** **without lime**	**Local +** **lime**	**Local** **Without lime**

Table 2. Brassica ICM-FFS weekly meeting curricula

No.	Meeting	Curriculum and activities
1.	Meeting I (30 April 2010)	FFS preparation, study contracts and FFS organisational structure establishment
2.	Meeting II	Making seed bed media (polybags and farmers usual methods), making plots/beds and applying lime, observations of seed growth
3.	Meeting III	Planting (plant spacing 55 cm x 90 cm), farmer studies (50 cm x 60 cm), sub-group presentations
4.	Meeting IV	Crop maintenance (pest management) introduction to agroecosystem, observations pertumbuhan tanaman
5.	Meeting V	Observations of pests and diseases and natural enemies, crop maintenance (fertiliser application), sub-group presentations
6.	Meeting VI	Observations (plant height, canopy width and number of leaves), observations of pests and clubroot, sub-group presentations
7.	Meeting VII	Observations (plant height, canopy width and number of leaves), crop fertilisation, pest and disease management
8.	Meeting VIII	Observations (plant height, canopy width and number of leaves), observations of pests and clubroot, sub-group presentations
9.	Meeting IX	Observations (plant height, canopy width and head formation), crop maintenance, observations of pests and clubroot
10.	Meeting X	Observations (plant height, canopy width and head formation), observations of pests and clubroot, sub-group presentations
11.	Meeting XI	Observations (plant height, canopy width), observations of head formation, discussion on harvest preparation
12.	Meeting XII	Harvest and weighing yield

Table 3. Brassica harvest yield and percentage of plants affected with clubroot

No.	Treatment	Production (kg/ group)	Yield (t/ha)	Percentage with clubroot (%)	Note
1	MX + lime	181	22.20	0	Formed large heads
2	MX without lime	155	20.20	5.00	Formed large heads
3	Local + lime	128	16.16	17.00	Formed small heads
4	Local without lime	117	14.77	40.00	Formed small heads or no heads at all

Note: 1 group = 8 plots

Figure 1. The ACIAR, BPTP monitoring team

Figure 2. Crops in the field

Figure 3. MX variety during head formation

Australian Government
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Final report appendix 12

title	AGB/2005/167 Post-harvest
prepared by	Bruce Tomkins
co-authors/ contributors/ collaborators	Peter Dawson

1 Executive summary

A post harvest specialist visited members of the potato and vegetable supply chain to ask their opinions about post-harvest handling and to observe current practices.

For seed potatoes there was a gap in the knowledge of physiological aging of the seed tubers. Extension information was prepared to fill this knowledge gap.

Potato stores inspected were all ambient temperature stores open during the day which allowed warm air to enter. Temperatures measured of tubers in stores were 28 to 31°C. The storage conditions could be easily improved with management changes. Better management would have the stores closed during the day and opened at night with fans used to ventilate the stores with cool night air. Structural changes would benefit many stores. Vents should be closed during the day and open at night. Ideally inflow vents in stores should be placed low to allow cool night air to replace the warm air which should escape through fan assisted roof ventilators. The tubers should be stored in trays on racks to allow improved ventilation and access for grading and sorting. They should allow filtered (diffuse) light in. A plan for a simple but improved cool store was provided in the extension material prepared.

Imported seed should be not be kept in an ambient store as this seed has previously been cool stored and will commence sprouting when warm. The rapid growth of shoots in the darl stores leads to rapid dehydration and physiological aging of this seed. Suitable cool store facilities were identified.

Table potatoes were observed to be harvested immature before their skins had hardened. They are then packed and transported in 65 - 70 kg sacks. Traders reported rots and damage to be a problem. Improved out-turns should result from harvesting the potatoes when they are mature, keep them as cool as possible and transport them to markets in rigid plastic crates.

For cabbage growers received little feedback on the quality of their product and there is little incentive for them to provide improved quality. Vegetable packers lack refrigeration. An intervention that may help is modified atmosphere packaging (MAP). At ambient temperatures MAP can act like refrigeration in slowing quality loss allowing broccoli to be kept in good condition for 10 days at 25°C in Australian experiments. The use of MAP for cabbages should be tested in Indonesia.

2 Background

2.1 Potato seed production

A brief description of the seed potato system is given from Central Java observations made in early 2009.

Potato seed production in Indonesia is begins at government run seed centres. One of these is at Kledung, near Wonosobo. They produce clean tissue culture material through meristem culture. The facility uses ELISA to test for viral pathogens. G0 and G1 tested by ELISA for diseases.

G1 plants are grown in 4 large aphid proof screen houses with soil less culture using rice hulls or alternatively steam sterilised soil. The rice hull method is cheaper.

G2 and G3 crops are grown in fields which have to have been first soil tested and certified by Balai Pengujian Sertifikasi Benih (BPSB) (Seed Certification Testing Agency) as disease and nematode free. The G2 and G3 crops are rogued.

The manager, Pak Aris, reports that rotation is 9 months between seed crops.

The Centre plant about 810 tonnes seed per ha that yields 20 - 30 tonnes

The G0, G1, and G2 seed is available for sale to certified growers. The price of this seed is shown in Table 2.1.

Table 2.1. Prices of various generations of Certified potato seed from Kledung Seed Centre 2009.

Generation	Price	Unit
G0	1000 - 1500	per tuber
G1	1000 - 1200	per tuber
G2	12,500	kg
G3	10,000	kg

The seed is then further bulked by Certified seed farmers. Trubus is one of 10 groups in the Banjarnegara district that can produce certified seed as well as 2 individual growers. As a group they rent land and produce Certified seed under the auspices of Kledung. They grow G3 and are allowed to sell G4 seed to other growers because they are certified. Yield depends on region and season. For example in wet season yields in Merbabu region (Kopeng) are 30 - 32 tonnes/ha while in Banjarnegara they are 10 - 15 tonnes.

The cost of producing seed is about Rp 40 million/ha. Average yield is 10 - 15 tonnes per ha. They sell G4 seed for about Rp 10,000/kg.

The seed can be stored for about 4 months under ambient conditions. Dormancy is about 3 months. Gibberellic acid is used very occasionally to accelerate the breaking of dormancy, usually at the start of the dry season.

Table potato growers buy G4 and propagate it to G7. Each crop they keep small tubers for seed and sell rest as ware potatoes. They do this because either they can not afford to buy G4 every year or because the G4 seed supply does not meet demand.

Main issue for seed production was reported to be the lack of land isolated from other Solanaceae crops.

2.2 Vegetable handling and market chain

An example of the vegetable handling and marketing chain is given as related by a potato trader in the Garung Sub-district of Wonosobo District.

The trader owns 5 trucks and handles around 60 tonnes of potatoes per month. His customers are other traders in Jakarta, Bogor and Sragen (Central Java).

Pays Rp 3,300 for premium quality tubers. Others say 20% of potatoes produced are in the premium Class and fetch Rp 5,000/kg wholesale.

He deals with 25 farmers directly. Farmers are given credit by buying fertiliser and pesticides and the cost of these is taken out of what he pays them for their crop. For example if the market price is Rp 3,300 he may pay the growers Rp 2,800. The difference pays for the fertiliser and pesticides. The trader pays farmers cash for their crop within 24 hours of delivery. If the trader uses collectors (brokers) to deal with growers indirectly he does not give them credit. Collectors take Rp 50/kg commission.

The trader sorts potatoes from farmer into good and bad quality. He pays full price for the good quality but only 50% of the market price for bad quality. Bad quality is usually 2% of consignment. The major quality issues are rots and skin damage.

The trader delivers tubers direct to market and never stores them as he thinks this is very dangerous.

The merchants he deals with in Jakarta and Bogor, West Java, pay him cash in about 3 days after delivery. Sometimes the price of potatoes is Rp 3,000/kg when his product arrives in Jakarta but the price can drop to 2,800 over the 3 days it takes for him to get paid and the merchants pay him 2,800. On at least one occasion he has not been paid by customer in Jakarta who owed him Rp 15 million. Jakarta and Bogor merchants pay his transport costs which are about Rp 2 million per 7 tonne truck.

The trader does not get paid according to quality. He claims that all his potatoes are good quality. However this does not agree with merchants and packers in Jakarta who claimed that there was 30% wastage of tubers from Wonosobo and 70% of this was due to damage. An audit of chain required to quantify level of damage and where it occurs in the chain.

The local merchants in Sragen, Central Java, pay cash on delivery. The trader pays his own transport costs when he sends product to Sragen. The transport costs to Sragen about Rp 1.3 million per7 tonne truck. He prefers to deal with Sragen because they pay cash on delivery and he gets current market price even though he pays his own transport costs.

All deals are done on trust. There are no contracts signed at any step in the chain that is from farmer to broker to trader to merchant.

Merchants he deals with that supply supermarkets pay better prices, Rp 400/kg more than others.

Market price is often affected by low quality cheap tubers from Medan in North Sumatra. Their premium tubers are exported to Singapore and the rest of the harvest is dumped unsorted and ungraded on the Jakarta market. The price in Singapore is Rp 21,000/kg.

The other 3 traders in the sub-district trade under similar arrangements.

3 Objectives

To assess the priorities for post-harvest activities for the project.

4 Methodology

The method used to assess post harvest priorities was for a post harvest specialist, Mr Bruce Tomkins Statewide Leader, Physiology and Food Science, Department of Primary Industries Victoria, to visit members of the potato and vegetable supply chain to ask their opinions about post-harvest handling and to observe current practices.

5 Achievements against activities and outputs/milestones

Objective 1: To adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas suited to Javanese conditions.

no.	activity	outputs/ milestones	completion date	comments
1.3	Conduct baseline survey for potatoes and Brassica farmers to determine cultivars, current yields, agronomic practices, pests and diseases, pesticide usage, **post-harvest practices, logistics** and overall costs, including sources of supply for purchases etc. *(Shared with activity 2.3)*	Document of supply chain's current post-harvest practices	November 2010	This work led to the production of the extension booklet for farmers *Memperbaiki penanganan, penyimpanan dan distribusi kentang di Indonesia (Improving potato handling, storage and distribution in Indonesia)* which illustrates best practice for post harvest handling of potatoes

PC = partner country, A = Australia

Objective 2: To develop and implement low-cost schemes that significantly improve the access of Indonesian farmers to quality potato seed.

no.	activity	outputs/ milestones	completion date	comments
2.3	Conduct baseline survey for potatoes and Brassica farmers to determine problems of **seed supply chain,** cultivars, percentage of farmers using imported certified potato seed, locally produced various generation certified seeds and uncertified seeds and review existing seed schemes. *(Shared with activity 1.3)*	Document of supply chain's current post-harvest practices	November 2010	The Indonesian seed potato industry will benefit if the requirements of seed potato storage and the control of physiological age of potato seed is better understood. These two issues were addressed in the extension booklet for farmers *Memperbaiki penanganan, penyimpanan dan distribusi kentang di Indonesia (Improving potato handling, storage and distribution in Indonesia)* which illustrates best practice for post harvest handling of potatoes

PC = partner country, A = Australia

6 Key results and discussion

6.1 Sources of information

16 members of the potato and vegetable supply chain were consulted during the Mr Tomkins' visit. They ranged from growers to wholesalers and packers as well as Department of Agriculture agencies. Details are shown n Table 6.1.

Table 6.1. Sectors of the vegetable marketing and handling chain consulted in February - March 2009 about post-harvest issues for potatoes and cabbage.

Chain sector	Name	Location
Supermarket supplier/Packing house	Pak Wispran	Jakarta
	CV. Bimandiri	Lembang
Vegetable wholesaler/trader traditional wet market	Pak Hendra	Jakarta
Potato wholesaler/trader traditional wet market	Pak Asep	Bandung
	Binangun Market	Wonosobo
Cool store	PT. Pluit Cold Storage Scott Martin	Jakarta
Research Institute	Balitsa Dr Eri & Dr Ali Asgar	Lembang
Dinas Pertanian	Pak Wawan Suherman	Garut
	Hari Susatyo, Pak Mufrodin, and Pak Hidayat Sardi	Wonosobo
Certified seed growers association	Agro Raya Sejahtera Ir. Dias Sudiana	Garut
	Klakah Sari Mulyo	Wonosobo
Seed store	Indofood Fritolay	Garut
Farmer groups	Pak Otang Group	Garut
	Tieng Group	Wonosobo
	Trubus group	Banjarnegara
Certified Seed Centre	Kledung Seed Centre Pak Aris Munandar	Wonosobo

6.2 Potato seed

6.2.1 Physiological age

There is a large gap in knowledge on physiological seed aging of the Granola variety under Indonesian storage conditions. Research is needed to address this.

Planting good quality seed potatoes is essential for a good quality crop. Seed should be physiologically young. Physiological age refers to how conditions other than time itself affect the performance of seed potatoes. Determining the physiological age of seed potatoes and its importance for subsequent crop establishment, tuber size and yield is generally poorly understood. The main physiological age stages are shown in Table 6.2.4.

Several factors influence the physiological age of seed potatoes:

- stresses on the potato plant during growth such as water or
- heat stress
- inadequate nutrition
- disease pressure
- physical injuries such as bruising during harvest handling,
- transport and/or storage
- high storage temperatures
- cutting seed or removal of sprouts.

These factors can all result in rapid and premature physiological aging of the seed crop.

In general, crops from young seed have:

- fewer stems per hill
- slow emergence
- lower tuber set
- larger, more vigorous plants
- longer time to harvest
- larger tubers.

On the other hand, crops grown from old seed have:

- rapid emergence
- more stems per hill
- higher tuber set
- shorter time to maturation
- smaller tubers at harvest.

This information needs to be extended to all stakeholders of the Indonesian potato industry.

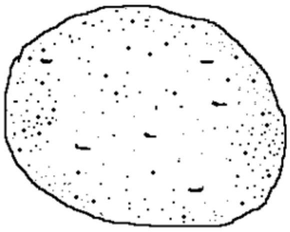
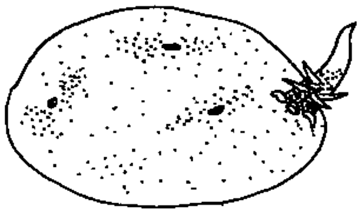
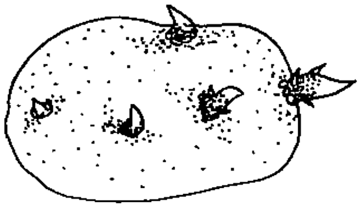
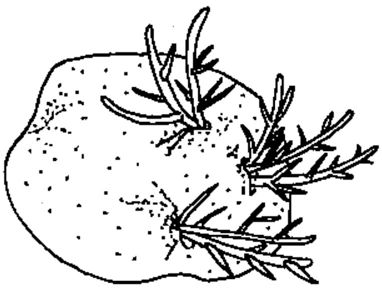
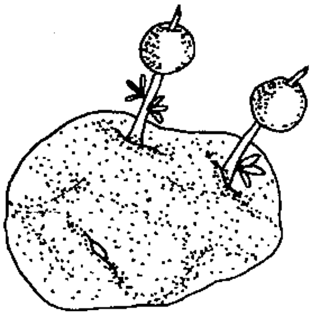
6.2.2 On-farm storage

Several on-farm seed storages were inspected. Most were found to be poorly designed. The following examples show the short comings and how these could be improved.

The seed store of Haji Otang at Garut stored seed in deep baskets stacked on top of each other. This meant that the seed was taking a load which would cause damage. There was not enough light getting to tubers and sprouts pale and etiolated.

The Tieng FFS Group stored seed in a shallow pile on a false floor of bamboo slats. The gap under floor needs to be larger to allow proper air flow. Seed was usually stored for 3 months. It was kept in dark for first 2 months in the belief that this prevents infestation with potato tuber moth. The store is opened to the light for last month. The pile of potatoes was too deep to allow light penetration so sprouts were pale and etiolated from tubers under the surface of the pile. The seed store temperature was 22°C. They plan to plant seed in one month and seed all ready at young to middle physiological age (p-age). It is most likely that the seed would be physiologically old by planting time.

Table 6.2.4. Stages of physiological age of seed potatoes

Seed age		Comments
	Dormant	• Dormant seed does not germinate and should not be planted • Dormancy period varies depending on cultivar • Chemical and non-chemical means to break dormancy
	Young	• Young seed is characterised by sprouts from apical end of tuber (apical dominance) • Fewer stems per plant • Fewer tubers but larger in size
	Middle aged	• Middle aged seed has multiple sprouts due to loss of apical dominance • Multiple stems (e.g. 3-6) per plant • More tubers per plant but reduced size • Seed that has been de-sprouted should be considered old
	Old	• Old seed has excessive branching of sprouts and loss of apical dominance within the sprout • Old seed does do not produce vigorous plants • High number of tubers but plants lack vigour to bulk up tubers, resulting in reduced yield and many • Small tubers
	Little tuber disorder	• Small tubers form on the sprouts of very old seed giving rise to little tuber disorder • This seed should not be planted

The Trubus group had seed in seed store that was G5 and due to be planted in 10 days. Seed was spread on floor in thin layer in light. Sprouts were up to 10 cm long. The p-age of seed was “old”. The growers were aware of this and said they wrap the seed in moss when they plant it and this improves the performance of the seed. They spread the tubers in the light when the sprouts have reached about 1 cm long after 3 - 4 months storage. The temperature in store was 25 °C.

The Agro Raya Sejahtera certified seed growers association Garut store seed for 1 month in the dark then 2 months in filtered light. They spray the store for potato tuber moth (PTM) before potatoes are put in store and then 3 times during storage. The store can hold about 30 tonnes of seed but this is not big enough. The seed is stored in plastic crates of about 10 kg. These crates are too deep for light to penetrate to all tubers within both the crates and in stacks. It was a very well built store but not very well designed for seed storage. It had a solid floor with no ventilation. The vents in walls were too small and too high. The store was not designed to make use of cool night air ventilation.

The Indofood Fritolay store had 216 tonnes of Atlantic, seed size 30 – 65 mm, in 25 kg sacks. The seed had sprouted. P-age ranged from young (apical dominance) to middle aged (apical dominance broken and other eyes sprouting). The age varied between sources (suppliers). The consignment was still being held under quarantine which is generally 3 weeks. The ambient temperature in the middle of day was 28 °C. The store reportedly cools to 16 – 18 °C during the night. The doors of store were open during the day with large fan blowing hot air from outside over tubers which would hasten dehydration and aging. Store should be kept closed during day and fans used at night to ventilate store with cool, humid night air. As seed already sprouted it could be past optimum p-age by time it is released from quarantine in about 3 weeks time. There was no protection against PTM which had free access to the tubers

These five sites need to store seed in shallow racks or trays 75 mm deep and expose seed to filtered light earlier on in storage. The design of simple on-farm seed potato stores would be improved with the use of cool night air to ventilate and cool stores. Store with raised floors should have a plenum below floor to direct cool night air through vents in floor to “chimney” vents in ceiling. An example of s simple store suitable for a farm is given in Figure 1.

The best store seen was at the Klakah Sari Mulyo seed group at Wonosobo store seed for up to 5 months. They store seed on shallow racks in filtered light store. One lot of seed ready for planting in 5 days has been stored for 4 months. The seed looks to be in very good condition. The p-age is young and seed still showing apical dominance.

6.2.3 Cool storage

The General Manager of PT. Pluit Cold Storage in Jakarta is Mr Scott Martin. Pluit Cold storage supplies supermarkets and food service with fruits and vegetables. It is a large cool storage facility with small packing/processing area. Pluit Cold Storage has the potential to store seed potatoes. Australian seed potatoes for the project which are shipped to Jakarta should stay in Pluit cool store until ready to be planted in farmer field school plots. This will prevent excessive aging of seed as occurred in the last consignment which was stored at ambient temperatures.

Expertise in cool storage appears to be lacking in Indonesia as plans for a new cool store and packing facility were seen. These were not well designed and not very functional and need to be redesigned.

6.2.4 Potato tuber moth

Both Balitsa and the Agro Raya Sejahtera (ARS) certified seed growers association Garut reported that control of potato tuber moth is an important issue for stored seed.

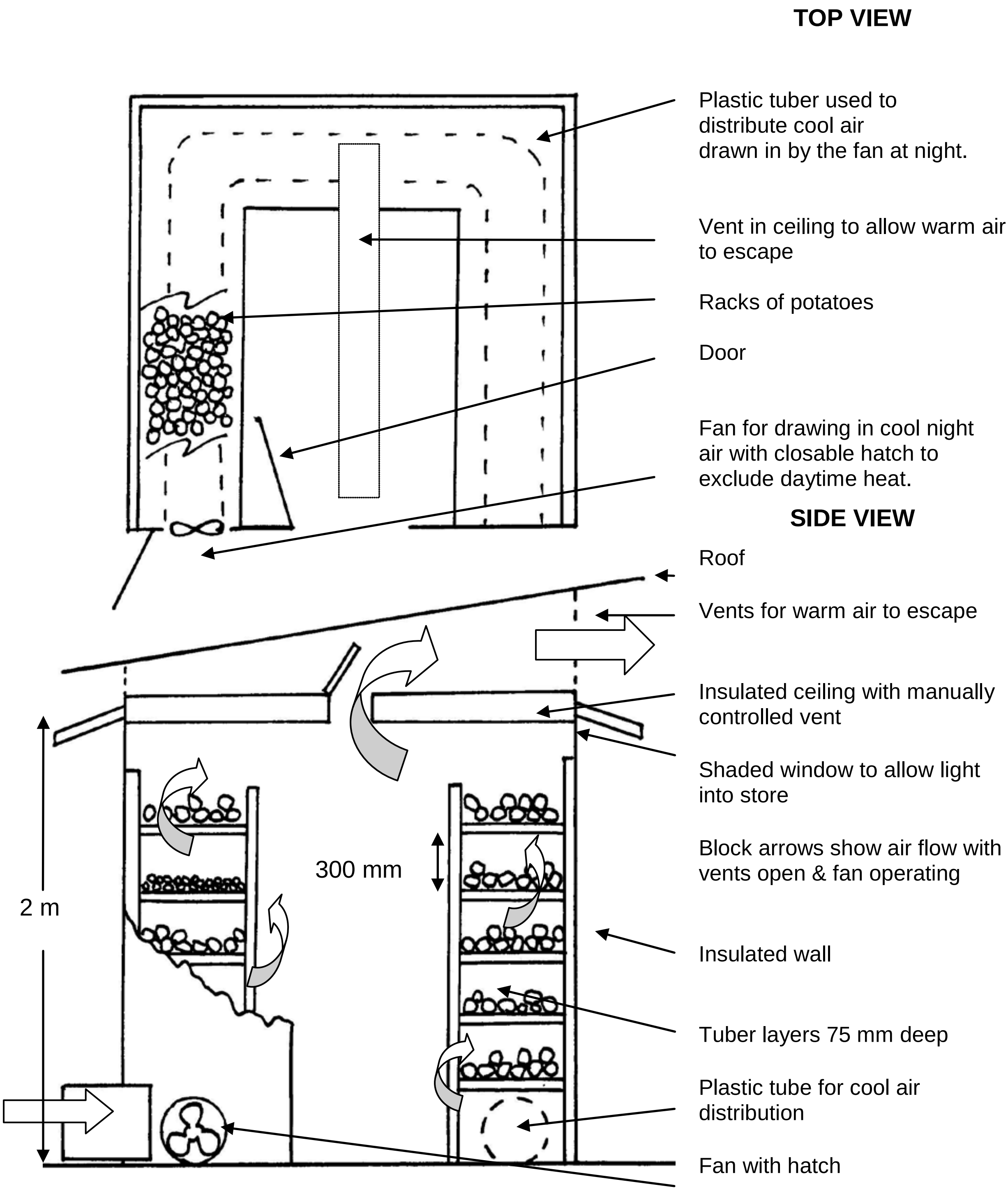


Figure 1. Design of small ventilated diffuse light potato store with capacity of 600 kg. Tubers are stored on racks in layers 75 mm deep. Racks are 300 mm above each other and 500 mm wide. The dimensions of the store are 2 m wide x 2 m deep x 2 m tall (to ceiling). The store is designed to allow cool night air to be drawn in at ground level to force out the warmer air near the ceiling. Clear plastic sheeting or glass windows allow light in but keep insects out. This store can be used for drying, curing and sorting potatoes after harvest. Modified from Calverley (1998). The average internal store temperature was 14.5ºC with a mean minimum outside air temperature (at night) of 10ºC and a mean maximum outside air temperature of 30ºC. Not shown is a thermometer which is to be placed in a bucket of water on the top rack. The water maintains a table temperature and so gives a good indication of the temperature of the tubers.

6.2.5 Potato late blight

The Trubus group reported that *Phytophthora* infections are a massive problem especially in the wet season. It was also widely reported that it is difficult to grow Atlantic seed because it is very susceptible to late blight.

6.2.6 Virus

It was widely reported that it is difficult to grow Atlantic seed because of virus problems. The first generation of plants show 0.5% symptoms of “mosaic” virus, while the next generation consistently shows 60%. Field observations backed this up with a 2 month old G4 crop appearing to have some virus symptoms. A more mature G7 crop had substantial amount of plants with virus symptoms.

6.2.7 Generations

Balitsa staff reported that less than 1% of seed planted is certified seed although farmers willing to pay ~US$ 1.00 – 1.20 per kg for certified seed. Most growers multiply seed for many generations. There is an opportunity exists for joint venture between seed producers and local growers to bulk seed but only for one generation.

Agro Raya Sejahtera (ARS) certified seed growers association in Garut reported that they can’t obtain enough quality G0 material.

Dinas Pertanian staff at Wonosobo report that nearly all crops are grown from local uncertified seed with only a very small proportion grown from certified G4 seed.

Kledung Seed Centre is the source of certified seed for Central Java. The centre is owned by Central Java Provincial Government. Certification is done by Balai Pengujian Sertifikasi Benih (BPSB) = Seed Certification Testing Agency which is under control of Central Java Government. About 15 local growers were sent to Kledung to learn how to grow certified seed but only one given accreditation to grow G3 to G4 under the auspices of Kledung. Another seed source is the Pangalengan Seed Centre in West Java.

Cost of certification is Rp 20,000 per tonne. Certified seed sells for Rp 9,000-10,000/kg

6.2.8 Rotations

In Central java farmers plant one potato crop after another without rotations. In other regions, e.g. Lembang, farmers rotate potatoes with other crops occasionally.

The Certified seed grower group Agro Raya Sejahtera (ARS) in Garut report that the low availability of land that is isolated from other crops, especially Solanaceae is a major constraint to seed production. This was also a complaint from the Trubus group.

The Trubus growers occasionally rotate plantings with cabbage. However this is not as profitable as potatoes and cabbage cannot be stored when prices are very low. Cabbage yield is about 30 tonnes per hectare and price generally ranges from Rp 300 to 1,500/kg. However price can fluctuate wildly. Examples were given of growers receiving Rp 3,000/kg in the morning and Rp 1,000 in the afternoon. They don’t grow broccoli because do not know the market. Also it is highly perishable and they do not have any refrigeration or ice.

6.2.9 Seed selection

Pak Asep, a potato wholesaler/trader in Bandung traditional/wet central market Caringin reported that when prices are low growers hold back small potatoes to use as seed. The Trubus group reports about 15% of the crop is kept for seed.

6.2.10 Seed performance

The harvest of a seed comparison plot of the Farmer Initiated learning group led by Haji Otang at Garut was observed. Treatments comprised Australian G4 Certified Granola seed ex Western Australia, local G4 certified seed and farmer seed. The plant tops sprayed with Gramoxone 2 weeks prior to harvest to desiccate the crop for ease of harvest and to accelerate the hardening of the skin. A rough yield comparison of the seed sources was: Australian seed 4 bags, local G4 certified seed 7 bags and local farmer seed 5 bags. Good things said about Australian seed is that it produces shorter more compact plants and that it produces a higher proportion of large tubers than Indonesian seed.

Photographs showed that Australian seed was physiologically old when it arrived and should not have been planted. However there did not appear to be many shoots on each tuber, only one or two. Grower photos of plots showed poor germination of Australian seed with seed rotting in the ground. The history of this seed was as follows. It was harvested on 10 May 2008 in Manjimup, Western Australia. It was left to cure for 3 weeks then cool stored until early September. On 2 September it was graded and packed then shipped to Jakarta in a refrigerated container. The seed arrived in Jakarta on 20 September and was cleared from Customs, removed from the refrigerated container and trucked to the Garut ambient seed store on 25th Sept. It was held here at ambient conditions under quarantine until its release on 25th October when it was transferred to Balitsa, then to Dinas Pertanian Bandung who forwarded seed to farmer field school at Garut. The seed was planted on 21st November. A data logger accompanied the seed shipment to measure temperature and humidity. This logger was never recovered. The seed once it was removed from the refrigerated container would have overcome dormancy and begun to sprout. The daytime temperature in the store at Garut was recorded at 28 °C (see section 6.2.2). Above 23 °C PTM takes four weeks to compete its lifecycle. At 37 °C this time is reduced to two weeks (Horne *et al*. 2002). The ambient storage conditions of high temperature, dark storage and lack of protection from potato tuber moth would have allowed the seed to grow long shots which lead to dehydration as well as infestation by PTM. The long time in storage not only damaged the seed, it also delayed planting time which would have affected crop performance.

The storage of seed in Indonesia has evolved for the short term ambient temperature storage of local, freshly harvested seed. This storage appears to be appropriate for 3 to 4 months storage if PTM is controlled. This storage system does not work well for imported seed. The imported seed has been cool stored with the results that once it is removed from cool store and arms up it is out of dormancy. The ambient non-diffuse light storage conditions means that the sprouts of the seed continue to grow. In the dark long shoots are produced which have a large surface area and lead to rapid dehydration of the seed tubers. This promote raid physiological aging. The quality of the seed is further impaired by the predations of PTM. The potato stores are not insect proof and are not regularly dusted with insecticide to protect against PTM. The result is premature aging of the seed and deterioration through PTM damage which leads to rots.

Similar problems with imported seed have been reported before. An example of the waste that can ensue is illustrated in Figure 2 which shows the percentage of waste against storage time in an Indonesian seed store. This data was supplied by a seed importer. It appears that 10 to 30% waste is normal but some seed lots have much and in one case total waste. In this storage situation the oldest seed should be released first

Therefore there is a need for the handling of imported seed to change to avoid this unnecessary deterioration. Once it has cleared from customs it seed should be transferred directly from its refrigerated container to a cool store set at 4°C in Jakarta under the guidance of personnel with seed care knowledge. The seed should remain in the cool store while it waits the lengthy quarantine clearance. A suitable cool store would be PT Pluit Cool Storage. The seed could remain in cool storage until the quarantine checks have been completed. It is important that the potato seed is not be stored with ethylene producing commodities (Tan and Considine 2006). Only a few days before the farmers are ready to plant the seed should it be removed from cool store. This cool chain storage will prevent the seed shooting and dehydrating and aging prematurely. The cool storage will protect against infestation by PTM as the pest cannot transfer from tuber to tuner when the temperature is below 10°C (Struik & Wiersema 1999). The cost of cool storage is Rp 100,000 for five pallets (total capacity 2,500 kg) per day which includes a humidification to 95%, Rp 40 per kg per day (Scott Martin personal communication so that's about $12 a day). The benefit of such storage is easily calculated. The average waste of seed lots shown in Figure 2 was 21%. If the imported seed is valued at Rp 10,000 per kg then for every kg of imported seed Rp 2,100 is lost as waste due to poor storage. This cost would allows seed to be cool stored for 52 days (Rp 2,100/40). There would be savings in transport costs as well as grading and as waste potatoes would not have to be sorted. Another benefit is that the performance of the seed would be better.

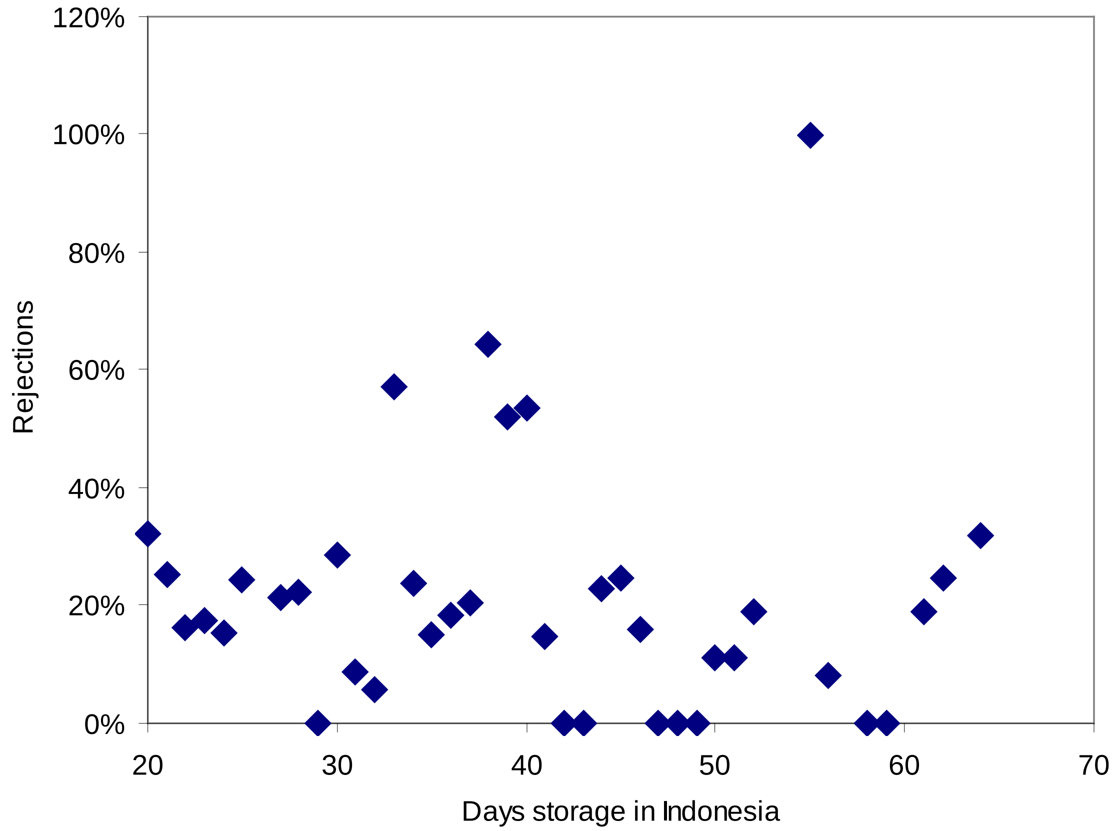


Figure 2. Rejections of seed with days kept in ambient temperature store in Indonesian highlands with no protection from potato tuber moth. Rejections were due to insect damage and rots. The average rejections rate was 21%.

6.3 Table potatoes – handling & market chain

The Klakah Sari Mulyo growers group report that they do not know what happens to their potatoes post farm gate as they do not receive any feed back on quality.

Banjarnegara growers reported that the biggest quality issue is that tubers are often harvested immature and get damaged easily. The tubers are harvested immature in response to market demand. That is when supply is short and prices are high say around Rp 4,000 per kg.

Price range for this group is between Rp 3,000 and 5,000/kg. When prices are low growers store tubers in the ground or in the home for up to one month. This practice could be related to the next biggest reported problem of rots.

6.4 Table potatoes - potato late blight

At Banjarnegara a close- to-mature crop had 90% late blight. This is a major problem and one grower Pak Didik who visited Perth in February said that 6 months or so ago the whole district was wiped out and those they do not know how to control it.

Information on control of late blight should be a high priority for extension material and should be a component of FFS trials.

6.5 Table potatoes - damage

6.5.1 Immature harvest

Pak Wispran, a potato supermarket supplier in Jakarta with a turnover is Rp 1.6 billion per year (~ $AUD 230,000). , reported that potatoes are getting more expensive and quality is dropping. He washes potatoes on arrival and graded. Approximately 30% graded out as waste. Of these 70% have physical injuries, 23% are green and 5% have rots,. He believes that physical injuries are mainly due to immature potatoes. That is, they are dug too soon after tops removed from plants and are not cured properly.

The Klakah Sari Mulyo group at Wonosobo cut the tops off their plants 10 days before harvest. In the wet season this is 90 days after planting, in the dry season 100 - 110 days. This may no be long enough for the skins to toughen sufficiently for harvest.

6.5.2 Packaging

The potatoes are collected from growers by middleman or “collector” (broker) on behalf of trader. The potatoes are either sorted by growers or collectors or traders and are packed in 65 – 70 kg sacks. They may be stored a few days during grading but then are transported in open trucks to Jakarta. Large sacks are used to cut costs. Sacks cost Rp 500, less than $AUD 0.10. Pak Wispran is negotiating with collectors to have potatoes harvested into returnable plastic crates to reduce physical injuries but cost is prohibitive. Pak Wispran packs potatoes into 1 kg pre pack under supermarket brand, 5 – 6 tubers per pack. 5 - 6 tubers per kg is the premium grade, i.e. 160 – 200 g. also packs own brands and supply some loose washed potatoes to small restaurants.

Trubus group reported that they do not use plastic crates for their produce as they are too expensive at Rp 80,000 each.

At the Binangun Market at Wonosobo traders sort and grade potatoes using recycled chicken feed bags. There could be a human health risk associated with this practice.

6.5.3 Rots

Several potato traders report that rots are a problem with potatoes. This is not surprising as the combination of high temperatures (above 18°C), immature skins and prevalence of *Phytophthora* (late blight) encourage rots. Solutions are to harvest the potatoes carefully when skins have matured, avoid damage, keep the potatoes as cool as possible and market promptly.

6.5.4 Handling

At one potato wholesaler/trader (Pak Hendra) people were observed sitting and standing on sacks of potatoes. This practice will cause physical injuries which promotes rotting.

6.6 Quality of potatoes - size

The price of ware potatoes depends on size with growers getting paid more for larger tubers.

Pak Hendra, a potato wholesaler/trader in Jakarta at the traditional/wet central market Kramatjati reports that the major quality problems are tubers too small with only 10% in premium size of 160 – 200 g.

Balitsa staff believe that only about 10% of potatoes produced are in the premium grade (i.e. 5 - 6 tubers per kg).

CV. Bimandiri Lembang, packing house of supplier to supermarkets, one of 6 similar, major supermarket suppliers in Bandung, reports that only 20% of potatoes received are over 120 g. Source of potatoes on the day was Garut, Pangalengan and Wonosobo/Banjarnegara.

6.7 Potato storage

The Klakah Sari Mulyo the Wonosobo seed group and growers do not tend to store potatoes in the ground as they do in West Java. Small growers can not afford to as they need the cash flow. Sometimes they will store tubers in the home for up to 2 weeks to try and get a better price if prices are low. Large growers will store potatoes in the ground for up to 5 months to release when the market price is high because they can afford to.

6.8 Potato storage temperature

Temperature in Pak Wispran's pack house was 30°C, temperature of potatoes 31°C. The Indofood potato store day time temperature was 28°C. Stores may be closed by closing doors and windows during the day and opening at night to introduced cool air.

6.9 Potatoes – taste

Pak Asep, a potato wholesaler/trader in Bandung traditional/wet central market Caringin reports that Granola quality varies between production regions, Wonosobo, Garut and Pangalengen, and tubers taste different based on consumer perception.

6.10 Cabbage - refrigeration

CV. Bimandiri Lembang, is one of 6 packing houses in the Bandung area that supply supermarkets. He handles a range of vegetable crops including potatoes, brassicas (cabbage, cauliflower, red cabbage, wong bok), carrots, iceberg lettuce, tomatoes, chilli, beans, ginger. Pre packs for 45 supermarket stores. Handles around 16 tonnes per day and turnover is Rp 2 - 2.5 billion per month. Typically for thse enterprises there is no refrigeration. The packaged product is in stores within 12 hours.

6.11 Cabbage - quality payments

There is little incentive for the Trubus growers to improve quality and handling practices for cabbage as they are not rewarded for it. They have no idea what happens to their cabbage post farm gate and never receive any feed back on quality.

6.12 Cabbage - modified atmosphere packaging

Farmers asked about whether there are any new post harvest technologies that they could use to prevent quality loss. The concept of modified atmosphere packaging (MAP) and how it can be adapted for use at high temperatures for brassica crops. At ambient temperatures MAP can act like refrigeration in slowing quality loss. It was explained how to make controlled ventilation packaging for Brassicas like cabbage and cauliflower. Australian experiments were described where broccoli was held in good condition at 25°C for more than 10 days in MAP but only 2 - 3 days without MAP.

7 Impacts

7.1 Scientific impacts – now and in 5 years

None

7.2 Capacity impacts – now and in 5 years

Reduced seed potato waste. Improved cabbage out-turn

7.3 Community impacts – now and in 5 years

7.3.1 Economic impacts

Reduced seed potato waste. Improved cabbage out-turn

7.4 Communication and dissemination activities

This work led to the production of the extension booklet for farmers *Memperbaiki penanganan, penyimpanan dan distribusi kentang di Indonesia (Improving potato handling, storage and distribution in Indonesia)* which illustrates best practice for post harvest handling of potatoes.

Table 7.1. Post-harvest survey communication and dissemination activities.

Date	Personnel	Organisation & Position	Location	Activities
Feb - Mar 09	Bruce Tomkins	Post Harvest Specialist, DPI Victoria	Central and West Java	Survey of members of the potato and vegetable supply chain to ask their opinions about post-harvest handling and to observe current practices.
May – Jun 09	Bruce Tomkins	Post Harvest Specialist, DPI Victoria	Victoria	Production of extension book *Memperbaiki penanganan, penyimpanan dan distribusi kentang di Indonesia (Improving potato handling, storage and* distribution in Indonesia)

8 Conclusions and recommendations

Potato seed stores are too warm. Store conditions could be improved through changes to management of the ventilation. The ventilation to the stores should be closed during the day and opened at admit cool night air. Further improvement could be made with store modifications. Ideally inflow vents in stores should be placed low to allow cool night air to replace the warm air which should escape through roof ventilators. The ventilation should be fan assisted. The tubers should be stored in trays on racks to allow improved ventilation and access for grading and sorting. Stores should allow diffuse light in.

Imported seed should be not be kept in an ambient store as this seed has previously been cool stored and will commence sprouting when warm. The rapid growth of shoots in the darl stores leads to rapid dehydration and physiological aging of this seed. Suitable cool store facilities were identified.

Table potatoes are sometimes harvested immature before their skins had hardened. Improved out-turns should result from harvesting the potatoes when they are mature, keeping them as cool as possible and transporting them to markets in rigid plastic crates.

The vegetable supply chain lacks refrigeration. An intervention that may help is modified atmosphere packaging (MAP). At ambient temperatures MAP can act like refrigeration in slowing quality loss. MAP should be tested in the Indonesian cabbage supply chain.

9 References

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Australian Government

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Final report appendix 13

title	AGB/2005/167 Impact assessment - farmer conference
prepared by	Peter Dawson
co-authors/ contributors/ collaborators	Ibu Asma Julie Warren

1 Executive summary

The overall purpose of this project is to assist farmers in Central and West Java, South Sulawesi and Nusa Tenggara Barat to increase their returns from the potato and Brassica production system by adapting proven Australian, Indonesian and CIP technologies to conditions in Central and West Java to develop best local farming practices.

The project aimed to:

1. Adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas suited to Javanese conditions.
2. Develop and implement low-cost schemes that significantly improve the access of Indonesian farmers to quality potato seed.

A farmers' conference was held at the end of the project to provide a forum where farmers involved in the project could discuss the achievements and short comings of the program and suggest how the project and other future work could be improved.

Farmers reported the following crop production capacity increases:

- Soil pH management,
- Fertiliser management
- Pesticide management, specifically improved knowledge of the active ingredients in pesticides which afforded them better pesticide selection and dose management.
- pet and disease control decisions through implementation of crop monitoring or improved more carefully planned spray programs.
- Farm management due to having a better understanding of the costs and returns and what level on investment was appropriate for their crop inputs.
- Greater awareness of potato cyst nematode and implementation of on-farm biosecurity measures to reduce the risk of introducing this pest.
- Greater care with seed selection with increased use of certified seed to reduce the risk of introducing pests like potato cyst nematode, reduced virus levels and to promote more vigorous growth.
- Yields improvement after adoption of project methodology. An example presented was an increase in yield from 8 t/ha to 26 t/ha. The net gain from this increased yield due to increased inputs was 33 million Rp per ha.
- Reduction in insect management costs due to decreased pesticide use due to spraying decisions now being based on the results of crops monitoring rather than calendar spraying as occurred previously.
- Reduced input costs through group purchasing of agricultural inputs.
- Group marketing of produce to obtain better prices and conditions from their agents.

Farmers reported the following social benefits:

- A better appreciation of the benefits of Farmer Initiated Learning groups demonstrated by improved attendance than was previously the case.
- A strengthening of relationships between growers.
- The establishment of independent FIL groups and the adoption of FIL technology to farmers outside the project through diffusion of information through community and religious affiliations.
- Greater self confidence of farmers involved with the groups.

- Greater awareness of the risks of applying pesticides and what steps could be taken to protect spray operators.

Farmers reported the following social benefits:

- Greater awareness of environmental impacts of their farming activities.
- The adoption of better targeted pest and disease control having a flow on effect to the environment through reduced pesticides applications.

Farmers made the following recommendations about the current and future ACIAR projects:

- information should be made available on the internet,
- additional farmer groups should be developed
- farmers should be given the opportunity to continue their skill development
- facilitators should be given the opportunity to develop their skills and knowledge,
- FIL activities should use bigger plots
- Farmers need information and training an how to improve their access to capital
- Farmers need more information and training on post-harvest care and processing of their product
- Farmers need more information and training on marketing their product
- Delays that occurred in seed supply through the project need to be overcome.

2 Background

The two major vegetable crops in the Indonesian provinces of West and Central Java are potatoes and Brassicas which are normally grown in rotation. Production from these provinces accounts for over 50% of the total Indonesian harvest for potatoes and Brassicas (1 million tonnes and 1.2 - 1.5 millions tonnes respectively). Vegetable production is also an important component of the rural economy in the highland areas of Sulsel and NTB, although they are only minor producers on a national scale.

Farmers producing these crops are mostly smallholders who are producing these crops for cash incomes rather than home consumption. The average yields for potato crops grown in these regions are 10-20 tonnes/ha. These are low by international standards and reflect the sub-optimal agronomic management, the unavailability of high quality seed and problems caused by pests and diseases.

The overall purpose of this project is to assist farmers in Central and West Java to increase their returns from the potato and Brassica production system by adapting proven Australian, Indonesian and CIP technologies to conditions in Central and West Java to develop best local farming practices.

The project aimed to:

1. Adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas suited to Javanese conditions.
2. Develop and implement low-cost schemes that significantly improve the access of Indonesian farmers to quality potato seed.

The project was involved the participation of around 40 farmer groups in the four target provinces. These approaches include adaptive field experiments to test and fine-tune novel technologies and improved agronomic practices with farmers.

The Farmer conference was held to enable participating farmers to review the project and make suggestions for further work.

3 Objectives

To provide a forum where farmers involved in the project could discuss the achievements and short comings of the program and suggest how the project and other future work could be improved.

4 Methodology

Farmers from every Farmers group were invited to attend the two day workshop. The workshop was held in at the farmers preferred site of Pangandaran which is close to the border of West and Central Java.

The workshop was held on the 3rd and 4th June 2010 at the Laut Biru Hotel.

The program was designed to allow farmers on the first afternoon, to break into 6 groups each with 10 persons to discuss significant change stories as outlined in questionnaire below. Each group was to be allotted one of the questions to discuss in detail. Following these discussions each group writes the key points around their question.

The results of all the group's discussion was to be collating for presentation by the leader of each group on the following morning to the entire workshop.

Questions for Group Discussion

As a result of being involved in this project over the last 4 years:

1. What do you think was the most significant change you have observed in your village?
2. What was the most significant benefit for your farming system?
3. What was the most significant benefit for farmers in your group?
4. What was the most significant change in pesticide usage?
5. What was the most significant change in fungicide?
6. What are your comments concerning future ACIAR projects?

Temu Tani Program

Thursday 3rd June 2010

Time	Activity
9:00	Welcome, Eri Sofiari, Indonesian Project leader
9:30	Welcome, Terry Hill, Australian Leader
10:00	Key technical issues, Peter Dawson,
10:30	Morning tea
11:30	Prayer
12:00	Lunch
12:30	Lunch
1:00	DVD Late Blight
1:30	Farmers break into 6 groups of 10 people
2:00	Farmer group discussion. Sebagai hasil dari keterlibatan dengan project ini selama 4 tahun terakhir (see questions below)
2:30	Afternoon tea
3.00	DVD Keeping Lombok PCN free
3:30	Farmer group discussion
4:30	DVD Clubroot to end day
Friday 4th June - Farmer Group Presentations	
8am Group 1	What do you think was the most significant change you have observed in your village?
8:20 Group 2	What was the most significant benefit for your farming system?
8:40 Group 3	What was the most significant benefit for farmers in your group?
9:00 Group 4	What was the most significant change in pesticide usage?
9:20 Group 5	What was the most significant change in fungicide?
9:40 Group 6	Other comments for future ACIAR projects
10:00	Morning tea
10:30	Summary, Dr Eri Sofiari and Mr Terry Hill
11:00	Close
11:30	Prayer
12:00	Check out
12:30	Lunch

5 Achievements against activities and outputs/milestones

Objective 1: To adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas/Alliums suited to Javanese NTB and Sulsel conditions.

no.	activity	outputs/ milestones	completion date	comments
1.10	Project evaluation workshop *(shared with activity 2.9)*	Achievements and lessons learned documented	4 June 2010	Documentation presented in Impacts section of this Appendix.

PC = partner country, A = Australia

Objective 2: To develop and implement low-cost schemes that significantly improve the access of Indonesian farmers to quality potato seed.

no.	activity	outputs/ milestones	completion date	comments
2.9	Project evaluation workshop *(shared with activity 1.10)*			See activity 1.10 above.

PC = partner country, A = Australia

6 Key results and discussion

This activity focused on the impacts that the project had achieved. These are presented in the following “Impacts” section.

7 Impacts

7.1 Scientific impacts – now and in 5 years

None

7.2 Capacity impacts – now and in 5 years

Soil pH

Knowledge of the importance of correct soil pH for vegetable production meant that farmers now measured soil pH and applied lime if needed.

Fertiliser

Farmers were now aware of the benefits of using composted organic fertilisers. It was reported that some groups now used increase organic fertiliser and more regular applications of chemical fertiliser.

Pesticide knowledge

The project made farmers aware of the active ingredients in pesticides. Before the project farmers would mix several pesticides together in the hope of obtaining better control. They now understood that one carefully selected active ingredient that was effective against the target gave better and cheaper control than ad hoc mixtures of on-hand pesticides. Mixing of agricultural chemical was reduced with the understanding of the active ingredients and the knowledge that rotating different active ingredients was better.

Farmers knowledge of applying the correct dose with a properly calibrated sprayer improved during the project.

Pest and disease monitoring

Farmers reported that pest and disease control decisions were now based on the results of monitoring the crop for pests and diseases.

Management decisions

Farmers were able to do their own management. This meant that they could make better decisions on management inputs as well as having an understanding of the costs and returns and what level on investment was appropriate for their crop inputs.

Two groups reported that planting density had been reduced. One group reported planting density had been reduced from 25 x 75 cm (53,333 plants per ha) to 35 x 60 cm (35,714 plants per ha). This change was made to allow for better potato late blight control through having a more open canopy which allowed faster drying after rain and better fungicide penetration and coverage. The change also meant that the cost of seed was reduced.

Potato cyst nematode

Farmers were more aware of potato cyst nematode and now considered the risk posed by this pest. Farmers were more ware of on-farm biosecurity measures that can be taken to reduce the risk of introducing this pest.

Seed

Farmers reported that the use of certified seed had increased as their knowledge of its benefits grew. Benefits were; reduced risk of introducing pests like potato cyst nematode, reduced virus levels and more vigorous growth.

7.3 Community impacts – now and in 5 years

7.3.1 Economic impacts

Yield

It was reported that yields had improved after adoption of project methodology. The example presented was an increase in yield from 8 t/ha to 26 t/ha. There was a concomitant increase of costs from 25 million Rp per ha to 38 million Rp per ha. This gave a before-project gross margin of - 5 million Rp per ha while the post-project gross margin was + 27 million Rp per ha. Assumptions used are that the potatoes were sold for 2,500 Rp per kg and the costs presented were the total variable costs. The net gain from this increased yield due to increased inputs was 33 million Rp per ha.

Input costs

Farmers reported that insecticide input costs were decreasing as a result of reduced pesticide use due to spraying decisions now being based on the results of crops monitoring rather than calendar spraying as occurred previously. One group was able to quantify the cost savings as 3.2 million Rp per ha. Before project methodology was adopted 9.4 million Rp per ha was spent and with project methodology this was reduced to 6.2 million Rp per ha

Some farmer groups were reported to have begun making group purchases of agricultural inputs in order to increase their bargaining power with the suppliers. These group purchases had led to reduced input costs.

One group reported that spraying frequency had increased to 20 sprays compared with 18 previously but that the number of pesticides applied had reduced as farmers were no longer mixing several pesticides together every time they went to spray their crops.

Marketing

It was reported that when farmers acted as a group to market their product they obtained better prices and conditions from their agents than when they acted alone. This was due to the increased marketing power enabled by their large amount of produce.

7.3.2 Social impacts

Group dynamics

The farmers reported that the ACIAR project had made farmers better appreciate the benefits that Farmer Initiated Learning groups could give them. Consequently they noted that attendance at FIL groups was better attended than was previously the case.

They reported that the FIL groups strengthened relationships between growers. This led the group decisions being made where previously individuals would have acted after only considering their own interests.

The success of the FIL groups had led to the establishment of independent (from the ACIAR project) FIL groups. It was reported that farmers from outside the FIL groups were adopting FIL technology through diffusion of information through community and religious affiliations.

Farmers self esteem

FIL group member felt they were more self confident and skilful as a result of their involvement with the groups.

Sprayer health and safety

It was reported that before the project the farmers were not concerned about the spray operators health and safety. During the project they become aware of the risks of applying pesticides and what steps could be taken to protect spray operators.

7.3.3 Environmental impacts

Farmers reported that they were more aware of environmental impacts of their farming activities as a result of project activities than they had been at the start of the project.

The change in pest and disease management away from calendar spraying of mixtures of pesticides to more targeted pest and disease control based on monitoring was discussed under Section 7.2 Capacity impacts above. This will have a flow on effect to the environment as there should be a net reduction in the amount of pesticides applied.

8 Conclusions and recommendations

8.1 Recommendations

One farmer group was asked to make recommendations about the current and future ACIAR projects. Their recommendations were that:

- information be made available on the internet,
- additional farmer groups should be developed
- farmers be given the opportunity to develop their knowledge
- facilitators should be given the opportunity to develop their skills and knowledge,
- FIL activities should use bigger plots
- Farmers need information and training an how to improve their access to capital
- Farmers need more information and training on post-harvest care and processing of their product
- Farmers need more information and training on marketing their product
- Delays that occurred in seed supply through the project need to be overcome.

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Final report appendix 14

title AGB/2005/167 Impact assessment - social impact study

prepared by Lembaga Pengembangan Teknologi Perdesaan (LPTP)

co-authors/ contributors/ collaborators

Eko Istiyanto	Team leader
Rahadi, SPd	Research consultant
Purwono Yunianto	Coordinator
Zamzaini	Enumerator (SS)
Sulistyo	Enumerator (SS)
Budi	Enumerator (WJ & NTB)
Lilik Mukhibah	Enumerator (CJ)
Gunawan	Enumerator (CJ)

1 Executive summary

The project 'Optimising the Productivity of Potato and Brassica Cropping Systems in West Java, Central Java, South Sulawesi and West Nusa Tenggara aimed to increase the production and profitability of the potato and cabbage system in West Java (WJ), Central Java (CJ), Nusa Tenggara Barat (NTB) and South Sulawesi (SS) through participatory technology transfer of appropriate market focussed crop management techniques. The participatory technology transfer platform initially used was the Integrated Crop Management Farmer Field School (ICM FFS) which evolved into the more manageable and effective Farmer Initiated Learning (FIL) procedure.

A study of the impacts of this project took place in February – April 2010. Methods used were as follows:

1. Interviews (in-depth interviews, focus group discussions).

2. Field observations (visual photos, observations in the field).

3. Analyses of documents (project proposals, activity reports, group documentation).

Since 2007 and 2008 potato and cabbage ICM-FFS began to be established in regions like WJ and CJ. Later, in 2009 and 2010, they were modified to FIL activities in Java and SS and NTB. FIL has been quite beneficial to group members and nearby villagers, not only in terms of increased knowledge and experience, but also in improving potato and cabbage farming production yield

FIL member farmers' knowledge has increased significantly; all of the respondents interviewed said their farming knowledge had increased especially in pest management and pesticide use. Farmers are now more selective and careful in using pesticides, and adjust their use to their needs. Many farmers admitted to excessive use of pesticides before taking part in FIL, they would not make observations first, but spray in the event of pest infestation. Some farmers would always spray pesticides even though there were no pests or diseases on their crops in the name of prevention. Each season, farmers would use an average of 50 - 60 kg/ha with a spraying interval of once every 2 - 3 days. Now they use only pesticides 20 - 25 kg/ha in a season. With this reduction in pesticides, farmers can be more economical in their farming enterprise expenditure. Almost all ICM-FFS member farmers in Central Java, West Java, West Nusa Tenggara and South Sulawesi said their earnings had increased with reduced outlay for pesticides. Pesticide expenditure on average has fallen from IDR 15 million/ha, to a current average of IDR 8 million/ha, meaning a reduction of IDR 7 million due to fewer and more directed pesticide applications.

In addition to lower costs, environmental impacts have also been improved as reduced use of pesticides and chemical fertiliser means less damage to farming land. The lower, more selective and careful use of pesticides will indirectly improve environmental quality and of course influence the health of the farmers themselves.

Another skill that farmers feel has improved is seed selection. Farmers usually secured seed potatoes from the market or from other farmers, which they would plant repeatedly. When they got good seed, their harvest yield would increase, but it was not uncommon for yield to fall due to diseased seed also being planted. Farmers can now select seed by themselves. They recognise the characteristics of good seed and now sort before planting.

During the FIL processes, farmers were taught how to conduct simple experiments that they could apply in their own fields. Though not all FIL member farmers conducted experiments, others have developed experiments of their own. The emergence of researcher farmers in the program regions will certainly be a positive influence on neighbouring farmers. Simple trials developed by farmers include variety trials, fertiliser application trials, natural pesticides trials, etc. Indirectly, farmers' capacity to carry out simple research is increasing. They no longer believe others who offer farming products without trials to prove their effectiveness.

With increased knowledge in potato and cabbage growing, now many non FIL farmers ask for members' opinions on certain matters. Their initial apathy has gone after seeing the knowledge he has gained from participating in potato and cabbage FIL.

2 Introduction to the regional situation

2.1 Location conditions

Indonesia is the largest potato producer in Southeast Asia, and potato farming employs around 300 – 400 man-days/ha of labour. The main producing centres are in WJ, CJ, East Java, SS, North Sulawesi, NTB and North Sumatra. The project focused on the provinces of WJ, CJ, NTB and SS.

Potato and cabbage producing centres in WJ are in Bandung District (Pangalengan and Kertasari subdistricts) and Garut District (Cisurupan, Cikajang and Pasir Wangi subdistricts). In CJ, they are in Wonosobo District (Garung and Kejajar subdistricts) and Banjarnegara District (Batur, Pejawaran and Wanayasa subdistricts). These are all upland montane with undulating topography and elevations of 1,000 – 2,000 metres above sea level. In all of these subdistricts, around 70% of the population is involved in farming, either as farmers or as farm labourers.

To get to Pangalengan Subdistrict, it takes around 3 - 4 hours from Bandung by bus or minibus, while Kertasari takes an additional two hours from Pangalengan. Similarly, it takes around 4 - 5 hours to get to Cikajang, Cisurupan and Pasirwangi subdistricts (Garut District) from Bandung by minibus.

The subdistrict locations in CJ can be accessed in around 45 minutes to 1.5 hours from the district towns, or around 5 hours from Semarang, the provincial capital.

The potato and cabbage producing centres in SS are in Tinggi Moncong Subdistrict, Gowa District at around 1000-1800 m asl. These can be accessed in around five hours from Makassar by chartering or hiring a car, as public transport only operates at certain times.

Another program location was in NTB, in Sembalun Subdistrict, East Lombok District at elevations of around 1,100 – 1,500 m asl. To get to Sembalun Subdistrict, you can take a minibus from the district town for a two-hour journey along a steep, winding road, but public transport only operates at particular times. The location is in a large, flat basin at the foot of Mount Rinjani.

2.2 Vegetable crop farming situation (Brassicas and potatoes)

Potatoes and cabbages are highland crops that require elevations of above 1,000 m asl to grow. Indonesia's potato needs can be covered with a growing area of approximately 70,000 ha/year, whereas in 2006 potatoes were grown on only around 50,000 - 60,000 ha/year. Based on farmers' experiences in these regions, average potato productivity is around 12-20 tonnes/ha, and cabbage about 21 tonnes/ha. Potatoes and cabbages are the main source of farming families' incomes, so increasing income for the vegetable sector can be achieved by increasing production and reducing production costs by farmers, for instance, producing their own seed, and reducing pesticide and chemical fertiliser use of their crops. To support their farming enterprises, most farmers rear livestock to produce organic fertiliser, though the amounts produced are insufficient, and must be supplemented by fertilisers from outside. Farmers generally own between 0.25 - 1 ha, or land, though some richer farmers can own scores of hectares. Many farmers also rent land for growing their crops.

The cropping patterns of most farmers in CJ and WJ have been: potato - cabbage - potato, potato – potato - potato, potato - cabbage – spring onion. The first planting season begins in September-October, the second in February and the third in May-June. In cropping, however, things that also need to be considered are rainfall and production cost conditions for every commodity.

In SS (Gowa) there is an average of only two planting seasons a year with the cropping pattern: potato - cabbage - legumes, potato – other vegetables - legumes. Only a few farmers have enough water during the dry season and plant three times with the following cropping pattern: potato - cabbage - carrot, potato - potato - potato, potato - cabbage – spring onion. The first planting season is in September with potato, then cabbage is planted in February, and then in May dengan with spring onion - potato - cabbage/or other crops. The land is left fallow between July -August.

Potatoes only began to be grown in East Lombok (NTB) in 2001 - 2002 in collaboration with IVEGRI. The cropping pattern in East Lombok (Sembalun Subdistrict) is: rice - potato - potato, rice – potato - garlic/other vegetables. The first planting season is in December with rice, the second in May; usually with vegetables including potatoes, and the third with potatoes or other vegetables. This cropping pattern is relatively good as it can break vegetable pest and disease cycles by growing rice.

Generally, around 20% of farmers source their seed potatoes from seed farmers, and around 75% from local markets, while 5% use certified seed. This means that certificated seed requirement can only meet 5-7% or total seed requirement in Indonesia. In East Lombok, seed is still sourced from Java or is imported from overseas.

2.3 Development potential

Potential in the regions includes:

- Factors supporting vegetable farming development in these regions include: the amount of land still available, particularly outside Java. However, this needs to be managed optimally to maintain fertility levels and conservation.
- Soil and water conditions are quite adequate for developing vegetable crops.
- Organic fertiliser is readily available either from livestock, or from other sources of organic material.
- Bio-pesticide materials are also available in the locations, so bio-pesticide production skills will slow the use of synthetic pesticides.
- Some farmers have seed propagation skills, which, if developed, will provide affordable quality seed for farmers.
- There are still farmer groups that can be developed to become more advanced.

2.4 Existing problems

The main problems affecting potato and cabbage farming are:

- Many pests and diseases are difficult to control: bacterial wilt, late blight (*Phytophthora infestans)*, aphids, thrips, potato tuber moths (*Phthorimaea), Liriomyza*, potato cyst nematodes, clubroot, cabbage cluster caterpillars (*Crocidolomia)* and *Plutella xylostella* on cabbages.

- Pesticide use is high in vegetable farming, both in terms of application frequency and rates. Pesticides used in one season can reach 4 - 18 litres through up to 20 applications.
- Less manpower is available for farming as many young people are happier to leave their villages than to stay and farm.
- The seed farmers use is generally low quality and of uncertain origin. Many farmers do not have the skills to recognise good and healthy seed.
- Soil fertility is falling due to constantly being farmed and excessive use of chemical fertilisers and synthetic pesticides.
- High prices of inputs (chemical fertilisers, pesticides, seed) greatly impact upon farmers' incomes.
- Limited farmer market networks, which forces farmers to sell their produce to brokers who frequently manipulate the prices paid to farmers.
- Farmers' limited access to capital due to the low levels of trust shown to farmers by both government and private banks
- Limited information access with the regions being far away from information centres and no information reaching farmers.

These issues generally apply to all regions. Therefore, the Optimising the Productivity of Potato and Brassica Cropping Systems project can alleviate the problems facing farmers.

Overall, 32 farmer groups with 636 members conducted these activities in 13 subdistricts, 6 districts in 4 provinces. Project activities were conducted through the farmer field school approach and ran for almost 4 years in CJ and WJ, and around 2 years in SS and NTB.

3 Project objective

The overall aim of the project was to help farmers in CJ, WJ, SS and NTB to improve sustainability and productivity as well as income through more efficient potato and cabbage cropping systems appropriate to existing potential.

3.1 Project interventions

Interventions included:

1. Holding training for potential facilitators from government and communities in four provinces;
2. Agriculture offices facilitating learning processes through ICM-FFS then FIL learning-by-doing (LBD) plots in each region and LPTP assisting facilitators and groups in all regions
3. Encouraging groups to conduct trials and experiments to help solve farmers' problems
4. Encouraging facilitators and farmers to develop study media for farmers, and produce films, posters, leaflets and manuals to help with the transfer of easy to understand information
5. Conducting a project social impacts study to see its environmental and social influence
6. Presenting farmer seminars with agriculture offices and IVEGRI, as a means for sharing information and all new farmer group findings between the regions
7. Monitoring and evaluating with agriculture offices to determine project developments and achievements.

3.2 Project outputs

1. Application of integrated management of vegetable yield through proper farming and post-harvest management.
2. Developed and implemented low-cost plans that can improve farmers' access to quality and improved potato seed.

4 Social Impact Study Implementation Methods

4.1 Objectives

Objectives of the ACIAR program social impact study were:

1. To prepare a portrait of the optimising potato and Brassica crop productivity project;
2. To ascertain the positive impacts of the optimising potato and Brassica crop productivity project;
3. To formulate input on project implementation, as the basis for preparing further programs.

4.2 Locations & Research Times

Social impact studies were conducted in six districts across four provinces in 2010 as shown in Table 4.2.1.

Table 4.2.1. Locations and participants in the social impact study.

Study Districts	Time	Number of respondents			
		Participants		Facilitators	Govt.
		FIL	Non FIL		
Central Java					
Wonosobo	8-13 Feb	6	4	1	1
Banjarnegara	8-13 Feb	9	6	4	1
Sub total		15	10	5	2
West Java					
Bandung	1–5 Feb	6	5	2	1
Garut	1–5 Feb	9	5	3	1
Sub total		15	10	5	2
West Nusa Tenggara					
East Lombok	13-16 Apr	12	5	3	1
South Sulawesi					
Gowa	12-16 Apr	12	5	3	1
Total		54	30	16	6

4.3 Data and information sources

Qualitative data and information in this research included:

1. Observation outcomes: detailed descriptions on situations, occurrences, people, social interaction, and behaviour observed directly in the field in relation to farming management activities

2. Discussion outcomes: direct quotes from people's statements regarding experiences, attitudes, and views on growing potato and cabbage crops
3. Written materials: extracts from, or complete project documents, written communications, records and reports

Data or information was taken from various data sources, whereas data sources used covered:

1. Informants

In qualitative research (impact studies) emphasis was on depth of data and field information. So to find informants, the model used was Goetz & Le Compte's criterion-based selection (1984). According to Patton (1983), the choice of informants can probably develop according to needs and researchers' data collection capacity.

Informants during the impact study were:

a. FIL participating farmers amounted to 54 people from farmer groups throughout the districts of Bandung, Garut, Wonosobo, Banjarnegara, East Lombok, and Gowa
b. Thirty non FIL farmers from around the FIL locations
c. Sixteen FIL facilitators consisting of facilitator farmers and agriculture office extensions officers
d. District agriculture offices from Bandung, Garut, Wonosobo, Banjarnegara and East Lombok, the SS Provincial Agriculture Office, and the SS and NTB food crop research agencies.
e. Records and official documents in the form of ACIAR program proposal "Optimising the Productivity of Potato and Brassica Cropping Systems in West Java, Central Java, West Nusa Tenggara and SS" (Project CP/2005/167), FIL activity reports from each group on the ACIAR program.

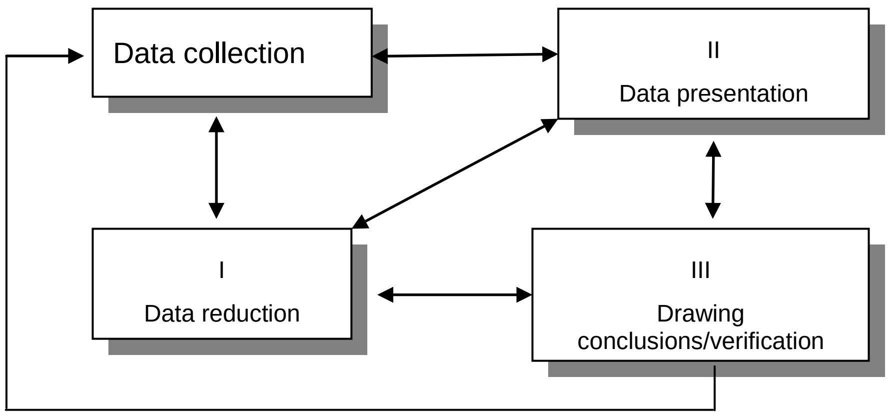
4.4 Data collection techniques

The methods used in this study were qualitative deductive methods put in context descriptively with cases as study findings. The methods used were as follows:

1. Interviews (in-depth interviews, focus group discussions). Interview instruments are attached
2. Field observations (visual photos, observations in the field)
3. Analyses of documents (project proposals, activity reports, group documentation).

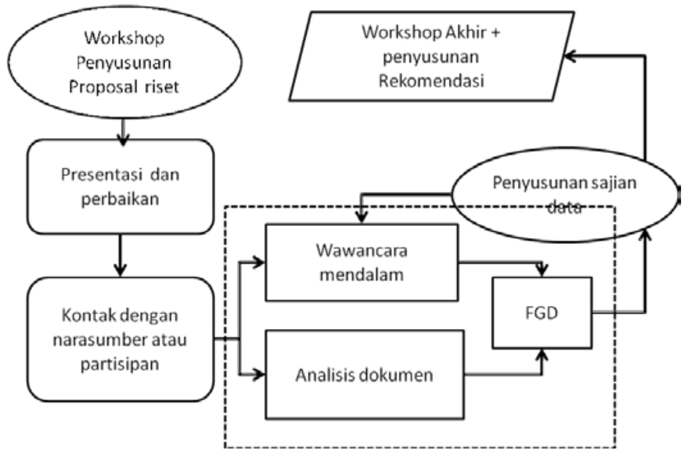
4.5 Analysis techniques

Interactive analysis techniques covered data reduction, data presentation and drawing conclusions or verification. Activities were conducted in interactive form with the data collection as one part of a cyclical process. Information and other sources collected went through a truthing process (reduction) to become facts. Subsequently, the presented facts were interpreted or analysed using a theoretical framework to draw conclusions. This interactive analysis process is shown below:



4.6 Flow and stages in the social impacts study

1. Flow of impact study activities



Translation of diagram text:

Workshop penyusunan proposal riset – Research proposal workshop

Presentasi dan perbaikan – Presentation and improvement

Kontak dengan narasumber atau partisipan – Contact with informants or participants

Wawancara mendalam – In-depth interviews

Analysis dokumen – Documentary analysis

Penyusunan sajian data – Data preparation and presentation

Workshop akhir + penyusunan rekomendasi – Final workshop and preparation of recommendations

2. Research procedures were as follows:

   a. Preparations covered:

      - Preparing research designs
      - Developing research protocols: finalising designs, developing guidelines for data and information collection, and preparing activity schedules
      - Establishing teams
      - Preparing locations and initial contact with already identified informants

b. Training for field research teams involving research consultants.

c. Fields research covered:

- Data collection in locations with observations, in-depth interviews and documentation
- Reviewing and discussing data collected (analysis), determining appropriate data collection strategies, and focus for further data collection
- Grouping data for analysis
- Developing forms of data presentation
- Formulating final conclusions as research findings
- Formulating policy implications as part of developing suggestions and recommendations in the final study report

d. Preparation of field findings covered:

- Preparing draft of field findings
- Research seminar held with experts and communities before report prepared in order to secure input and test findings

e. Research report preparations covered:

- Draft report preparation
- Workshop for review and improvements
- Report finalisation

4.7 Social impact study team

The impact study team members are shown in Table 4.7.

Table 4.7. Impact study team members.

No	Name	Role
1	Eko Istiyanto	Team leader
2	Rahadi, SPd	Research consultant
3	Purwono Yunianto	Coordinator
4	Zamzaini	Enumerator (SS)
5	Sulistyo	Enumerator (SS)
6	Budi	Enumerator (WJ and NTB)
7	Lilik Mukhibah	Enumerator (CJ)
8	Gunawan	Enumerator (CJ)

5 Impact Study Processes

5.1 Processes

Field research covered:

1. Making contact with potential farmer, facilitator and government informants to accelerate discussion and interview processes to ascertain information based on pre-prepared questionnaires.
2. Conducting in-depth interviews with informants in each location when they had free time, either during the day or in the evening. These interviews yielded sufficiently in-depth data.
3. Focus Group Discussions (FGD) to collect data and clarify information and look at the possibility of there being any new information. These were held with group members in several locations and also between different groups.
4. Conducting field observations – these were important to determine the actual situation in the field and took place after interviews and FGDs.
5. Documenting all activities as data for processing into information, and subsequently, reviewing and discussing the data collected.
6. Developing forms of presenting information from data and discussing study findings from drafts and research result seminars, then formulating conclusions and recommendations.

5.2 Problems encountered during the study

Problems faced by the research team included:

1. Technical problems in the field: it took a long time to gather information from respondents, enumerators had trouble meeting respondent farmers outside Java, as their arrivals did not coincide with regular group meetings. Consequently, evening meetings were quite effective for gathering information from respondents.
2. Difficulties understanding the local languages during discussions and interviews with farmers, particularly in Goa, meant local interpreters were required.
3. Could not meet the Gowa District agricultural extensions officer as he could not be contacted and lives far from the FIL site. Information could only be secured from facilitator farmers and officers from the SS Agriculture Office and Food Crop Research Agency.

6 Achievements against activities and outputs/milestones

Objective 1: To adapt and apply robust integrated crop production, pest management and post-harvest handling systems for potato and Brassicas suited to Javanese conditions.

no.	activity	outputs/ milestones	completion date	comments
1.9	Impact evaluation of ICM activities through i) survey of Brassica/potato farmer groups to measure changes in practices and perceptions and ii) case studies to identify social change impacts	Crop management, economic and social change attributable to the project documented.		

PC = partner country, A = Australia

Objective 2: To develop and implement low-cost schemes that significantly improve the access of Indonesian farmers to quality potato seed.

no.	activity	outputs/ milestones	completion date	comments
2.8	Impact evaluation of ICM activities through i) survey of seed farmer groups to measure changes in practices and perceptions and ii) case studies to identify social change impacts *(shared with activity 1.9)*	Document showing crop management, economic and social change attributable to the project.		

PC = partner country, A = Australia

7 Key results and discussion

A study of the impacts of the ACIAR program on 'Optimising the Productivity of Potato and Brassica Cropping Systems in West Java, Central Java, South Sulawesi and NTB', which took place in February – April 2010, has provided many benefits for FIL participant farmers in particular and surrounding communities in general.

This section explains the outcomes of data collection from primary sources (interviews and direct observations) as well as studies of existing documents. This information was obtained from data collected in CJ, WJ, NTB and SS.

The data was grouped by respondent: FIL participant farmers, non FIL farmers, facilitators, and related institutions or government offices. The final section looks specifically at problems occurring during the FIL activities.

7.1 Impact study outcomes based on participants of farmer initiated learning (FIL)

7.1.1 Before FIL

For many reasons, and with a multitude of aims, community groups sprung up in almost every village. These groups were formed for religious, social, cultural or agricultural purposes, with farmer groups and farmer field schools in integrated pest management being formed for the latter. Such groups were usually set up by the farmers themselves or in collaboration with the agriculture office or NGOs.

One type formed by farmers in collaboration with the agriculture office, LPTP and ACIAR is ICM-FFSs (Integrated Crop Management Farmer Field Schools) for potatoes and Brassicas. These were set up in the districts of Banjarnegara and Wonosobo in CJ, Bandung and Garut in WJ, Gowa in SS and East Lombok in NTB.

Beginnings of potato/Brassica farming

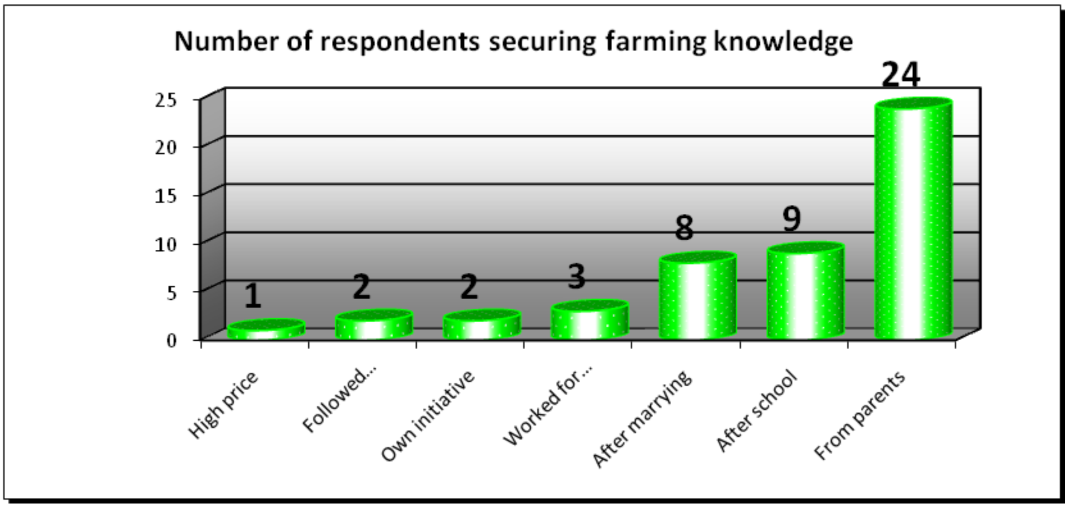
In Garut District in WJ farmers began growing potatoes/Brassicas for various reasons. Of the eight respondents interviewed, one said he followed friends as he was unsure how to grow them, and another said he learned from working in another person's field. Five respondents said they had learned from their parents, while one began growing vegetables after getting married. On average, they began to learn potato growing from around 1990.

Of the 12 respondents in Bandung District, six said that followed in their parents footsteps as farmers, one began farming after leaving school, three after marrying and two on their own initiative.

One farmer respondent in Banjarnegara District in CJ, Samsu Qodarmaji, said that he originally began farming due to needs, and conditions in the village pushed him to grow potatoes/Brassicas. Other participants, meanwhile, learned about growing potatoes/Brassicas instinctively or because it was common practice in local communities. Of five respondents interviewed in Wonosobo District, only one was tempted to grow potatoes or Brassicas by their prices. Some farmers began to grow potatoes from the age of about 20, while other respondents have been farming for generations. According to Ahmad Bared, they grow potatoes in line with what their ancestors have done for years. Another person said he followed farmers from Dieng in potato growing.

One farmer respondent in East Lombok District, NTB said he had learned to grow potatoes from his parents when he was small, while another seven said they had learned as teenagers, either from their parents or from neighbouring farmers. Four others learned to farm after marrying; working their own land and becoming members of the Horsela farmer group.

In Gowa District, SS, 80% of the 12 respondents had been growing potatoes for generations, while the remaining 20% learned from WJ businessmen Haji Rafiuddin and Haji Ilyas Supriyatna.



The graph above shows that most farmers grow potatoes and Brassicas because they learned how to from their parents after finishing school or getting married. However, some also learned to farm after working for other farmers, on their own initiative, copying friends, or attracted by the high vegetable prices.

Parties providing lessons in growing potatoes/Brassicas.

The eight respondents in Garut District said they learned from government agricultural extensions officers, neighbouring farmers, parents or potato businesspeople. Ujang and Asep said they had learned from their parents in law. Meanwhile, of the 12 respondents in Bandung District, five learned from parents, while the others learned from farming friends, agricultural extensions officers and pest observers.

Five farmers in Banjarnegara District said they learned about growing potatoes/Brassicas from other farmers, while the rest learned from agricultural extensions officers, parents, or pesticide sellers or formulators. Of the six farmers interviewed in Wonosobo District said most FIL participants learned ploughing, planting and harvesting techniques from their parents. However, one person, Ali Mazhar, said he had learned from neighbours who were already growing potatoes and Brassicas.

In East Lombok, farmers learned from watching their parents or neighbouring farmers. Other respondents learned either directly from agricultural extensions officers from the provincial BPTP office, or from the literature they provided.

Similarly, farmers in Gowa learned from family members, other farmer group members, the Agricultural Training and Rural Self-sufficiency Centre (Pusat Pelatihan Pertanian Pedesaan Swadaya (P4S) as well as from outside business people.

In each region, almost all farmers said they learned to grow potatoes and Brassicas from their parents, the agriculture office (agricultural extensions officers), from businesspeople and neighbouring farmers. Only respondents from NTB said they had learned from printed literature.

Potato/Brassica farming knowledge or technology

Potato/Brassica farming knowledge or technology developing in Garut and Bandung districts, WJ included: cultivation technology, soil preparation, seed bedding, fertiliser application, seed sorting and crop maintenance. Pest and disease management technology involved knowing application rates and how to use pesticides.

Meanwhile, in the districts of Banjarnegara and Wonosobo, CJ, 15 of the respondents interviewed said they had learned about seed selection and use, field preparation and planting methods, fertiliser application, pest and disease management, and harvesting methods. According to Ahmad Bared, a respondent from Wonosobo, there was nothing specific about the existing knowledge and technology; it had been passed down from parents. In potato growing, for instance, was a spacing of 60 cm between rows, in row spacing of 25-35 cm, and spraying intervals of 1-3 days.

Respondents in NTB had learned field preparation, seed selection, planting techniques, plant spacing, pest and disease eradication and comparing produce. These techniques still required improvements, particularly seed selection to prevent rotting, management methods that consider economic and environmental aspects, and appropriate production and use of organic compost.

In Gowa, SS, aspects requiring improvements were seed selection, management, planting maintenance, fertiliser application and pest and disease management.

Old knowledge needing improvement

Pre FIL knowledge requiring improvements is as follows:

No.	District	Knowledge and technology requiring improvements
1	Garut	Cultivation knowledge and technology: knowledge of soil pH, cultivation techniques, selecting quality seed, calculating harvest time, knowledge on pesticide use and seed potato growing technology
2	Bandung	Cultivation technology: ways to select good potato seed, knowledge of and measuring soil acidity, N/P/K nutrient deficiencies, soil management, appropriate application of chemical fertilisers according to needs, planting methods, appropriate and effective pesticide application, seed potato growing technology
3	Wonosobo	Land preparation technology, planting, spraying, maintenance and plant pattern organisation
4	Banjarnegara	Six respondents said that the excessive and inappropriate use of chemical fertilisers needed to be improved. Three respondents said that seed selection needed improving, so there should be further help from the agriculture office and related institutions
5	East Lombok	Cultivation methods beginning with land and soil preparation, balanced fertiliser use appropriate to needs, seed selection methods, planting methods, pest and disease management methods, seed production and processing methods, ways to produce good quality compost or organic fertiliser
6	Gowa	Crop management techniques, pest management techniques, how to mix pesticides and fungicides, farming enterprise analyses and cultivation technology to achieve optimum productivity

The table above shows that there is still a need to increase knowledge and technology regarding good potato and Brassica growing practices, developing alternative fertilisers and independent seed management. According to Ma'ruf from Wonosobo, what needs to be improved is when in the past depths reached one metre, now they are only 40 cm. Whereas, for fertiliser application should use ripe manure or now what is used is fermented CM (chicken manure).

7.1.2 During the FIL process

Beginnings of ICM-FFS/FIL in villages

According to respondents in each region, ICM-FFS/FIL began:

No.	District	ICM-FFS/FIL began
1	Garut	Six of the eight respondents said they began in 2007, and two started taking part in ICM-FFS in 2008
2	Bandung	Eight of the 12 respondents said they began in 2007, two in 2007 - 2008, and two said IPM began in 1998 and ICM-FFS since 2006 - 2008
3	Wonosobo	According to some participants from Mlandi, ICM-FFS has been in their village since 2006. In Tieng Village, ICM-FFS began around 2008, and in Tambi Village in 2007.
4	Banjarnegara	According to participants from Wanaraja in Wanayasa Subdistrict, the ICM-FFS appeared in 2007, while in Beji in Pejawaran Subdistrict, the ICM-FFS appeared around 2008.
5	East Lombok	In 2008, ACIAR facilitated ICM-FFS activities in Sembalun.
6	Gowa	ICM-FFS began between March and June 2009, with most villages beginning in June 2009.

History of FFS/FIL group membership in each region

Initial interest in becoming FIL group members

No	District	Reasons for becoming members of FIL groups
1	Garut	Desire to learn about cultivation, to study in groups to add insight into potato farming methods. Invited by group leader
2	Bandung	Wanted to join the FFS after hearing there would be group activities, invited to join the FIL by facilitator or group leader
3	Wonosobo	Seven respondents interviewed, said they had been invited by friends. According to Zaidah, an FIL group member from Mlandi Village, Garung Subdistrict, she joined the FIL group because she had an offer from friends. Two other respondents said they joined the FIL because they wanted to increase their knowledge of potato growing and environmentally friendly cropping patterns
4	Banjarnegara	From extensions and information from facilitators or group leaders, to represent the RT in the village, younger people given more priority and want to add insight about cultivation, invited by friends
5	East Lombok	A common wish to increase knowledge and skills to improve farming enterprises, so some members took part in FIL activities facilitated by ACIAR through recommendations from organisers, and some were appointed directly by BPTP
6	Gowa	Members' participation in FIL study groups stemmed from socialisation to farmers, around 80 % of FIL members were invited by friends or family

Reasons for joining FILs were almost identical in all the villages; an interest in learning, invitations from friends or family, appointment by group organisers or from government, or appointment to represent the neighbourhood. The most prevalent reason was invitation.

FIL study group membership selection and motivation:

No.	District	Member selection method	Motive behind the group
1	Garut	• Based on criteria, i.e. farmers always in locations and serious about learning • Appointed and determined by facilitators or group organisers • Own initiate, to learn	To increase knowledge or insight into potato growing
2	Bandung	• Farmers interested • Members chosen by facilitators • Some village representatives were invited to join the groups	Desire to know about better farming practices or cultivating healthy potato crops
3	Wonosobo	Three respondents said members were chosen for their interest, desire, activeness, and group awareness. One respondent, Hadman felt that other criteria included having land so farmers could practice what they learned in their own fields	Desire to increase knowledge and experience, particularly in farming enterprises, modern farming technology, and progressive ideas in growing potatoes and Brassicas
4	Banjarnegara	Seven respondents said that people were chosen/appointed to represent each RT, and two respondents said that FIL study group members were chosen if they were interested in joining the field school	Desire to improve farming methods, and increase knowledge about cultivation
5	East Lombok	FIL members were active farmers who wanted to learn and had their own land planting the same commodities as their neighbours. Though some put themselves forward as FIL group members	To increase knowledge of potato growing techniques so farmers become better and more successful
6	Gowa	Invited male and female farmers who were motivated, wanted to learn and had time and fields. Village governments also gave a picture of who was invited to join. Existing groups selected their members	FIL farmers were interested in increasing knowledge about potato and Brassica crops to increase yield and income

Respondents interviewed said methods varied for selecting members, and included using certain criteria, being chosen by groups or government offices, or based on interest. Their motivation was to increase their knowledge to optimise their potato and Brassica growing.

Types of group activities

FIL activities included:

No	District	FIL activities
1	Garut	1. Field schools, practicing in fields, carrying out observations, discussing observation outcomes, continuing discussions with all groups and the UPTD to analyse growth 2. Research or trials covering pest and disease research, seed trials, fertiliser use, proper pesticide use and new findings 3. Capacity building training covering making botanical pesticides and making bokashi 4. Developing study materials, to add knowledge and motivation, on good seed, land preparation methods and visits to other groups
2	Bandung	1. Farmer field schools 2. Research or trials covering fertiliser, Australian potato seed, using varying amounts of pesticides, varieties and laboratory testing 3. Group organisation to motivate activeness and sustainability, group contributions, depositing and borrowing
3	Wonosobo	All the respondents interviewed agreed FIL activities took the form of observations, research, trials/practice, crop monitoring, pest and disease observations and relaying materials in class. Materials are usually based on handbooks or pre-made curricula
4	Banjarnegara	FIL activities included observations, research, trials/practice, crop monitoring, observing crop pests, relaying materials and discussions
5	East Lombok	Activities covered: making potato demo plots, using organic fertiliser, planting techniques, research on potato late blight and pesticide treatment and doses trials Regular weekly meetings were held in the field to observe pests and diseases and try out materials from facilitators
6	Gowa	FIL activities conducted: practice, regular weekly meetings, seminars (aligning members' perceptions), research and observations in the field

ICM-FFS/FIL learning processes

The steps involved in ICM-FFS/FIL learning processes in Garut District were gathering in rooms, opening the event, facilitators explaining study objectives, making observations in the field, writing observation results, field transects and then presenting and discussing and responding to observation results. At the end of activities, conclusions were drawn and plans made for the following meeting. Later the change to FIL method meant the groups selected an appropriate management input to study from the Technical Toolkits that were prepared to support FIL. The testing of the management input was co-ordinated within the District by facilitators to ensure the several groups tested the same management techniques.

In Bandung District the first step was gathering in community rooms, followed by making study contracts and assigning tasks to group members, going to the crop fields, making observations of pests and diseases, collecting data on observation outcomes, holding group discussions and presenting discussion outcomes, discussing observation results and making follow-up plans.

The processes in Wonosobo and Banjarnegara districts were almost the same as in the districts in WJ.

The ICM-FFS/FIL learning process in East Lombok began with group heads opening events, observing crops in the field, making presentations and discussing them. An expert from BPTP was always in attendance. In Gowa, the process was the same as in the other regions.

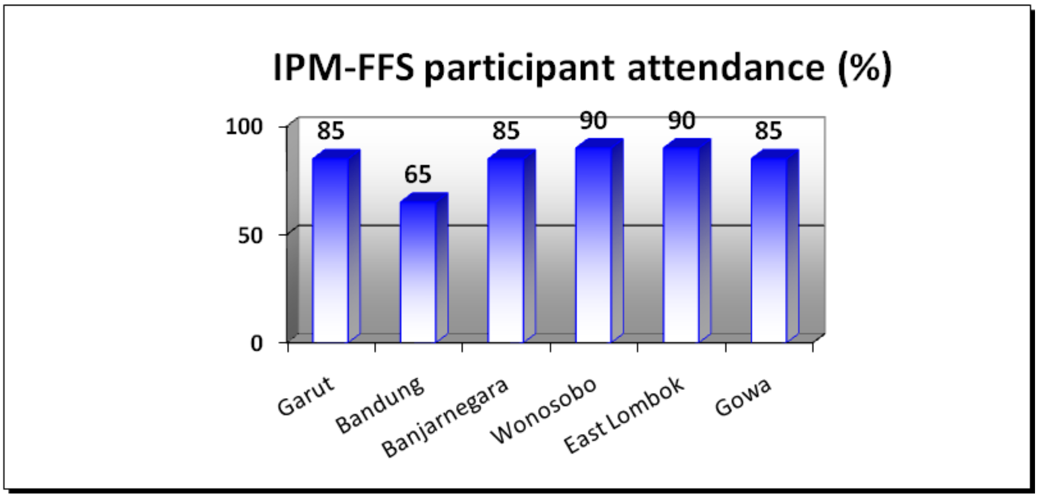
Group member attendance levels

Respondents said the level of attendance at FIL in the Garut District program region was 70%, 80%, 90% and 100%. In Bandung District attendance levels were between 50-80%. Absences were due to illness, other business, or meetings coinciding with spraying schedules or other pressing personal or work needs, or rain.

In Banjarnegara and Wonosobo districts in CJ, participant attendance was between 85% - 90%, indicating high levels of interest in attending field schools. Any non attendance had to be with prior permission, if not, members would be sanctioned in accordance with rules agreed together.

In the East Lombok District program region, according to four respondents attendance levels in each FIL group were 100%. One respondent said it was 97% and another 95%. Three respondents said 90%, and another two said 75% and 60%, so average attendance was 90.6%. The remainder did not attend either because they were busy or had family matters to attend to. Nevertheless, one respondent said that farmers other than group members would sometimes attend meetings out of curiosity.

According to respondents, FIL attendance in Gowa, SS was 80% - 90% or 2-3 not attending. Absence was due to illness, and a rule allowing family members to represent non attendees.



The graph above illustrates participants' enthusiasm to learn about farming. Any absences from FIL activities were due to other more pressing matters.

Efforts made by members to ensure FILs ran well

To help FILs run properly, group members in the Garut District program area frequently communicated with other group members, made activity schedules for discussion at meetings, formed farmer cooperatives or farmer group associations (Gapoktan), group managed enterprises and capital, and asked facilitators or experts to relay materials more clearly.

In Bandung District members obeyed group agreements and rules, joined all activities responsibly, relayed their knowledge from studies to surrounding farmers, conducted trials in the field, post-harvest management, and worked together to produce organic fertiliser.

According to Samsu Qodarmaji, a farmer in Banjarnegara District, imposing fines of IDR 20,000 on participants that did not attend would raise capital for group enterprises. According to eight other respondents, efforts included making joint agreements and improving members' attitudes. Zaidah and Salimin from Wonosobo District said there had to be agreements, all members had to attend, and invitations were used for meetings. Ma'ruf, Fathul Anam, and Bared said that in order for groups to run well, there had to be funding and group management of crops.

In East Lombok, field school schedules were made every week, and group members would remind each other of the schedules. Members always strived to attend, and make observations in accordance with field school instructions. Rules were agreed with strict penalties, though respondents did not elaborate on these. One respondent said that compost production was one activity that helped the group run well.

Finally, in Gowa, SS, facilitators directed participants to plant and practice what had been done in accordance with the FIL model, and made it a learning medium for comparing potato growing methods, maintained communication, harmony and openness between members.

Group members' duties, roles and responsibilities

In Garut District, respondents said they all played the same roles and responsibilities in the group for tending crops, doing voluntary work in group fields, participating in regular meetings as well as guiding, motivating and sharing experiences with other members.

In Bandung District, meanwhile, members have to adhere to group consensus in every activity, attend all meetings both indoor and in the field, and obey group rules to make it big and beneficial to the community.

In Banjarnegara District in CJ, each member has duties and responsibilities to encourage other group members, maintain harmony within the group to ensure continuity and sustainability of the field school, as to attend every meeting. Farmer members in Wonosobo District said that everyone had their own different roles and responsibilities including community relations, financial management and socialisation or just attending and learning.

Duties, roles and responsibilities within the group in East Lombok are assigned through deliberation. All members are obliged to attend every meeting and play an active role in discussions. The secretary notes all occurrences, and the chair is responsible for group activities. One respondent said that every FS member had to apply what they learned from field schools in their own fields.

Meanwhile, in Gowa, SS, members took turns in conducting observations, drawing and presenting observation results, planning group activities, ensuring group cohesion, and reminding each other of members' duties and responsibilities.

Group management of funds

From study outcomes in Garut District, respondents said that group capital originated from transport and food money, and little was use for growing potatoes; growing expenses and spraying was according to needs and by mutual assistance. Some respondents said there was no money managed in the groups.

Respondents from farmer groups in Bandung District said the money managed by the group originated from the ACIAR program for FS participants' transport and food, and the group agreed not to distribute it, but collect it for capital provision (group cash). The funds were used for group administration and development by planting crops other than project crops, buying seed, fertiliser, pesticides, group enterprise capital and shared enterprise land. All income and expenditure was recorded and books kept.

Respondents from Banjarnegara District said funds were managed jointly for a shared potato seed growing enterprise, and all are responsible for their duties and roles. According to Imam Mustamil, meanwhile, the money was used for practicing organic farming apart from the jointly managed potato and Brassica crops.

In Wonosobo, all respondents said that every group had cash that members managed together. The money was used for members' interests, such as for credit or group capital and procuring farming inputs. In addition, the FIL group in Mlandi Village also used cash for practicing together in the fields.

In East Lombok, there were no special FIL group funds from the project, so there was no separate financial management. However, the group called Horsela managed substantial amounts of money as it is working with Indofood marketing its potatoes.

Most farmer groups in Gowa, SS had no managed funds, but farmers got money for transport to training, and if members did not attend, then their transport money would go to group cash. Groups did not manage grants from the program or credit for groups.

Rules agreed by groups and how they are implemented

In Garut District, respondents said that rules agreed by groups included meeting rules, work schedules, particularly spraying, rules on attendance, on experimentation plots, and on how yield would be shared equitably and could be planted in all members' fields. All of these were coordinated by the group leader.

Farmer respondents in Bandung District said they have group rules and weekly meetings in their fields. Participants have to be on time, and present from 7:30 – 12:00, and must have permission for non attendance. There are rules for post-harvest sharing of produce. There are penalties for members: missing three meetings is deemed resignation from the group. Money is used for group cash requirements.

Farmer groups in Banjarnegara District also have rules agreed by consensus including having regular weekly meetings. There are fines for those violating group decisions, and the group decides on the amounts involved. FIL groups in Wonosobo also have rules agreed upon together. In Tieng Village, according to Fathul Anam, these are laid out in group statutes and bylaws. For all group members in the villages of Mlandi, Tambi and Tieng, there is a rule whereby participants who do not attend must pay attendance funds of around IDR 7,500 – 12,500, despite having asked for and being granted leave of stay. Cash collected was also in fact for joint interests, one of which was credit for members. Group members could borrow a maximum of IDR 1,000,000 for a cropping season. Interestingly, the management of the FIL group in Tieng Village formed divisions with members becoming supervisors.

Of the 12 participants interviewed in East Lombok, 10 said they had agreed on rules, for instance, on weekly meeting and FFS schedules, organised spraying patterns and crop thinning. However, the other two members said the group had no written rules agreed upon and enforced with strict penalties. Whereas, in Gowa, SS, every group has rules made and agreed by group members. Rules covered: attendance, sanctions and group activity plans. Rules ran well enough at the member level despite a few violations relating to attendance, but these were discussed and resolved.

Problems faced in activating FIL

According to respondents in the Garut District program area, problems faced in activating FIL were a lack of cohesion among farmers, their behaviour, meetings coinciding with more pressing jobs, problems making observations every day, group capital, and many people not yet knowing about the benefits of FIL. In District Bandung, problems were a lack of easy to understand learning media as many old men cannot be bothered to write, a lack of books on potato growing, problems understanding the materials, and a lack of understanding of pests and diseases. Other things were members' personal activities often coinciding with FIL schedules, members having to remind each other because they live far apart, no activities in the dry season. For cultivation techniques: excessive rainfall caused diseases to develop quickly.

Nine farmer respondents in Banjarnegara District said the problem was the FIL coinciding with farmer's normal working hours. According to other respondents the problems were a lack of adequate facilities/farming implements, meetings taking place in the morning which is the best time for working, and a lack of manuals on farming methods from ACIAR. Meanwhile, in Wonosobo District, problems are informants, problems in the fields and farmers' awareness. Three respondents said that informants lacking quality, lacking knowledge and not mastering the materials would be a dominant problem. Two respondents said that the problems were with the members themselves. In their opinion, group members being busy in the fields were the reason for their inactivity. Farmers own only small plots of land making it difficult to find land for practicing. One respondent, Ma'ruf, added that minimal funds were also a problem in activating FIL.

One respondent said the problem activating FIL in East Lombok was that elderly members had trouble digesting the information learned. Five respondents said that the distance to the location from home often meant group meetings would not start on time. Six respondents said there were no major problems. Problems in Gowa, SS, included a lack of understanding on nature conservation, a lack of understanding of the effects of pesticide residues, limited group funds for developing organic fertiliser and farmers' train of thought, which is always instant in looking at outcomes and learning processes.

Continuation of group activities

In the Garut District region, respondents said that if the ACIAR project finishes, group activities must still continue as they knew more about potato growing methods with the FIL. In future they want to study tomatoes and Brassicas. In Bandung District respondents said that groups should continue to exist and run even without an injection of funds, as they already have capital and provide benefits; sharing knowledge and experience.

All respondents in Banjarnegara District hoped that the group activities would continue, as they are beneficial to participants and constitute a vehicle for farmers to get together and share ideas on all the problems they experience, and hopefully find appropriate solutions. Meanwhile, in Wonosobo District respondents said participants still want to continue with FIL activities through routine monthly meetings despite the project ending. They consider FIL to be a part of their group and a vehicle for learning as indirectly the groups help them individually.

All respondents in East Lombok District said their group will continue even without the ACIAR project, and that their meeting place could be moved. Whereas, in Gowa, SS, almost all FIL participants are enthusiastic to continue with the FIL groups as they are a medium for farmers to increase their potato yields.

Ensure groups continue to function

In Garut District, respondents said that to ensure groups continue, they can put funds aside for group capital, which can be used for renting land to plant vegetables so they can learn together in the land provided, and also strive to disseminate group knowledge.

Respondents from Bandung District said that group members must be cohesive and work together, hold routine meetings, have group land and group funds/cash, and utilise existing potential. As they are interested in seed growing, groups have a deposit and credit system. Group activities include arisans (lotteries), group social gatherings, pooling funds for joint enterprises and post-harvest management such as producing potato crisps.

In Banjarnegara District, respondents said they would hold regular monthly meetings, and manage enterprises together, which will directly bond study group members. In Wonosobo District, respondents said that to ensure groups continue, there should be activities, communication, routine meetings once a month, monitoring and joint enterprises.

In East Lombok, efforts include intensifying weekly or monthly meetings, openness among members and groups, and all rules must be applied fully. In Gowa, SS, respondents said they will continue to hold regular meetings to nurture an understanding of the importance of working together in groups, maintaining the trust of every member and communicating and providing motivation to carry out better activities.

7.1.3 After the FILs

Motivation and reasons for disseminating knowledge to non FIL group farmers

In Garut and Bandung districts, respondents said they wanted to disseminate their knowledge to those near to the location, through visits to homes or in the field, as they had felt the benefits; improved standard of living, wise use of chemical pesticides and maintaining environmental health. Four farmers have disseminated information in Garut District.

In Banjarnegara District, all respondents want to disseminate knowledge to non FIL group member farmers. Similarly farmers in Wonosobo District have felt benefits from implementing environmentally friendly field schools, cutting down production costs, more appropriate handling being more profitable, and have changed cropping patterns or increased their productivity.

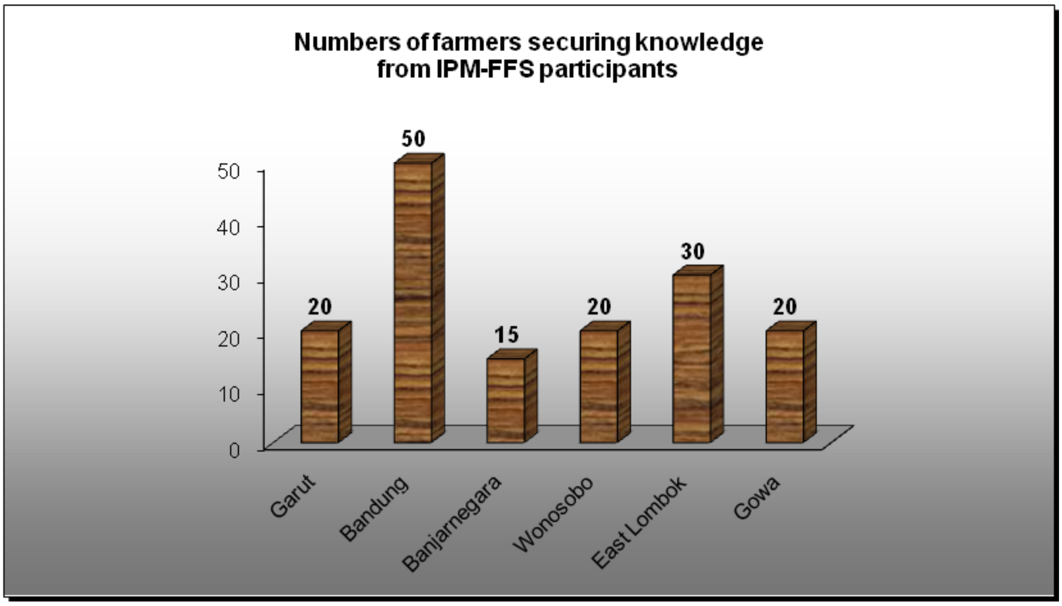
Farmers in East Lombok and Gowa also said that after FIL activities finished, there is still a desire to disseminate information on successes to other farmers so all would benefit, knowledge would continue to develop and farmers' livelihoods would improve.

Numbers of farmers outside groups learning from FIL participants and their locations

Ten farmers learned from FIL participants in Garut District facilitated by Rukman Salim. Five respondents said farmers in one hamlet around the village had had lessons. One respondent, Abdul Madjid) said that 10 other people had learned from FIL participants. In Bandung District, seven of 12 respondents said that knowledge was disseminated in one village, while the rest disseminated to around 5-15 farmers.

In Banjarnegara District, seven respondents interviewed said that many farmers both inside and outside the villages had been given lessons by FIL participants, though they did not mention exact numbers. According to other respondents, they disseminated lessons to 15 people in each RT (Rukun Tetangga = Village level classification of households). In Wonosobo District only around 20 outside farmers have felt the benefits.

In East Lombok, however, every member disseminated information to between one and ten people in their own villages and three outsiders. In Gowa, SS a field school participant could disseminate information to 2 – 5 non FFS farmers in or outside the program location villages.



The graph above shows that FIL participants care about other farmers. All respondents said they had disseminated knowledge to other farmers to the best of their ability.

Ways groups (individuals) provided lessons for other farmers, and materials taught

According to respondents in Garut District, other farmers were taught during visits, or when other farmers asked FFS members about the results of the field schools. Information (lessons) relayed included land preparation and appropriate use of pesticides or chemicals, crop cultivation problems, ways to make beds during the rainy and dry seasons, and about sterile soil for crop growth. In Bandung District, farmers discussed with others farmers they met in the farming land, in homes in the road or at the market. Information relayed included good ways to plant seed, lime application after measuring soil pH and soil preparation, good planting methods, good fertiliser application methods, ways to manage pests and diseases, using pesticides appropriately and at the right times, integrated pest and disease management methods, the dangers of poison on vegetables and food, food security, harvesting methods and sorting seed.

Meanwhile, according to some respondents in Banjarnegara District groups/individuals gave lessons to other farmers with discussions in the fields when they were working on or spraying their crops. They taught them about using chemical fertilisers in accordance with crop needs, using pesticides appropriate for the level of pest/disease infestation, and about good farming practices. According to Farid Fauzi information was relayed by gathering farmers together for informal discussions or meeting in the fields. Information relayed was about healthy seed, fertiliser application methods and pest and disease management.

According to respondents in Wonosobo District, participants disseminated information in a number of ways; through village events, gathering when there was a kenduri[1], meeting when working in the field or a spraying time. Materials relayed included soil preparation methods, seed selection, appropriate use of pesticides, pest and disease observation methods, balanced use of fertiliser and organic fertiliser, and also about the use of healthy seed.

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[1] Kenduri *is a Javanese ritual for wellbeing where many people get together.*

Similarly, according to respondents in East Lombok information was disseminated through discussions either when farmers asked questions, or when participants had the intention of passing on what they learned in field schools. Locations varied between fields and homes, and information relayed included: fertiliser application, introductions to pests and diseases, pesticides and spraying methods, managing pests and diseases by planting trapping crops such as maize around the edges of fields. These methods were also used in Gowa, SS, though more information was discussed, starting from growing conditions, seed selection, fields, planting and maintenance, pests and diseases, harvesting and storing produce, as well as the prospects for the commodity itself.

New ideas from villagers in planning programs after FIL finish

New ideas from villagers in Garut District included:

- ways FILs can be developed at the farmer level (outside the program) for commodities such as tomatoes, Brassicas and coffee. Then,
- running good government programs to increase production and farmer welfare and make them potato seed growers.

In Bandung District, farmers' ideas included continuation, groups not splitting up, becoming seed growers, and having comparative studies. Group enterprises needing development include the establishment of a seed growing cooperative.

Four respondents in Banjarnegara District had an idea for activities to make potato farming more successful and productive. Meanwhile, five other respondents hoped FIL activities would develop outside groups. Hamdan, Imam Mustamil, Zaedah and Makruf from Wonosobo District said they want to continue with the activities they studied and carry on learning as technology is always developing, while farming issues and problems become increasingly complex. Other respondents said they will form new groups to disseminate knowledge more evenly, and said there should be more FILs to support future activities.

Respondents from East Lombok proposed several ideas including producing their own potato seed, growing potatoes by increasing the use of organic fertiliser and spraying wisely and working with Indofood to produce chillies, so they still require further help from BPTP and ACIAR. Meanwhile, in Gowa, SS, new ideas from villagers for planning program activities included: applying and disseminating knowledge on FIL techniques to communities, continuing with regular group meetings, making plots for trials independently, particularly for commodities that were studied in FFS activities.

Forms of independent study groups in crop management

Independent potato crop management study groups have been formed in Cisurupan Subdistrict in Garut and in Bandung. Both the Jaya farmer group in Garut and the Warga Mandiri group in Bandung apply FIL principles.

The Ngudi Luhur group in Wanaraja Village in Banjarnegara District has formed and independent study group for managing potato crops together with other farmers and conducting trials facilitated by FIL participants. Five respondents from Wonosobo District said there is already an independent study group in Tedunan Hamlet, Mlandi Village, Garung Subdistrict learning about potato seed growing. According to three other respondents, their group is looking into becoming an independent study group.

In East Lombok there are no longer any independent groups due to there being a large group; Horsela, which is involved in organisation and potato marketing with Indofood. In Gowa, SS, only around 25% have independent study groups for managing potato crops through seed growing with own seed.

Farmers' independent experiments

Respondents in Garut District said FS members had conducted their own integrated pest management activities independently in their potato and Brassica fields. These independent experiments included spraying various pesticides and ploughing methods. In Bandung District, experiments involved seed growing, applying various kinds of homemade organic fertiliser, and trials with botanical pesticides and biological agents.

Farmers in Banjarnegara District in CJ said that seven respondents had experimented independently with Brassicas/potato seed selection. Subhan said he had conducted liming trials on Brassica crops to control clubroot, and Suyoto had undertaken PGPR (Plant Growth Promoting Rhizobacteria) treatment on potato and Brassica crops. In Wonosobo District, six respondent farmers also conducted trials with potato and Brassicas and other crops such as chilli, tomato, spring onion, celery, carrot, green beans and Dieng beans in their own fields. Two respondents: Fathul Anam and Ali Mashar said they had yet to conduct any trials at all in their own fields.

Eight respondents interviewed in East Lombok said that farmers had begun trials in their own fields including using detergent to manage crickets on their Brassica crops, using organic fertiliser on potatoes and Brassicas, and trials using the Granola potato variety.

Farmers in Gowa said that around 50% of farmers had conducted independent experiments growing potatoes or Brassicas by intercropping with other vegetables, such as tomatoes, leeks and carrots.

Existing potato farmer organisations

Respondents from Garut District said there is a potato seed grower group in the Mukti Tani group and organic fertiliser production in Telagasari. Bandung District farmers said there is a group network with Indofood for marketing potato produce, and almost all groups have potato seed growers.

In Banjarnegara District, according to Suyoto from the Bukit Madu farmer group in Kasimpar Village, Wanayasa Subdistrict, following FS activities, the group have worked together in growing potato seed, and all group members are enjoying the benefits and subsidising or assisting other groups in his village. The remainder is sold to other villages, such as Gumelem Village, Petungkriyono Subdistrict in Batang District.

In Wonosobo District, respondents said that organisations or group enterprises have developed. A respondent named Ahmad Bared from the Manunggal farmer group in Tieng Village, Kejajar Subdistrict, said that his group are now supplying and selling farming inputs, and are pioneering a farming production marketing organisation. Seven other respondents said their groups had yet to have any new organisations for developing farming enterprises.

All the respondents interviewed in East Lombok said that the FIL groups constitute part of the organisation/cooperative named Horsela, so the groups have not formed any new organisations.

In Gowa, SS, respondents said that until now no new potato farmer organisations have appeared in the groups, but there is an idea for groups to form a network.

Organisational management

Respondents from Garut District said the organisation was managed jointly and group meetings were held once a month. Whereas in Bandung District, respondents said no one could explain organisational management, though other members said that existing organisations had management.

Conversely, in Banjarnegara and Wonosobo districts in CJ, respondents said that potato seed growing was managed jointly or in groups. Roles and duties are adjusted for each member; some are involved in storage, in marketing or other functions. More advanced groups will provide guidance to weaker ones.

Respondents in East Lombok said the organisation (Horsela) will set up small groups to grow seed. It also has rules and statutes and a clear management structure. However, one respondent said he did not know how to manage the organisation because he had only recently become a member.

In Gowa, SS, respondents said that group management has so far been limited to routine meetings to discuss and plan activities, with additions if there a group finding activities.

Organisations efforts to collaborate with other parties

According to Respondents from Garut and Bandung districts, group member farmers work with the Indofood factory, the livestock office, plantations office and state forestry company Perhutani in developing potato.

Meanwhile, respondents in Banjarnegara and Wonosobo districts said that organisations had made efforts to collaborate with parties such as Indofood, the industry office, the agriculture office, and financial institutions to support their efforts.

Groups in East Lombok have worked with Indofood, BPTP, the agriculture office and private parties.

Two farmer groups in Gowa, SS worked with agricultural vocational high schools (SMK) and colleges to give students work experience during one potato cropping season and conduct research in members' fields. They also worked with large brokers in determining prices and supplying goods to markets.

Forms of collaboration by groups

In Garut District, groups worked with the government livestock and estate crops offices and Perhutani in developing livestock to produce manure, providing guidance to groups on environmental conservation and water sources. Groups also worked with Indofood on seed management, capital and marketing produce. Farmers in Bandung District worked with Indofood, which lent money to groups on the basis of a contract system for every harvest, supplied seed and bought groups' produce.

In Banjarnegara District collaboration involved financial institutions helping with capital for farming. According to one respondent, Subhan, cooperation involved price contracts and mutually beneficial commodities. In Wonosobo District, cooperation with groups was geared more towards provision of agricultural inputs, on principles of mutual trust and benefit.

Collaboration developed in East Lombok was with BPTP and the agriculture office in cultivation techniques, with Indofood in marketing Atlantic potatoes, with private parties in disseminating information on farming technology developments, and with Bank Indonesia for credit provision.

In Gowa, groups worked with colleges, BPTP, the agriculture office and seed businesses on principles of learning together and mutual benefit in improving their enterprises.

7.1.4 Social Impacts

Positions and roles of participants in the community or village institutions

Before joining the FIL, six of eight respondents in Garut District said that the positions and roles of FFS members were as normal farmers in the community. One was a farmer group manager and another in the village organisation and also chair of the farmer group. Meanwhile, 12 respondents from Bandung District said that participants acted as regular farmers (50%), while others were organisers in the village environment.

In Banjarnegara District, nine respondents said that villagers saw them in their farming management as normal farmers with unsatisfactory production. In Wonosobo District, four respondents said it was like normal and not particularly successful, while four others said they did not know.

In East Lombok, 12 respondents said participants were community figures, normal farmers, village government staff, hamlet heads and in the village development committee (LKMD).

In Gowa, SS, most respondents (75%) said their position and role in the community were only as farmers. Men still dominate village institutions.

Five of eight respondents in Garut District said that after joining the FIL, they remained normal farmers, while three others were farmer group managers. Six of the 12 respondents from Bandung District were normal farmers and the others were facilitators or RT/RW or PKK leaders.

Six respondents from Banjarnegara District also said that after taking part in the FIL the community considered them more advanced and results had been quite satisfactory. Two respondents felt no difference, and still considered themselves seen as common farmers.

According to Imam Mustamil a respondent from Wonosobo District, he was previously just a farmer, but is now a village development planning cadre. Zubaedah and Makruf are still active in village activities, while Ahmad Barid said his involvement in the village has increased and he is now helps with farming village conservation and is a member of the Dieng Plateau land rehabilitation work team.

Of the 12 respondents interviewed in East Lombok, one group member has become chairman of the Farmer Water Users Association (P3A). Another now works in the village administration and has been given a greater role as a water regulator. Ten other respondents, meanwhile, have experienced no change of status within the community. The majority (75%) of respondents from Gowa, SS said there were no changes, and around 20% said there were social changes with women becoming involved in village planning and another program (PNPM), and 5% not knowing about women's involvement in the village.

Field school participants have significantly different views of changes, and this will affect the process of disseminating results during studies; the braver and more open that participants become in speaking during forums, the more faith the village government has in them, and this has its own impact on village dynamics.

Villagers' opinions and views of FIL participants' potato and Brassica farming management

Before joining the FIL, respondents from Garut and Bandung districts said villagers viewed participants as not being able to farm, and never asked their considerations on farming. The same went for Banjarnegara and Wonosobo districts, where respondents said that villagers considered them regular farmers with generally unsatisfactory produce. Farmers from East Lombok and Gowa, SS felt similar.

However, after joining the FILs, several changes occurred. In Garut District, for instance, other farmers often ask respondents to discuss proper potato crop management, and many neighbouring farmers are following participants' methods. Also, in Bandung District respondents are involved in sharing opinions on potato farming, and are asked about proper growing and how to overcome pest problems. Villagers have responded more favourably.

Participants from Banjarnegara District have also felt similar views. After taking part in FILs, six respondents said that villagers saw them as more progressive and effective at farming. Two respondents felt no difference and were still considered regular farmers. According to Fathul Anam, a respondent from Wonosobo, things were still normal as a long time was needed for farming management using FIL approaches to be successful. Two other respondents, Ali Mashur and Ahmad Bared said there had been a positive response, particularly towards pest and disease management methods, and pesticide use had become more selective. Meanwhile, three other respondents, Makruf, Imam Mustamil and Hamdan said villagers remained unaware of their management methods and looked only at their production. Zubaidah and Sakimin, meanwhile, said they had become successful farmers.

The farmers in East Lombok are considered more knowledgeable and their farming deemed better than those who did not take part in field schools. Respondents have become discussion friends on potato farming. However, nine other respondents said things remained normal and they were not considered better than other farmers. Participants from Gowa, SS are viewed as farming potato and Brassica crops more successfully with increased production, so other villagers are copying them and practicing FIL models in their own fields.

7.1.5 Men's and women's roles in farming

In farming management

Before taking part in the FIL

In Garut District, respondents said that farms were managed based on other farmers' practices and what farmers had been doing for generations. In Bandung District, pesticides were used unwisely, management was disorganised, and farming was based on what other people said. Women's role was to prepare food to take to men working in the fields.

In Banjarnegara District, eight respondents planted and maintained crops without any planning or rules. According to Subhan, farmers controlled pests and diseases without plans or rules. In Wonosobo District respondents said that cultivation practices were based on habit with no rules governing fertiliser application or spraying, and no attention was paid to cropping patterns.

In East Lombok, respondents said that before joining FIL activities, practices were field preparation, seed procurement, planting, unbalanced fertiliser application, weeding, spraying without attention to doses or pesticide types, and harvesting. In Gowa, SS respondents said that if there were any pests, they were immediately sprayed with pesticides without paying attention to natural enemies.

After taking part in the FIL

In Garut District respondents said that there are deliberations with families, there have been changes in cultivation and appropriate spraying in accordance with group observation outcomes. These are starting to be practiced in farmers' own fields following developments from field schools in attempts to increase farming yield. Decisions on potato growing are made by consulting wives. In Bandung District respondents said they farm based on the theories and observations in FILs, they use pesticides wisely and manage wisely. Women take part in farming management.

Respondents from Banjarnegara said that they have begun farming according to rules and with plans. According to Toifudin, he now plants by looking at planting patterns and environmentally friendly technology. In Wonosobo District, respondents said that their sons now help observe crops, looking at types of pests and diseases, when to spray, and more selective use of pesticides. According to Ali Masher, daughters have been involved in planting and weeding before and after FFSs, while six other respondents said they are not involved in farming management since they are still at school.

Respondents from East Lombok said that after taking part in FFSs, they manage farming better, considering seed, pests, natural enemies, types of pesticides and spraying methods, harvesting and marketing. In Gowa, SS, cultivation is planned based on needs, paying attention to pests and natural enemies and considering economic and environmental factors.

Husbands and wives' roles in farming management

Before taking part in FIL

In Garut District they helped maintain crops and worked together to manage fields. Women helped till and work the land, prepared food, helped with harvesting, and helped with managing finances. In Bandung District, respondents said they worked together spraying, selling and planting. Wives helped in the field, prepared food, spent money and didn't really care.

Meanwhile, in Banjarnegara District all respondents agreed that husbands would farm the fields while their wives would take food to their husbands. In Wonosobo District, respondents that husbands spent more time managing their farming enterprises. Three respondents said their husbands would leave in the morning and come home at midday, and one respondent, Ali Masher said there was no clear division of time between husbands and wives. In East Lombok, respondents said that women's activities involved preparing food and taking it to the fields, cutting back grass and helping apply fertiliser to crops. In Gowa, SS, respondents also said that wives would help their husbands in the fields, look after the children and prepare food.

After taking part in the FIL

In Garut District, respondents said they could learn to work in the fields with their husbands, help prepare soil, prepare food and with harvesting, as well as helping to manage the finances. In Bandung District, respondents said there was consensus between husbands and wives, because there were certain rules, developing knowledge from FILs, wives helped in the fields, managed finances and administration as well as being involved in decision making.

Meanwhile, in Banjarnegara District, wives play a greater role in managing finances, help select seed and harvest together. In Wonosobo District, there have been no changes in roles since the FILs. In East Lombok, respondents said women have a direct role in farming management; preparing and delivering food, weeding grass, helping with fertiliser application and harvesting in addition to finishing routine tasks at home. In Gowa, SS, most of the FIL participants (90%) were single men, so men's and women's roles in farming management remained unchanged. Around 10% of respondents said there were minor changes in men's involvement in farming management, where they now used tractors instead of mattocks.

Sons' involvement in farming management

Before taking part in the FIL

Eight respondents in Garut District said their sons helped in the fields with crop maintenance and spraying, while four respondents said their children were still at school and not involved in farming. Of 12 respondents in Bandung District, one said his sons helped, one said his son was still at senior high school, while 10 respondents' children were still small.

In Banjarnegara District, eight respondents said their sons helped them to till their fields, and one's sons were still small. In Wonosobo District, Ali Masher said his sons were involved in planting and weeding, while six other respondents said their children were not involved in farming because they were still at school.

In East Lombok, five respondents said they helped in the fields when possible, applying fertiliser and weeding. Seven other respondents said their children were still small. In Gowa, SS, 90% of FIL participants were single men.

After taking part in the FIL

Of eight respondents in Garut District, four said their sons helped in the fields with spraying, crop maintenance, observations and practicing the results of field schools. One respondent said his son was still small and another said his son worked alone. One of the 12 respondents in Bandung District said his son helped with farming, another that his son would help during the school holidays and 10 other respondents' sons were still small.

In Banjarnegara District, meanwhile, eight respondents said their sons helped with farming management both before and after the FIL by tilling the soil. One respondent did not answer as he had no sons. In Wonosobo District, they helped to observe crops, decide when to spray, and what pests and diseases were so they could use pesticides more selectively. According to Ali Masher, his sons were involved both before and after field schools in planting and weeding, while six other respondents said they were not involved in farming as they were still at school.

In East Lombok, five respondents' sons' involvement changed little after their fathers joined the field schools. They helped prepare fields to the best of their ability by applying fertiliser and weeding. Seven other respondents' sons were still small. In Gowa, SS, around 10% of respondents said there were minor changes in their sons' involvement in farming management. Any changes were due to different equipment with sons now helping their fathers to use tractors.

Daughters' involvement in farming management

Before taking part in the FIL

In Garut District, one of eight respondents said his daughters helped with farm management and were also at school. Two respondents' daughters were still at school, one respondent's daughter only helped in the home and four respondents' daughters were still small and not involved in farming. In Bandung District, nine of the 12 respondents said their daughters were still small and not involved in farming, two said they helped with farming and helped their mothers, and one respondent's daughters were still at school.

In Banjarnegara District, eight respondents said their daughters helped with planting and harvesting, and one respondent did not have any adult daughters. In Wonosobo District, according to Ali Masher, his daughters are involved in planting and weeding, while six other respondents said they were not involved in farming as they were still at school. In East Lombok, they helped with weeding, delivering food and applying fertiliser (to the best of their ability). In Gowa, SS, 90% of respondents said their daughters' roles in farming management had not changed much, and most helped their mothers cook at home. Meanwhile, primary school age daughters went to the fields to help their parents to cut grass and bring food.

After taking part in the FIL

In Garut, Bandung, Banjarnegara and Wonosobo districts, all respondents said there were no changes at all before or after the FIL. Respondents in East Lombok and Gowa, meanwhile, said that men's and women's roles in farming management changed very little after the field schools.

Men's and women's time allocation in farming management

Before taking part in the FIL

In Garut District, eight respondents said men were involved in farming from 07:00 or 08:00 – 12:00 every day whereas women worked from 08:00 or 09:00 – 12:00. Some respondents said that women would sometimes help with harvesting. In Bandung District, 12 respondents said men's roles were tilling fields, crop maintenance, pest and disease management, harvesting, leaving for work in the morning. Women's roles were taking care of the home, and later in the day helping in the fields whilst delivering food.

In Banjarnegara District, nine respondents agreed that there were differences in the amount of time men and women spent farming. Men would spend the whole day in the fields, while women would only farm for half the day as they had to do housework as well. The same thing applied in Wonosobo District. Respondents in East Lombok said men go to the rice fields and women take care of the children and help in the fields, depending on the condition of the crops. They would usually leave together, but women would return home first, so men spent 80% of their time and women 20%. Men's role in the field was more dominant in Gowa as well at 70% with women at 30%.

After taking part in the FIL

Eight respondents in Garut District said spent the same amount of time farming after the FILs. Two respondents said they had observation schedules at least twice a week in the FS fields. In Bandung District, 12 respondents said things were the same as before joining the FILs, but with more attention to observations.

In Banjarnegara District, nine respondents there were no changes in time allocation after the FILs. The same was the case in Wonosobo. Respondents in East Lombok and Gowa also said there were no differences in men's and women's roles before and after the field schools, with men remaining at 80% and women at 20%.

Women's involvement in community activities (answers specifically from women)

Before taking part in the FIL

According to eight respondents in Garut District only one was involved in arisan while seven had no involvement in community activities. Of 12 respondents in Bandung District, seven said they were not involved in community activities, one was involved in education and four were involved in integrated health service posts, family health studies, arisan and Koran recitals. In Banjarnegara District, all respondents were men so there were no answers to this question.

A respondent from Wonosobo District, Zaidah, said she was involved in family health studies before and after FFS, while seven other respondents said women were more involved in household duties. In East Lombok, all FIL members were men, so there was no data. Most women (75%) in Gowa, SS said they were not involved in community activities, but some wives of FIL members or female participants themselves are involved in family health studies and the government PNPM program.

After taking part in the FIL

There have been no changes in women's community activities before and after FILs in any of the regions, but wives of FIL members or female participants themselves have begun to take part in community activities.

Reasons for husbands allowing their wives to take part in FIL activities

In Garut District, only one of eight respondents became an FIL member to increase knowledge and experience. In Bandung District, six of 12 respondents became FIL members to increase knowledge, insight, experience and skills in growing healthy crops and for goodwill.

In Banjarnegara and East Lombok, all FIL members were men, so there was no data, while in Wonosobo and Gowa districts, many women helped with potato farming management and increased knowledge on farming. "When our husbands ask us to buy them pesticides, we could understand their functions," said Hasnawati from Gowa. In addition, Tilong said, "so women's work is not just looking after kids at home and cooking."

Reasons for participants relaying information to spouses and other family members

Seven of eight farmers in Garut District gave no information before taking part in FILs because their wives did not know about farming and were not invited to talk. Only one respondent tried to relay information, though rarely, only at harvest time. However, after taking part in FILs, many things could be relayed to wives on the outcomes of FFSs, and wives also needed to know about farming developments. Of 12 respondents in Bandung District, six did not want to relay information because there was none and they did not understand and were afraid of making mistakes. Six respondents discussed farming management plans and problems with their wives after every FIL meeting.

In Banjarnegara, Wonosobo and East Lombok districts, both before and after joining FFS, respondents relayed information to their spouses and other families, to disseminate new knowledge. In Gowa, they only relayed information to their families after taking part in the FIL.

Types of information relayed

Types of information relayed before joining FILs in Garut, Bandung, Banjarnegara, Wonosobo and East Lombok districts was on land preparation, ways to secure good seed, cultivation methods, harvest produce, prices of inputs, and ways to manage pests and diseases, but in Gowa there was nothing. But after joining the FILs, information relayed covered seed selection, good farming practices, pest and disease management, differentiating between pests and natural enemies, maintenance (fertiliser application), and developing organic fertiliser.

7.1.6 Decision making

Farming decisions (in families)

Before taking part in FILs, of all respondents from Garut, Bandung, Banjarnegara, Wonosobo, East Lombok and Gowa, 90% said fathers made decisions regarding farming. However, after the FILs, 20 - 70% of farming decisions were made by married couples.

Ways of determining farming decisions

Before the FILs in Garut District, eight respondents said that fathers, as the heads of household, would make decisions in discussions, whereas, in Bandung District decisions were made in collaboration with brokers and by husbands. In Banjarnegara and Wonosobo districts, all respondents agreed that farming decisions were by family consensus both before and after the FFSs. In East Lombok and Gowa, however, men played the dominant role in decision making.

After joining the FILs, in almost all regions, 80% said they carried out observations in the field and held discussions with family members to make decisions on actions to take.

Considerations in farming

Twenty respondents in Garut and Bandung districts said considerations used in farming before joining the FILs just planting and expenditure. No thought was given to seed, prices, seasons, types of crops, seed price, fertiliser, and prices and types of pesticides. After taking part in FILs, considerations were seed quality, pesticide prices, environmental safety, observations, forms of cultivation, capital, seed prices, seed quality, selling prices, types of pesticides and their impacts on the environment and benefit principles.

Considerations used in farming before the FILs in Banjarnegara and Wonosobo districts were cheap seed, manure and chemicals inappropriate to crop requirements, seasons, capital and commodities. After joining the FILs, considerations were good seed, using fertiliser in accordance with rules and doses, using pesticides appropriate to pests/diseases, capital and planting seasons. In East Lombok and Gowa, 11 respondents said considerations were planting times/seasons, while one respondent said commodities, seed availability, markets, capital, and pesticides were considerations before deciding anything.

Post-harvest management

Eight respondents in Garut District said harvest produce management decisions before the FILs were mainly taken by husbands, while in Bandung District, six respondents said by fathers, five said based on discussions or consensus between husbands and wives, and one respondent said decisions were made by brokers. In Banjarnegara District 100%, and in Wonosobo 50% of decisions were made by husbands. In Sembalun (East Lombok) 100% of harvest management decisions were made by wives, and in Gowa decisions were made by husbands and brokers.

After the FILs, decisions in all regions were made by family consensus.

Dominant roles in determining how money from selling produce is used

In Garut District, 60% of respondents said husbands and wives played roles in determining how money from farming produce sales was used before the FILs. In Bandung, 40% and in Wonosobo 70% of respondents said it was managed by husbands and wives, but in Banjarnegara 100% of respondents said it was managed jointly. In East Lombok 100% was managed by wives and in Gowa 100% by husbands.

After taking part in FILs, in Garut, Bandung, Banjarnegara, Wonosobo and East Lombok districts decisions on spending money from produce were made by family consensus, but in Gowa, despite deliberations, wives actually played the role as they are better at managing money.

Uses of money from selling produce

Before there were FILs, all respondents from Garut, Bandung, Banjarnegara and Wonosobo districts said they used money from selling produce for household, everyday, farming or capital needs, paying school fees and debts. In East Lombok and Gowa, the proceeds of sales are used for everyday expenses, paying debts and capital.

After participating in FILs, respondents in Garut and Bandung districts said they used the proceeds of sales for everyday needs, business capital, children's education or school fees, paying debts or opening businesses, whereas, in Banjarnegara, Wonosobo, East Lombok and Gowa districts they are used for household needs, business capital, education or savings. Some respondents in East Lombok also set money aside for health needs.

Benefits felt during and after taking part in FIL activities

Respondents in Garut District said that they knew the objectives of the FILs; securing farming knowledge and experience with potato growing, adding insight on integrated farming to increase farming production, knowing types of pesticides and ways to use them, good seed varieties and species of natural enemies on crops, so that farming production could increase and other farmers and government officers could know about it. In economic terms, it can reduce production costs.

For respondents in Bandung District, benefits were increasing numbers of social gatherings, a means for exchanging opinions on vegetable farming from preparing land to harvesting, many friends, adding knowledge about potato growing, seed production skills, recognising healthy seed so production could increase and be environmentally friendly. Economically, production costs could be reduced, thus increasing income. Increasing skills in making bacteria for organic fertiliser, organic fertiliser, biological agents and crisp making. Adding study networks.

In Banjarnegara and Wonosobo districts all respondents said the same things: increasing knowledge and skills in potato Brassica growing, skills in making observations as the basis for drawing conclusions, so production is optimised and farming enterprises become more efficient. In East Lombok and Gowa, meanwhile, farmers became more skilled at differentiating between pests and natural enemies.

Suggestions for similar activities in the future

Eight respondents in Garut District said there was continuation and guidance from the government to help groups to become more advanced, so their farming enterprises can compete in the market and make farmers more prosperous. Similarly, respondents from Bandung District suggested continuing the program as lots of knowledge and skills can be absorbed, it helps access to capital, and groups had become learning centres for nearby villagers.

According to respondents in Banjarnegara and Wonosobo districts there is a handbook on potato growing techniques, comparative studies to add motivation and insight, and improved environmentally friendly technologies. Meanwhile, 50% of respondents from East Lombok suggested the program should continue, while others suggested additional locations/groups so information on farming technologies can be disseminated more quickly and Sembalun Subdistrict (East Lombok) can be a study centre for seed growing and a home industry training centre. Respondents from Gowa said they hoped to be given certificates as awards to help in village organisation, and wanted field schools for all crops including onions, tomatoes, Brassicas and carrots so production could increase by involving many farmers.

7.2 Impact study outcomes based on non FIL participant farmers

7.2.1 The presence of FILs

One hundred percent of respondents from Garut, Bandung, Wonosobo and Banjarnegara districts said they were aware of the FIL in their villages, while in East Lombok, only 33% of respondents said they did not know. In Gowa 100% of respondents said they were aware of the FIL.

7.2.2 Definitions of FIL

According to three respondents from Garut District, FIL are schools for improving farmers' agricultural knowledge, particularly potato crops, and their activities are about good potato farming and being more economical. Seven respondents from Bandung said integrated crop management field schools about potatoes were conducted to observe potato growth. Farmers in Banjarnegara said FIL are field schools for practicing potato and Brassica growing, and others defined them as schools where participants practice the theories they learn in class directly in the field.

Farmers from Wonosobo said farming training schools studied all agriculture. Respondents from East Lombok said that potato integrated field schools studied potato pests and diseases, and farmers in Gowa defined them as study activities for farmers with land to plant potatoes.

7.2.3 Farmers' responses to FILs

No.	District	Outcomes
1.	Garut	3 respondents said some people did not accept them as they were different from their potato growing habits. Almost all other farmers accepted the groups because they invited them to grow potatoes efficiently
2.	Bandung	7 respondents said that only some farmers could accept them, but in time all villagers would be accepting. FILs can be accepted because they research the condition of crops in the fields
3.	Banjarnegara	6 respondents interviewed said FILs could be accepted by all other farmers because they do not adversely affect non FIL participant farmers, and actually benefit them indirectly
4.	Wonosobo	4 respondents said villagers could accept them
5.	Sembalun	All respondents said villagers generally accepted FILs because farmers needed knowledge from group activities on proper potato growing
6.	Gowa	Around 75 % of non FIL farmers accepted these study models, practices or farming methods

Generally, in all locations farmers said they accepted the presence of FILs as they helped increase income through production cost efficiency, but not all farmers applied their practices as their fields are far from their homes.

7.2.4 FIL participant member selection methods

No.	District	Outcomes
1.	Garut	3 respondents said members of FIL study groups were determined by agricultural extensions officers and group leaders, invited by facilitators, by looking at farmers' potential. Also for the reason they wanted to know about potato growing methods
2.	Bandung	7 respondents said that FIL study participants were chosen on the condition that they were experienced, were starting out with little theoretical or practical farming knowledge, people who could be invited to work in group fields and community members interested in joining groups
3.	Banjarnegara	According to 3 respondents, FIL participants were selected from certain group members, those who attended and were active in every meeting and active in providing input and suggestions. 3 other respondents said FIL members were appointed to represent each RT, so information could be accessed quickly by other villagers
4.	Wonosobo	Of 4 respondents, 1 said he did not know whether members were appointed or not, while 2 respondents said whoever was interested could join, and one said through friendship or gathering you could enter the farmer group
5.	East Lombok	According to two respondents, FIL members were appointed directly by the group organiser. Four others said discussions were held beforehand to decide on FIL group members
6.	Gowa	According to a non FIL farmer, FIL members were recruited by facilitators, were farmers with speaking skills, were delegated by groups regions and were motivated with time available for study

All respondents in the regions said that most members were chosen by consensus or appointed by officers and group leaders based on conditions determine by the groups.

7.2.5 Differences in farming methods between FIL group members and non members

No.	District	Outcomes
1.	Garut	3 respondents said differences were sales through groups, seed provided by groups, pest and disease management looked at the pests and diseases first and then spraying, FIL members' farming practices were more planned in terms of planting and applying inputs than regular farmers FS members use lime in preparing fields, whereas some non FS farmers use lime and others don't
2.	Bandung	7 respondents said differences were FIL being based on theory and practice and usually had to follow directions from facilitators, researching diseased plants, and observations continued to take place in group fields every week Non FIL farmers work from experience without support from theories or farming schools, based on their own rules, do not research, but just spray. In their own fields there are no weekly observations
3.	Banjarnegara	According to 5 respondents, FIL members differ from non member farmers because they are beginning to be selective in using pesticides, and do not use excessive amounts of fertiliser, and according to one respondent, Wahono, FIL members use rules when farming, while non FS farmers just farm without using rules
4.	Wonosobo	1 respondent said he didn't know why crop growth was different, 3 respondents said differences were those not in FSs did things manually, while those that did got lessons from the government and government offices, FS groups use environmentally friendly concepts, while non FS farmers remain monotonous
5.	East Lombok	Four respondents said that FS participants made routine weekly observations, whereas non FS farmers made none. Two other respondents said participants made observations and analyses and then sprayed, while non FS farmers only read the labels on pesticide bottles and then sprayed their crops
6.	Gowa	Differences between FIL and non FIL farmers were in planting, spraying, making beds, production costs and yield: FIL: planting recognised seasons, spraying applied less pesticide, beds were more complicated and neater, production costs were lower Non FIL: planting paid little attention to seasons, more pesticides were sprayed, simple beds were made, and production costs were less economical

Generally, respondents said what differentiates FIL farmers from non FIL farmers are planning, observations and lower production costs.

7.2.6 Suggestions for improving FIL member farmers' growing methods

Three respondents from Garut District said suggestions for improving growing methods in the future were: 1) producing their own potato / vegetable seeds; 2) stricter supervision is necessary to ensure established rules are followed in the field; 3) spraying should timely and appropriate doses should be used.

In Bandung District, seven respondents said improvements were still required, so a longer learning process was necessary to increase knowledge and better research was required to address issues.

Six respondents in Banjarnegara District said that all FIL members still need to learn to practice study outcomes. Examples are unbalanced fertiliser use and not using proper planting patterns. In Wonosobo District, four respondents suggested improving seed selection methods. 50% of field school participants can select viruses, while non FFS farmers cannot, so skills need to be improved further. Land preparation needs to be improved in line with conservation principles.

In Sembalun (East Lombok), one of six respondents said bed making methods need improving, while one other said that post-harvest management required attention so prices are higher and more profitable. Four other respondents said that FFS participants' farming management methods were better than those who had not joined field schools. In Gowa, SS, FIL member farmers need to improve spraying techniques, knowledge of pests and diseases, and improve communication and dissemination of knowledge to other farmers.

7.2.7 Application of FIL activities for other farmers and their numbers

In Garut District, three respondents said that other farmers copied the pest and disease management methods because they were more economical and considered the number of seeds planted, amounts of fertiliser and the types of pesticides used. These farmers included six from RT Sukahaji, and four in Ngamplang, RT 03, RW 01, Cikajang, Karamat Wangi Village.

Meanwhile, in Bandung District seven respondents said neighbouring farmers also copied some of what FIL members were doing. For instance, rules must be followed in applying fertilisers and pesticides. Quite a number of farmers took part in practicing in Cibeureum Kertasari Village (no numbers mentioned). Some said just family members, while in Pangalengan Subdistrict around 20 people.

In Banjarnegara and Wonosobo districts, all respondents answered 'yes', but for different reasons. Fahrul Anton copied FFS members' practices because they could cut costs and be selective, whereas five other respondents said the reason was that pesticides were being used appropriately to target particular pests or diseases. In Banjarnegara, around 10 other farmers from each RT[2] followed and practiced what they saw coming out of the FIL, and in Wonosobo, 50% of villagers or around 200 farmers did the same.

In Sembalun (East Lombok), farmers generally copied what FS participants were doing; preparing fields, making beds, arranging plant spacing, and methods for planting, pest control, spraying and applying fertiliser. Outside farmers copying FIL members' farming management methods reached 80% of 800 people (some said 100, 300, 400 or 700 people were copying methods).

In Gowa, SS most non FIL farmers (70%) copied FIL participants' activities because they saw improved results. However, 30% did not want to do so because they considered FIL techniques to be more complicated, and without using them they could still enjoy their harvest yield.

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[2] *RT is the smallest neighbourhood unit in a village.*

7.2.8 Benefits for farmers in village areas

No.	District	Benefits for farmers
1.	Garut	• Know good potato growing methods • Can see and hear about new farming innovations and see direct proof of those innovations • Before there were FS members, those spraying were often poisoned, but not anymore, and now money is saved on insecticides and labour
2.	Bandung	• Increased community human resources capacity, increased farmer insight into better farming practices • Increased farmer welfare, increased production, reduced pesticide expenditure • A means for disseminating information and knowledge to other farmers • A place for farmers to discuss issues and share experiences
3.	Banjarnegara	5 respondents interviewed said benefits were additional understanding, additional insight/knowledge into farming methods, and according to one respondent, Wahono, benefits to farmers in villages are increased enthusiasm for growing potatoes, additional knowledge for villagers about pests and diseases and how to manage them
4.	Wonosobo	Four respondents said yield had improved, and knowledge and income had increased
5.	East Lombok	Three of six respondents said increased skills in managing pests and diseases, and three others said increased production had raised farmers' income from the previous year
6.	Gowa	Can develop technologies in using poisons or pesticides so relatively little is used. According to Abdulah Khalik, in addition to villagers and farmers being able to compare harvest produce from FIL members, they learn lessons about potato growing with a different model to that used in the community for generations. Other benefits are increased income for FIL farmers

7.2.9 Suggestions for improving existing FIL groups

District	Suggestions for improvements
Garut	Make information easy to understand for farmers Tighten control of finances for FIL expenses so it is not misappropriated by certain parties, make stricter rules that will be applied in its supervision For groups to run well there must be discipline
Bandung	Continue with earlier programs from ACIAR or others so they increase theoretical and practical knowledge of integrated farming Follow up in the future for requesting help with capital or seed My suggestion is learn vigorously, research and work in the fields
Banjarnegara	Involve other groups in FIL, hold frequent FILs to add knowledge as the longer pests and diseases develop, the more difficult they are to control, plant and sell quality potato seed
Wonosobo	4 respondents said: Disseminate knowledge through posters or other media Intensify socialisation to increase knowledge on farming production to other farmers
East Lombok	Three participants said add new groups so their knowledge can be disseminated to other farmers. Three other respondents suggested making sure existing groups continue to function actively
Gowa	Improve communication to farmers who do not know about effective farming methods Monitoring, assistance, controlling or looking at community farming conditions and providing guidelines or direction to farmers Increase members' attendance at meetings in existing FIL groups Increase farmers' enterprise analysis and marketing capacity

7.3 Impact study outcomes based on FIL facilitators

7.3.1 The bases for establishing groups

District	Results from respondents
Garut	Certain criteria were used in determining project locations: use of large amounts of seed, use of chemical fertilisers, and large amounts of pesticide in eradicating potato pests and diseases. The locations chosen were already potato producing regions. Other considerations were farmers' interest in developing new and better in potato growing methods, and communities' need to conduct research. In Garut District, average group membership was 20 people: 16 men and 4 women. According to some respondents, groups were established based on guidance or suggestions from the government
Bandung	Locations were determined by criteria looking at farmers' anxiety over using high levels of seed, pesticides and chemical fertilisers. In addition, the locations had no vehicles for group enterprises, and had a common need and desire to increase knowledge or potato/vegetable IPM technologies. Some respondents said that group establishment was based on a desire to get projects, as expressed by one facilitator, Amang Tarya. After following facilitator training, there was follow up from project activities
Banjarnegara	From a desire to add farming knowledge and common interests and need, particularly for seed. According one facilitator, Widodo, the group arose because there was a similar commodity in 1985, so the hope was there would be the same thinking about expectations or things they wanted to achieve
Wonosobo	According to Sadilan SP, groups arose due to common interests among group members; including a desire to increase potato productivity. There were also sociological and economic factors behind considerations to establish study groups. Sadilan said that income levels were still low
East Lombok	Three of four respondents interviewed said groups were formed because of the ACIAR program. The other respondent said there was a forum for learning together to observe potato pests and diseases
Gowa	According to facilitators, farmer groups were set up because: • There were problems of high levels of inputs for potatoes, so farmers wanted to gather and learn with support and facilitation from a government program • FIL famers could be in groups to learn how to increase potato productivity in their region

7.3.2 Group establishment facilitation methods

The establishment of groups in Garut District was facilitated in three ways: 1) Holding heart to heart meetings to ascertain villagers' interest in forming groups, and then conferring with villagers to form groups (deliberations with potential members), then consulting with agricultural extensions officers and setting up groups and organisers as well as work programs; 2) establishing groups first, coordinating with village authorities, villages strengthening groups and group work plans; 3) beginning with socialisation from the agriculture office (agricultural extensions officers), coordination with village heads to form farmer groups with the knowledge of subdistrict heads.

In Bandung District, facilitators told farmers about the importance of forming groups. The next process was for the agriculture office, village and subdistrict heads to strengthen group members. FIL implementation is theory and practice.

According to four facilitators in Banjarnegara District, group establishment were facilitated by socialising FFS to local farmers, holding meetings on joint ideas, providing information on the importance the activities and encouraging people to take part in field schools. Other methods were conducting socialisation, inventorying problems and critical points for potatoes, directing groups to grow their own seed so they were no longer reliant on seed from outside, and caring about other groups.

In facilitating the establishment of groups in Wonosobo District, Sadilan tried using adult education techniques, applying a method where group members teach and help each other. According to all respondents in Sembalun (East Lombok), group establishment began by gathering members (farmers in the region) to deliberate on the importance of FIL, and then forming FIL study groups.

Finally, in Gowa, SS, facilitators said the FFSs used already established groups. In addition, groups were also formed by inviting potential members from villages and giving them explanations about FIL. Most of these FIL members live close to the area, are good speakers and have time and land.

7.3.3 Making study groups more dynamic

<table>
<tr><th>District</th><th>Making study groups more dynamic</th></tr>
<tr><td>Garut</td><td>Study techniques: discussions with members to determine study contracts, input from every member’s experiences to be applied by all members (sharing experiences), study materials on healthy cultivation methods to increase income
Study media: groups learned directly in the field in experimentation locations
Support encouraged dynamic learning: routine visits from officials and extensions gave encouragement to members
Organisation: group guidance</td></tr>
<tr><td>Bandung</td><td>Developing study media, making displays appropriate to group processes
Developing group dynamics
Teaching techniques: telling about modern vegetable farming technologies and PHT methods for potato / Brassica crops
Group organisation: always transparent in all activity outcomes, developing group finances to replant crops using new techniques
Working together to provide experimentation plots, environmentally friendly use of pesticides and insecticides</td></tr>
<tr><td>Banjarnegara</td><td>According to facilitators the ways to make study groups more dynamic are common rules agreed together on group discussions involving all participants, having a principle of common enterprise makes groups strong and is essential for group resolution of all things. Other ways are having incidental and routine meetings, providing help with fertiliser and seed, for instance, so that participants learn to be more enthusiastic. Holding training sessions for farmers, if necessary, on seed growing</td></tr>
<tr><td>Wonosobo</td><td>To make FIL groups dynamic, Sadilan always invited group members and facilitators to carry out their own functions. He also explained that all people have strengths and weaknesses, so they must complement each other</td></tr>
<tr><td>East Lombok</td><td>To make study groups dynamic, facilitators made FS observation blocks, made pest and disease observations, presentations, then gave direction on the importance of forming groups</td></tr>
<tr><td>Gowa</td><td>To make study groups dynamic, facilitators used shared learning with the adult education model. There were no teachers or students, but every member had a role in the learning processes

In every meeting, notes were taken, explanations given, and groups discussed all problems in the field. Mutual respect among members maintained group stability</td></tr>
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7.3.4 Practicing activities in facilitators' fields

In the Garut District program area, facilitators also practiced knowledge learned through FILs in their own fields, such as ways to grow healthy crops, overcoming pest problems, integrated pest management methods and doses, ways to make botanical pesticides and utilising waste for organic fertiliser. They practiced themselves on one-hectare fields of runner bean, carrot and, cabbage crops. In Bandung District they practiced in their own fields first, and when results were good, they would pass on the information to all group members.

Facilitators in Banjarnegara District taught participants and also practiced themselves, so they would know not only theory, but practice as well. In Wonosobo District, facilitators learned many things and gained many experiences along with their FIL groups. According to Sadilan, knowledge gained in FILs was put into practice both in the class and in the FS field.

Facilitators in Sembalun Subdistrict (East Lombok) also practiced what they learned in their own fields (statement from one respondent) and FIL facilitators in Gowa, SS always practiced what was studied in the learning process beforehand in facilitating and practicing potato growing in the fields with their families. This was to show other members and farmers in disseminating FIL study outcomes.

7.3.5 Study group facilitation models

District	Outcomes
Garut	1. Regular facilitation in weekly meetings, or at any other time required 2. Discussion with farmer group to decide on learning contract, organising work plan, program and allotment of roles 3. Routine meetings with practicals and discussions of outcomes 4. Seed trials (local, G4, Australia, region local), pests and diseases (Phytoptora), thrips, Lyromyza 5. Collaboration between groups, subdistrict-level comparative studies 6. Utilised local natural resources 7. Training on potato seed certification technology innovations
Bandung	1. Participants were invited to the field to practice 2. Participants observed pests and diseases around crops 3. Explained outcomes of observations in the field 4. Participants were invited to discuss materials, share experiences with members and resolve problems together or inform members of IPM technologies 5. Learned ways to make groups dynamic
Banjarnegara	Three facilitators said group facilitation involved learning together in the field, there were no teachers or pupils and participants studied better processes together. In the event of problems, they were resolved with discussions between members. ToT for participants. Facilitator Widodo, likened the facilitation model to drops of oil; little by little can spread to other participants and continue
Wonosobo	The facilitation model applied by Sadilan was quite in depth because he applied the *ing ngarso sung tulodho, ing madya mangun karso, tut wuri handayani* teachings from Ki Hajar Dewantoro in facilitating the group in Kayugiyang Village, Garung Subdistrict, Wonosobo

District	Outcomes
East Lombok	Study group facilitation involved weekly crop observations in plots, discussions following observations, and plenary sessions after every two observations, and then evaluations
Gowa	Facilitators did not take on the role of teachers, but leaders for group practice in the field. Approaches involved visits to homes or other farmers' fields to discuss potato growing and FIL study outcomes

7.3.6 Things needing improvements

In Garut District things still requiring improvements are: 1) participants' discipline and harmony between members; 2) seed for experiments was procured too late, so it was too old and had not adapted to the field; 3) participants had trouble understanding agricultural extensions officers' language and use of foreign terms, and required further explanations; 4) supporting study media (libraries) that can belong to farmers, a lack of brochures, books and posters on vegetable farming, documentation of group activities, supporting equipment for group facilitation (soil pH meters to determine lime and fertiliser requirements); 5) pest and disease management: what factors cause wilting, ways to use pesticides.

In Bandung District, things that need improving are: 1) understanding of pest and disease research; 2) post-harvest management; 3) growing quality seed; 4) facilitators need training and study visits on marketing, entrepreneurship education management and cooperatives.

According to Ahmad Nurkholis from Banjarnegara District, things requiring improvements are experiments, as they have yet to have real results that FIL participants can feel. According to other facilitators, other things are facilitation skills and materials; facilitation methods felt inappropriate to participants who felt they were too monotonous. More attention needed from government offices, times were inappropriate or became drawn out, administration incomplete or recorded incorrectly.

In Wonosobo, problems felt by Sadilan were low group member participation levels, so members were yet to really feel the benefits. Participation needs to be improved. Facilitators in East Lombok felt that facilitators' knowledge and skills need to be improved, and to complement facilitation processes, better observation equipment is necessary so results are more accurate. As an example, there were either no soil pH meters, or the ones that were distributed were still relatively small.

Similarly, in Gowa, SS, according to facilitators, the thing still requiring improvement is group administration, particularly finances because in future groups also plan to tie membership to financial management, strengthening institutions and facilitator's capacity to facilitate group members to communicate with other farmers.

7.3.7 Study group strengths and weaknesses

District	Strengths	Weaknesses
Garut	• Members knowledge has increased and they have shared experiences • There are contributions to support group capital for shared enterprises • Good documentation, for instance: attendance registers, records of meeting outcomes, guest books, daily cash flow books, farmers keeping observation outcomes / research result documentation • Members responsive to new innovations • As learning centres for groups or other farmers • Some farmers speak on potato growing in the Cisurupan BPP	• Only a few members can provide input during discussions • Not punctual in meetings • Lack of harmony in meetings, documentation (photos, results of experiments) taken by officials • Yet to have cash flow books or libraries • Groups yet to manage any marketing
Bandung	• Groups always discuss their activities • Can be directed in terms of positive activities	• Minimal research equipment (magnifying glasses, pH meters, inadequate secretariat) • Capital required for potato and Brassica growing • Lack of knowledge on growing potato seed
Banjarnegara	Participant attendance levels of up to 100 % indicate enthusiasm or high levels of interest in FIL study processes	Some participants still not active in asking questions, no new topics discussed, members not punctual in attending meetings, inadequate facilities
Wonosobo	Enthusiasm to learn	Members still reluctant to voice their opinions and appear quite inactive
East Lombok	Members' skill on observation, recognising pests and disease, farming and IPM technologies have generally improved	Means and facilities not very supportive, group members cannot be active, not all study group members can disseminate what they have learned to other non-group farmers
Gowa	• Members can be mediums for study groups to meet and share with farmer members • Farmers more interested in discussing potato growing	• Problems understanding terms used in the learning processes • Inappropriate timing of routine meetings

7.3.8 Problems faced in building study groups

No.	District	Problems faced
1.	Garut	• Some FS participants' lack of confidence or shyness can diminish enthusiasm • Many opinions, but difficulties doing their jobs • Around 25 % of group members are inactive because they already know about potato growing and are busy

No.	District	Problems faced
		• Member numbers are limited by the pre-determined IDR 10,000 attendance fees, and IDR 3000 – 4000 for food, meaning those that take part have few funds for other things • Providing awareness outside FSs to prevent careless use of pesticides in pest and disease management (monitoring required)
2.	Bandung	• Lack of active participation (some only 50 %), some participants lack of enthusiasm in the learning processes • Lack of capital to develop vegetable, potato and Brassica cultivation
3.	Banjarnegara	Participants' lack of courage to voice their opinions. According to one facilitator, Amin Didik, a problem in building study groups is different levels of education and experience causing differences in the way participants think
4.	Wonosobo	Group member participation still low, members yet to feel benefits
5.	East Lombok	According to ten respondents, one group has trouble getting its members together due to the distances between them, farmers' different thoughts and wishes held up the learning processes
6.	Gowa	• Unhealthy competition among members over produce affects the atmosphere in study processes • Members still reluctant to voice their opinions and make decisions and give the impression of just following group opinions • Facilitators' lack of capacity in facilitating groups

7.3.9 Supporting factors used as considerations in establishing study groups

No.	District	Supporting factors
1.	Garut	• Potato farming has been in the region for generations and there are many potato farmers • There is little distance between farmers • Support from local government • Presence of study fields • A desire to change farmers' habits and become more progressive
2.	Bandung	• Common need for new technology or IPM or potato seed propagation • Desire to seek knowledge • Desire to learn modern technology • Wish for there to be a farmer association • Yield was always low • Farmers grow potato crops on their own initiative
3.	Banjarnegara	• Increased knowledge to seek solutions to existing problems, materials adjusted to farmers' problems and not fixed only on handbooks, so solutions to problems can be found appropriately and quickly • Villagers' wishes to learn more about vegetable farming, consideration for improving welfare
4.	Wonosobo	• Supporting factors include sociological and economic considerations or a wish to improve livelihoods • Villagers really wanted to learn more about farming, particularly vegetable farming • There were problems with potato growing so solutions needed to be found through FIL and materials adapted to farmers' problems • There were experts, or group leaders who could become farmer cadres or facilitators to continue with group facilitation
5.	East Lombok	• Three respondents said locations were close to each other and planted the same crop (Atlantic potatoes) • Farmers were encouraged to form groups because they could not make crop observations and did not know about management methods
6.	Gowa	• Farmers' desire to improve yield • Group members' potential and assets such as land, fields, sufficient water, and motivation • Encouragement from *Gapoktan* and village government • The presence of Pusat Pelatihan Pertanian Swadaya (a farming institutions set up by the agriculture office and the community) as a medium for farmer capacity building

7.3.10 Suggestions and input for forming community study groups

No.	District	Suggestions and input
1.	Garut and Bandung	• Groups must have clear objectives, particularly for their own members and for villagers in their community • A need for sustainable facilitation • Seek marketing networks for produce • Comprehensive study media, books, and brochures for group libraries • Research equipment (soil pH) • Group capital: group harvest produce can be made the capital for future plans so that all members can continue with activities • Seed growing development • Development of group economic enterprises, such as credit unions, opening up means for meeting non group member farmers' needs (kiosks)
2.	Banjarnegara and Wonosobo	• Materials appropriate to farmers' problems • Facilitation not optimal as they did not attend every session • Future facilitation methods: support from all stakeholders, supporting facilities, improved study concepts • Experts needed for every topic • With farmer groups, communities can increase their harvest yield, so further FSs and aid from the agriculture office is required • A model group approach with focus on the strengths or special qualities of every group
3.	Sembalun	• More training and cultivation skills required • FILs continue as farmers' learning places • More locations for FS groups so more farmers are involved • Additional equipment for studies, such as soil pH meters, moisture gauges, etc. • Binding rules for group members and clear programs • Officials from government offices should give more guidance to farmers on better potato growing practices: fertilisers rates, and appropriate use of pesticides
4.	Gowa	• Formal legality for village-level FIL groups so they can easily access programs, aid or capital • Help with capital that can be used to develop group activities • Continuing with FIL learning activities both in forming groups and growing potatoes • Increase facilitators' capacity with comparative studies and work placement in more advanced regions • Increase farmer group leaders' capacity

7.4 Impact study outcomes based on institutions and agriculture offices

7.4.1 Roles undertaken by institutions in supporting community study groups

No.	District	Roles undertaken
1.	Garut	• Facilitating farmers as FIL participants • Facilitating the determination of locations for FIL • Facilitating learning media: pH meters, leaflets, meeting places, weekly monitoring and evaluation in the field, and monthly for officers/facilitators • Undertaking district level obligations; collecting soil and water samples to test pesticide residues • Motivating field officers involved in the FIL program. Every month, the office assigned six field officers to undertake coordination and monitoring • Facilitating promotion through farmer markets every week in Garut District
2.	Bandung	• Facilitating and guiding farmer groups • Partnering farmers • Guiding farmer groups in crop protection
3.	Banjarnegara	According to Ir. Suhari from the Banjarnegara agriculture office, it was monitoring, motivating and evaluating study group activities in the classroom and in the field, so that participant felt the office was taking notice
4.	Wonosobo	Mufrodin SP from the Wonosobo District Agriculture Office explained that the office's role in supporting study groups was as a bridge between the farmers and the government or NGOs. Another role was to facilitate and provide facilities for study activities
5.	East Lombok	• Developing farmer group institutions • Providing guidance on farming enterprise cultivation techniques • Helping to increase yield • Handling and marketing yield
6.	Gowa	According to Arifudin, the agriculture office provided moral support to study groups, and defined the functions and objectives of program activities for both consultants and farmers. Support included providing information on seed and training for FIL farmers

7.4.2 Efforts by institutions to ensure the continuation of community study groups

No.	District	Institutional efforts
1.	Garut	• Nurturing ACIAR program farmer groups • Preparing new facilitator cadres for 4 subdistricts (Cijeruk, Gotambang, Cileduk and Samaran) for inclusion in the APBD regional budget for 2011 • Approaching suppliers in partnership activities for potato crisp businesses, already included in 2010 budget • Preparing potential certificated potato seeds to FIL farmer, H. Otang, and 5 farmers in Barokah FIL • Facilitating an agroclinic in Cisurupan with a crop pest observer
2.	Bandung	• Guiding and facilitating existing farmer groups • Facilitating learning means and facilities for IPM-FFS biological agent FFS and FIL activities • Including groups in activity planning for the 2010 – 2011 budget
3.	Banjarnegara	Following up on activities with other regular learning activities such as monthly meetings, seed growing activities that benefit farmers. These are intended so FS participants are more enthusiastic in learning, and not bored with what is taught in field school materials
4.	Wonosobo	Empowering study groups through agricultural extensions, making demonstration plots, potato seed growing training and efforts to fulfil learning means and infrastructure. According to Mufrodin SP from the Wonosobo District Agriculture Office, these activities are to ensure study groups continue to exist
5.	East Lombok	• Continuous or sustainable facilitation for farmer groups • Holding regular group meetings • Relaying new information on farming technologies
6.	Gowa	• Building strong coordination and communication so activities run smoothly • Regional government also has an idea to finance the continuation of FIL groups

7.5 Problems with management of FILs

The presence of FILs since 2006 has provided benefits for both group members and surrounding villagers. These benefits are not only increased knowledge and experience, but also increased income from potato and Brassica farming. However, there are still problems affecting farmer group and organisation development. These include:

1. A lack of capital for group cash, or minimal funding, limited funds for groups and farmers to develop organic fertiliser and cultivation methods.
2. A lack of study media or visual aids which are easy for members to understand, as some members are elderly and have problems writing. A lack of books relating to potato growing, and farming research facilities (farmer laboratories).

3. Problems understanding materials and speakers. Some experts/facilitators used language that was difficult for participants to understand, and had not fully mastered the materials they were presenting. Farmers always look only at immediate results from learning processes, which affected study outcomes. Therefore, any experts selected must be capable and work in line with their expertise.
4. Group member participation remained low because sometimes FIL meetings coincided with jobs that could not be left. In addition, groups having relatively elderly members also affected learning processes, so members should be chosen more selectively.
5. Organisation – a lack of group awareness for developing study groups as well as different levels of education and experience were major influences and led to differences in the way members thought.
6. Cultivation techniques. Problems of excessively high rainfall caused diseases to develop and reduce yield.

8 Impacts

Before potato and cabbage FIL were established, communities had already grown potatoes and cabbages for generations. Initially, the majority of local villagers grew potatoes or cabbages, learning by instinct until it became habitual. One respondent, Ahmad Bared from Wonosobo, said that they had grown potatoes based on what their ancestors had done for many years.

The exact date that potatoes arrived in Indonesia is unknown. However, potato crops have grown throughout the country since 1811 in the mountains of South Sumatra, Padang, Minahasa, and Java. The earliest known potato crop was in Cisarua, Bandung in 1794. This proves that farmers have been growing potatoes from generation to generation for a long time.

Since 2007, potato and cabbage FILs began to be established in regions like WJ and CJ. Later, in 2008 and 2009, they were developed in regions outside Java in SS and NTB.

Participatory FIL processes put more emphasis on the role of participants in seeking solutions to problems with growing potatoes and cabbages, which have impacted significantly on group member farmers. Group participants were not only given theories on growing potatoes and cabbages, but were also invited to practice directly in their fields. They were asked to monitor crop growth, draw conclusions and make joint decisions on what should be done with crops in the practical fields.

The majority of FIL members studied potato and cabbage cultivation for two planting seasons, and secured a lot of knowledge and experience. In the four-year timeframe of activities, participating farmers have felt many benefits for themselves and for non FIL members.

8.1 Scientific impacts – now and in 5 years

Enter text

8.2 Capacity impacts – now and in 5 years

8.2.1 Farming knowledge and skills

The presence of FILs since 2007 has been quite beneficial to group members and nearby villagers, not only in terms of increased knowledge and experience, but also in improving potato and cabbage farming production yield.

FIL member farmers' knowledge has increased significantly; all of the respondents interviewed said their farming knowledge had increased. As Fathul Anam from Wonosobo and Farid Fauzi from Banjarnegara said, knowledge in pest management is increasing steadily, particularly in pesticide use. Now they are more selective and careful in using pesticides, and adjust their use to their needs. Ahmad Bared, a respondent from Wonosobo added that he would carry out careful observations before spraying.

Many farmers admitted to excessive use of pesticides before taking part in FILs, and some even admitted to mixing different pesticides together. They would not make observations first, but spray in the event of pest infestation. Some farmers would always spray pesticides even though there were no pests or diseases on their crops in the name of prevention. Each season, farmers would use an average of 50 - 60 kg/ha with a spraying interval of once every 2 - 3 days. Now they use only pesticides 20 - 25 kg/ha in a season.

With this reduction in pesticides, farmers can be more economical in their farming enterprise expenditure. Almost all FIL member farmers in CJ, WJ, NTB and SS said their earnings had increased with reduced outlay for pesticides. Pesticide expenditure on average has fallen from IDR 15 million/ha, to a current average of IDR 8 million/ha, meaning a reduction of IDR 7 million due to fewer and more directed pesticide applications.

Farmers' knowledge of fertiliser application has also improved. Now they can produce their own PGPR (Plant Growth Promoting Rhizobacteria). In their opinion, PGPR can increase plant growth and control diseases, resulting in slightly less expenditure for pesticides and fertilisers.

Another skill that farmers feel has improved is seed selection. Farmers usually secured seed potatoes from the market or from other farmers, which they would plant repeatedly. When they got good seed, their harvest yield would increase, but it was not uncommon for yield to fall due to diseased seed also being planted.

Farmers can now select seed by themselves. They recognise the characteristics of good seed and now sort before planting. Farid Fauzi from Banjarnegara and other farmers said they are now much better at selecting seed.

During the field school processes, farmers were taught how to conduct simple experiments that they could apply in their own fields. Though not all FIL member farmers conducted experiments, others have developed experiments of their own. The emergence of researcher farmers in the program regions will certainly be a positive influence on neighbouring farmers. Simple trials developed by farmers include variety trials, fertiliser application trials, natural pesticides trials, etc.

Indirectly, farmers' capacity to carry out simple research is increasing. They no longer believe others who offer farming products without trials to prove their effectiveness. Many farmer researchers have emerged in WJ, CJ, NTB and SS.

With increased knowledge in potato and cabbage growing, now many non FIL farmers ask for members' opinions on certain matters. Suyoto, a respondent from Banjarnegara said that many other farmers want to copy what he has learned from FILs. Their initial apathy has gone after seeing the knowledge he has gained from participating in potato and cabbage FILs.

In accordance with what was planned in Optimising the Productivity of Potato and Brassica Cropping Systems in Central and WJ by ACIAR, that in addition to increasing farmers' profits, knowledge would also be increased. Farmers usually learn from what they see from others around them, so farmers participating in FIL could become examples and direct them towards profitable potato and cabbage farming in their communities.

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

See ACIAR Project Final Report AGB/2005/167 Appendices 2 and 4, Baseline economic survey of potatoes and Baseline economic survey of cabbage respectively.

8.3.2 Social impacts

By taking part in FILs, one respondent felt that he had developed the courage to speak in front of groups of people. During a group learning process, Ma'ruf was asked to present the results of his group's discussions. Initially he was embarrassed to do so, but overcame his reluctance and was able to present in front of all the groups. From that point, he said, his confidence has continued to increase.

Half of all other respondents interviewed also said they had become more confident to voice their opinions. Respondents from Wonosobo; Imam Mustamil, Salimin and Zaidah said their experiences in FILs had allowed them to meet other farmers, but also to share their views and experiences.

This courage to speak in public has led villagers to entrust various things to FIL members. Many farmer participants in CJ, WJ, SS, and NTB have felt changes. Where previously they had been regular villagers, now they are often invited to take part in village planning, become committee members in village activities and also RW or PKK heads.

Villagers have entrusted Ahmad Bared from Wonosobo and Suyoto from Banjarnegara with becoming work team members in a number of village activities involving outsiders, such as village conservation to restore fields in Dieng, Gapoktan, and other village activities. Ma'ruf from Wonosobo has now become the RT head in his hamlet, which is a source of pride for him.

In East Lombok, one FIL member was entrusted to become the chair of the Farmer Water Users' Association (P3A), become part of the village government and in charge of regulating water use.

With farmers having the courage to speak up and relay their experiences to other farmers, indirectly, local facilitators have emerged. In every FIL group, at least two farmers have become local facilitators, and have become more self-confident and motivated to develop and progress.

Following the FILs, independent groups have emerged, particularly in potato crop and nursery management. Potato seed producing groups have emerged, for instance: the Bukit Madu, Trubus, Sekar Tani and Ngudi Luhur farmer groups in Banjarnegara District, and the independent study group in Tedunan Hamlet, Mlandi Village, Garung Subdistrict in Wonosobo.

These seed potato production enterprises have succeeded in providing seed for their own members and other groups in the villages, and one in Gumelem Village, Petungkriyono Subdistrict, Batang District has even been supplying seed to others outside the district.

Independent groups have even emerged for farming inputs, such as the Manunggal farmer group in Tieng Village, Kejajar Subdistrict, Wonosobo, which provides and sells farming inputs and acts as a credit union for its members. Now it is looking into marketing both fresh and processed potato products.

In WJ, a number of independent groups have emerged, whose activities focus on FIL principles, i.e. the Jaya farmer group in Cisurupan Subdistrict in Garut District, and the Wargi Mandiri group in Bandung District. These farmer groups adopted technologies and learning processes in FILs before developing them into group activities.

In East Lombok District, there is an organisation called Horsela (Hortikultura Sembalun Lawang); an association of different groups that markets potatoes to Indofood. In Gowa, SS, the idea of establishing independent groups remains just an idea.

Groups have done a number of things to develop groups or organisations, including working with financial institutions to secure capital. They have worked with Bank Indonesia, to secure credit, and on land certification. So, indirectly, farmers have established networks with other parties.

Farmers and their groups need to work with others, not only with financial institutions, but also with government offices, Perhutani and NGOs to support group enterprises and allow them to develop rapidly. The Sekar Tani group from Gembol Village, Pejawaran Subdistrict, Banjarnegara, is even working with Gadjah Mada University in Yogyakarta on research into pests and diseases, and managing potato cyst nematodes.

Farmers have collaborated with large companies such as PT. Indofood, particularly in providing potato seed, capital and marketing. Despite having no written contracts, farmers agree contract systems and prices each season.

Some are working together with village governments, as with their support, all group activities are more easily accepted. In some FIL locations, village officials have also become FIL participants. This helps the groups to use village facilities such as village halls and village land, etc.

Gender - Men's and women's roles

The majority of female farmers only help their husbands, and are only considered everyday homemakers, despite playing a significant role in farming. Generally, the levels of participation and capacity to secure work opportunities are still low for women, as these are still dominated by men.

Men's and women's roles are clearly defined in farming management. Wives play a role in selecting seed, planting, harvesting and maintaining potato crops. Other roles are as homemakers, so in addition to working in the fields, they must also cook, prepare food and deliver it to their husbands working in the fields.

Families usually teach their sons about farming; digging, planting, spraying etc. from an early age, and they become involved when they become adults. After following FILs, they also teach them to observe crops to detect signs of pest or disease infestations. Daughters' involvement in farming is usually at planting, weeding and harvesting times.

The differences in men's and women's involvement in farming began when they were still small, and this has affected the knowledge passed down from parents to sons and daughters. A daughter will not be taught how to use a mattock or spray crops as those are a man's jobs. Women are only involved in the lighter jobs in farming.

Men usually work much longer hours in the fields, departing in the morning and returning home at midday. Women, meanwhile, only work half days from 08:00 to 11:30 as they also have to work in their households, and cleaning their homes, preparing food, and looking after the children requires a lot of energy. The burden for farming women ultimately increases.

Gender - Men's and women's decision making

Interviews during the impacts study revealed that women have yet to become more involved in decision-making, and female farmers are rarely involved in making decisions relating to farming. Almost all respondents said that men made the decisions on when to spray, the types of crops, fertiliser application, etc. Nevertheless, in some places in Banjarnegara District, women are involved in discussions relating to farming, but ultimately, men make the final decisions.

Female farmers are rarely trusted to make decisions relating to farming; determining seed type, what pesticides will be used, fertilisers, etc.

Similarly, decisions relating to harvest yield management and sales before FILs were always made by men. There have been some changes since FILs with men and women making decisions together in accordance with common considerations and agreements. However, this is only the case with a small percentage of FIL participants.

The proceeds of harvest production sales are usually used to meet families' everyday needs. Here women are the most dominant in determining how these proceeds are spent. However, since participating in FILs, some families put aside a certain amount as farming capital for the following season. There have been changes in the way villagers use the proceeds from their harvest yield.

8.3.3 Environmental impacts

Concomitant with lower pesticide costs detailed under *Section 8.2.1 Farming knowledge and skills*, according to Samsu Qodaraji from Wonosobo, environmental impacts have also been improved as reduced use of pesticides and chemical fertiliser means less damage to farming land. He has been growing potatoes and cabbages for years felt that as the years went by his soil had become harder and more acidic and led to ever-shrinking harvest yield. The lower, more selective and careful use of pesticides will indirectly improve environmental quality and of course influence the health of the farmers themselves.

8.4 Communication and dissemination activities

This impact study dealt one to one with many project participants and non project farmers. Individuals and groups consulted are shown in the Annexes.

9 Conclusions and recommendations

A number of conclusions and recommendations have been made from our findings in the field:

9.1 Conclusions

1. FIL study processes went according to plan and field school methodologies.
2. Group activities will continue in spite of the project having finished.
3. Learning processes have motivated FIL member farmers to conduct their own trials and research.
4. FIL study processes have provided benefits to participating farmers, and other farmers from inside and outside the FIL villages.
5. New roles have emerged in communities for FIL group members as their organisational capacity has improved. For instance, being entrusted with managing community institutions.
6. Communities have a positive view and opinion of FIL members is beneficial to farmers in particular.
7. There is more equality in the division of roles within families and farming decision-making, and deliberation has evolved as a means for decision-making.
8. Some FIL groups are working with various parties, from the livestock office, estate crops office, Perhutani, BPTP, agriculture office, Bank Indonesia, Indofood, agriculture high schools, and colleges, agricultural inputs, and collaborating with large brokers to support farming and production yield management.
9. There have been changes in knowledge, skills and behaviour in growing potatoes and cabbages in particular, and vegetables in general. There have also been changes in the way farmers manage their finances, with consideration for family living expenses, farming enterprise capital, children's education fees, and health costs.

9.2 Recommendations

1. For participants and farmer groups
    a. Need to strengthen organisational, administrative, financial, documentary and marketing management to improve the capacity of organisations as farmer learning centres
    b. Need to identify and increase facilitation, research and organisational skills in each farmer group
    c. Need to develop small-scale enterprises for farmer groups, particularly in production and post-harvest management
    d. Develop simple research together to improve skills and find new things in developing vegetables
    e. Strengthen marketing cooperation with Indofood, markets and supermarkets
    f. Strengthen district-level and inter-district FIL farmer networks to develop learning processes

2. For facilitators
    a. Need to develop capacity in facilitation, organisation, social analysis and policy studies in supporting sustainable farming management
    b. Need to develop further research at the FIL group level
    c. Encourage and strengthen FIL groups in efforts to build farmer learning centres.
3. For agriculture offices
    a. Develop or disseminate outcomes of group studies on farming knowledge and innovative technologies by preparing new cadres (local facilitators) to facilitate groups and develop surrounding regions, and strive to include it in regional APBD budget planning.
    b. Strengthen the development of trials and implement research outcomes at the group level
    c. Help and facilitate capital access for FIL groups in developing enterprises together with banks
    d. Maintain group sustainability by facilitating improved quality in terms of cultivation, post-harvest management, management, administrative and financial organisation as well as marketing networks by supporting funding from APBD/APBN budgets or other sources.
4. For NGOs
    a. Need to follow up and develop FIL facilitation models that focus not only on farming, but also marketing development
    b. Need to develop easy to understand farmer learning media to support information dissemination
    c. Strengthen facilitation and organisation methodologies for facilitator farmers or local organisers
5. For ACIAR
    a. Facilitate the development and dissemination of group study outcomes to other regions with similar topography that have yet to be facilitated by the program.
    b. Support is needed to improve ICM-FFS learning materials; both written and visual media relevant to farmers
    c. Support to develop further farmer-level research and placements for farmer cadres
    d. Support required to develop post-harvest management at the group level, and develop marketing networks

So ends this social impacts study conducted in the provinces of WJ, CJ, SS, and NTB. We hope that the results of this study will be beneficial for all parties involved and can be followed up in accordance with shared expectations

10 References

Goetz, JP & MD Le Compte (1984) Ethnography and qualitative design in educational research. Orlando, FL: Academic Press.

Patton, MQ (1983) Qualitative Research and Evaluation Methods (SAGE Publications, Thousand Oaks California)

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11 Annexes

11.1 Respondents names

11.1.1 FARMER INITIATED LEARNING PARTICIPANTS

Kode	Nama	Tempat / tgl lahir	Alamat	Nama suami / istri	Jumlah keluarga	Kepemilikan Lahan	Nama Kelompok	Status Keanggotaan Kelompok	Bulan/tahun masuk kelompok
01 /pst / Grt	RUKMAN SALIM	Garut, 24 Jan 1952	Kp. Sukahaji, Desa Cisero Kec. Cisurupan, Garut	Mimin	4 Orang	05 Ha	Sukahaji	Ketua	April 2009
02/pst/Grt	Nanang S	Garut, 25 Jan 1978	Kp Ngamplang, Ds Cibodas, Cikajang, Garut	Sari	3 Orang	1 Hektar	Tani Mekar	Anggota	November 2007
03/Pst/Grt	OBAY	08 Sept 1968	Kp. Cirandog RT 05 RW 04 Cisurupan, Garut	Ibu Rohanah	5 Orang	1,5 Ha	Tani Jaya	Anggota	November 2009
04/pst/Grt	Asep Tatang R	Garut, 23 Des 1972	Cirandig, Rt 02/01 Cisurupan, Garut	Neneng	2	Pemilik	Tani Jaya	Bendahara	Maret 2007
05/Pst/Grt	DADANG	Garut, 15 Juli 1965	Palalangan, Cisurupan, Garut	Diah	5	Sewa	Tani Jaya	Anggota	Januari 2008
06/Pst/Grt	AGUS NURDIANA	Garut, 08 Agustus 1979	Kp Pasar Wetan, Cisurupan, Garut	Belum Kawin	-	Tanah Garapan	Tani Jaya	Anggota	**Oktober 2007**
07/Pst/Grt	MAMAT	Garut, --	Cirandog, Cisurupan, Garut	Neni	4		Tani Jaya	Ketua / Anggota	Oktober 2007
08/Pst/Grt	Ajang Abdul Majid	Garut, 2 Oktober 1972	Kampung Sarimukti (HP : 085310010757)	Nur Hasanah	5 orang	200 tumbak	Mukti Tani	Ketua Kelompok	Oktober 2007
09 /pst/Bdg	Ujang Wahyudi	Bandung, 10 Desember 1970	Kampung Plered, Desa Cikembang, Kec. Kertasari	Pipik Kodar Ningsih	6 orang	Sewa ; 1 Ha	Tunas Tani	Anggota	Juni 2006

Kode	Nama	Tempat / tgl lahir	Alamat	Nama suami / istri	Jumlah keluarga	Kepemilikan Lahan	Nama Kelompok	Status Keanggotaan Kelompok	Bulan/tahun masuk kelompok
10 /pst/Bdg	Ibu Indah	Bandung, 2 Juli 1981	Kampung Palered	Asep Budi	3	Milik	Tunas Tani	Anggota	Juni 2006
11 /pst/Bdg	Heri Taryana	Bandung, 12 Desember 1982	Kampung Pleulered, Desa Cikembang, Kec. Kertasari	Rima	4 orang	Sewa	Tunas Tani	Anggota	Juni 2006
12 /pst/Bdg	Ujang kurniawan	Bandung, 27 Mei 1981	Kampung Plered	Yuyun	3 orang	Sewa	Tunas Tani	Anggota	Juni 2006
13/Pst/Bdg	ASEP S	Bandung, 23 Jan 1980	Cibeureum	Siti Komala	2 (dua)	1 Ha	Mekar Tani	Anggota	Tahun 2008
14/Pst/Bdg	A. GUNAWAN	Bandung, 28 Agustus 1979	Lebak Sari	Aas Sulastri	2 (dua)	9 Patok	Mekar Tani	Sekretaris	November 2007
15/Pst/Bdg	DEDI RIKMAYADI	Bandung, 17 desember 1980	Kp Sukasari RT 03/13 Ds. Cibereum			½ Hektar	Kelompok Mekar Tani	Anggota	Tahun 2008
16/Pst/Bdg	DADANG KOSWARA	Bandung, 25 Juli 1978	Jl Lapang Sari RT 02/15	Neng Yati Suryati	3 (Tiga)	½ Hektar	Mekar Tani	Anggota	Nopember 2007
17 /pst/Bdg	Ai Rohani	10 – 10 - 1969	Bab. Kiara, Desa Marga Mekar	Mamat R	3 orang	0,5 ha	Anugrah	Anggota	
18 /pst/Bdg	Ayin Kurniadi	Bandung, 15 – 09 – 1961	Babakan Kiara, Desa Marga Mekar	Nining Kurniasih	7 orang	Milik : 1400 m^2, Sewa : 5000 m^2	Anugrah	Anggota	Oktober 2007
19 /pst/Bdg	Wiwin Dewi Kuroesin	Bandung, 05 Juli 1969	Kp Mekar Bakti RT 04/01, Desa Marga Mekar	Ade Rubini	5 orang	Milik : 1400 m^2, Sewa : 4200 m^2	Sauyunan → Anugrah	Anggota	Tahun 2005
20 /pst/Bdg	Mamat Rahmat	Bandung, 10 – 10 - 1964	Babakan kiara, Desa Margamekar	Ai Rohani	3 orang	0,5 ha	Anugrah	Anggota	Oktober 2007
21/pst/bnjr	Samsu qadaraji	Banjar negara, 16 juli 1982	Wanaraja RT 03/01 kecamatan wanayasa Banjarnegara	maryati	3	0,5 H	Ngudi luhur	Ketua	Desember 2003
22 /pst/bnjr	Nurul hilal	Banjar negara, 17 september	Pagondangan, RT 03/ 01	salipah	0,3	0,5 H	Ngudi luhur	Anggota	Desember 2003

Kode	Nama	Tempat / tgl lahir	Alamat	Nama suami / istri	Jumlah keluarga	Kepemilikan Lahan	Nama Kelompok	Status Keanggotaan Kelompok	Bulan/tahun masuk kelompok
		1980							
23/pst/bnjr	sunarwan	Banjar negara, 1949	Beji RT 01/ 01	sumini	3	1 H	Sumber rejeki	anggota	Tahun 2007
24/pst/bnjr	Edy sukirno	Banjar negara, 11 nopember 1960	Beji RT 03/ 02	Siti M	5	1,5 H	Sumber rejeki	anggota	Tahun 2007
25/pst/bnjr	Farid fauzi	Banjar negara, 14 nopember 1974	Batur, RT 08/ 03	Tri hidayati	3	1 H	Trubus	Seksi lahan	Tahun 2006
26/pst/ bnjr	Toifudin	Banjar negara, 1972	Batur, RT 05/ 03	Umu	4	1 H	Trubus	Sekretaris	Bulan: Tahun 2006 s/d Bulan feb tahun 2010
27/pst/bnjr	Subhan	Banjar negara, 1972	Gembal	Umu salamah	5	1,5 H	Sekar tani	anggota	Tahun 2007
28/pst/bnjr	suyoto	Banjar negara, 14 september 1977	Kasimpar, RT 07/02	Tari	5	1,9 H	Bukit madu	Anggota	April 2006
29 / pst / bnjr	irwan	Banjar negara, 1973	Kasimpar	sueti	5	2 H	Bukit madu	Anggota	April 2006
30/pst/wnsb	Hadman	Wonosobo, 7 Nopember 1976	Tambi, RT 21 / X kecamatan kejajar	Tatik Farida	Empat (4) orang	2 H	Klakah Sari Mulyo	Bendahara	Agustus 2007
31/pst/wnsb	Imam mustamil	Wonosobo, 1 maret 1978	Tambi, RT 18 / 06 kecamatan kejajar	Sulastri	Empat (4) orang	0,5 H	Klakah Sari Mulyo	Wakil ketua	Agustus 2008
32/pst/wnsb	Fathul anam	Wonosobo, 21 maret 1979	Tieng, kejajar wonosobo		6 orang	1,5 H	Manunggal	Anggota	Maret 2005
33/pst/wnsb	Ali mazhar	Wonosobo, 15 Juli 1973	Tieng, kejajar wonosobo	Yansyah muzdalifah	2 orang	1 H	Manunggal	lapangan	Maret 2005
34/pst/wnsb	Ahmad barid	Wonosobo, 24 Mei 1975	Tieng, kejajar wonosobo	khusniati	5	0,5 H	Manunggal	Sekretaris	Maret 2005
35/pst/wnsb	Zaidah	Wonosobo/15 Januari 1978	Mlandi RT 4 RW 4	Mustofa	Enam (6)	1,6 H	Sri rejeki	Anggota	Februari 2006
36/pst/wnsb	Salimin	Mlandi , 5	Mlandi RT 1 RW	Jaroyah	Lima (5)	1 H	Sri rejeki	Bendahara	Februari

Kode	Nama	Tempat / tgl lahir	Alamat	Nama suami / istri	Jumlah keluarga	Kepemilikan Lahan	Nama Kelompok	Status Keanggotaan Kelompok	Bulan/tahun masuk kelompok
		Agustus 1967	2 kecamatan Garung						2006
37/pst/wnsb	Ma'ruf	Tambi , 1 juni 1943	Tambi, RT 23 / 08 kecamatan kejajar	sukirniah	Dua (2) orang	2 H	Klakah Sari Mulyo	Anggota	Maret 1996
38/Pst/NTB	H. SURYADIN	17 September 1974	Sembalun Lawang	Sohmah	5 orang	1 Ha milik sendiri, 0,5 Ha sewa	Horsela/ Paok	Anggota	Juli 2009
39 /Pst/NTB	HERDI	Sembalun, 1969	Lebok Daya, Sembalun Lawang	Siswi Budiyanti	5 Orang		Horsela / Orong Lendang Luar	Anggota	Juli 2009
40 / pst / ntb	A. Nia	3 Maret 1969	Sembalun Lawang	I. Tisna	5 orang	Milik sendiri : 40 are (1 are : 10 x 10 m)	Orong Pauk	Anggota	Juli 2009
41 / Pst / NTB	Saleh Udin	Sembalun, 20 Mei 1979	Lebak Daya, Sembalun Lawang	Ihis Sugianti	3 orang	Hak milik 20 are	Horsela (Orong Tenjong)	Anggota	Juli 2009
42 /Pst/NTB	RUSPINO	Sembalun Lawang, 03 Juni 1975	Dusun Lebak Lauk, Sembalun Lawang, Kec. Sembalun	Indih Indah Yati	5 orang	Hak Milik 65 Are	Orong Paok	Anggota	Juli 2009
43/Pst/NTB	SAPRUDIN	Sembalun, 19 September 1975	Sembalun, Baret Desa	Ela	4 orang	Sendiri, 50 Are	Orong, Dayan Desa	Anggota	Juli 2009
44/Pst/NTB	DARWASNI	Sembalun Lawang, 12 september 1971	Sembalun	Eni	5 orang	50 Are	Orong Tenjong	Anggota	Juli 2009
45/Pst/NTB	JUDAN	Sembalun, 10 Mei 1974	Barat desa	Muslimatin	4 orang	Milik sendiri 50 Are (1 are : 10 m x 10 m)	Orong Tenjong (Horsela)	Anggota	Juli 2009
46 / pst / ntb	A. Leo	26 April 1975	Sembalun Lawang	Nun	3 orang	Milik sendiri	Orong Tenjong	Anggota	Juli 2009

Kode	Nama	Tempat / tgl lahir	Alamat	Nama suami / istri	Jumlah keluarga	Kepemilikan Lahan	Nama Kelompok	Status Keanggotaan Kelompok	Bulan/tahun masuk kelompok
47 /pst/ntb	AQ. Naya	Sembalun Lawang, 1974	Dusun Dasan Kodrat	IQ Naya	4 orang	milik	Dayan Pansor	Anggota kelompok	Juli 2009
48 / pst / ntb	Mohlisin	Sembalun, 6 Juni 1966	Sembalun Lawang, Kec. Sembalun	Mindasari	4 orang	Milik 25 are (1 are : 10 x 10 m)	Horsela (Orong Dayang Pangsor)	Anggota	Juli 2009
49 /pst/ ntb	H. Sayuti	Sembalun Lawang, tahun 1959	Lemdang Luar	Hj. Rushiati	6 orang	Milik 1,6 ha	Horsela	Anggota	Th.2008
50/pst/sls	Hadriah	Maros, 15-05-1967	Bullubalea, Pattapang,	M Zaid KArim	6 orang	Milik sendiri	veteran	anggota	2009
51/pst/sls	Rudi Mumang	Bulubaea,	bulubalea	-	-	Bagi hasil	veteran	anggota	Desember 2009
52/pst/sls	M Zaid Karim	Patoflores, 17-08-1960	Bulubalea, pattapang	Hadriah	6 orang	Milik sendiri	veteran	Ketua kelompok	Nopember 2008
53/pst/sls	Sapri	MAjannang, 25-08-1979	Kampung baru, pattapang	-	4 orang	Milik sendiri	Kayu putia	Ketua kelompok	2009
54/pst/sls	Hasnawati S	Sidrap, 26-09-1976	Bulubalea, pattapang	Halik hasbi	3 orang	Milik sendiri	Kayuputia	Ketua kelompok	2009
55/pst/sls	Salahudin dg Rani	Bone, 1974	Buluballea, pattapang	Herlina	5 orang	Milik sendiri	Kayuputia	Anggota	2009
56/pst/sls	Budi pate	Pattapang, 07-09-1971	Lemo-lemo	Aisyah	4 orang	Milik sendiri	Lemo-lemo	Ketua kelompok	Maret 2009
57/pst/sls	Ani/Tilong	Pattapang, 10-10-1979	Lemo-lemo	Sukku	5 orang	Milik sendiri	Lemo-lemo	Anggota	Maret 2009
58/pst/sls	Rabia	Pattapang, 17-10-1975	Lemo-lemo	Baharuddin	4 orang	Milik sendiri	Lemo-lemo	Anggota	Maret 2009
59/pst/sls	Summang P	Pattapang, 08-08-1968	Lemo-lemo	Ani	6 orang	Milik sendiri	Lemo-lemo	Bendahara	Maret 2009
60/pst/sls	Suhardi	silanggaya	Silanggaya	-	2 orang	Milik sendiri	Silanggaya	anggota	Juni 2009
61/pst/sls	Hasbi	Silanggaya	Silanggaya	-	1 orang	Milik sendiri	Silanggaya	Anggota	Juni 2007
62/pst/sls	Sulkarnaen	Silanggaya, 04-04-1984	Silanggaya	-		Milik senidri	Silanggaya	anggota	Juni 2007
63/pst/sls	Mustakim	Silanggaya,	Silanggaya	Hafsah	2 orang	Sewa	Silanggaya	Anggota	Juni 2009

Kode	Nama	Tempat / tgl lahir	Alamat	Nama suami / istri	Jumlah keluarga	Kepemilikan Lahan	Nama Kelompok	Status Keanggotaan Kelompok	Bulan/tahun masuk kelompok
		24-04-1982							
64/pst/sls	Anwar	Silanggaya, 26-02-1978	Silanggaya	Darmawati	3 orang	Sewa	Silanggaya	Anggota	Juni 2009
65/pst/sls	Sapri	Malino, 09-08-1978	Pattapang	Munirah	3 orang		Tunas muda	Ketua kelompok	
66/pst/sls	Rahmawati	Makasar, 09-06-1969	Pattapang	M Nasir	4 orang	Milik senidri	Beringin	Ketua kelompok	Juni 2000

11.1.2 PETANI NON PESERTA SLPTT

No	Kode	Nama	Tempat / tgl lahir	Alamat	Nama suami / istri	Jumlah keluarga (orang)	Kepemilikan Lahan
1.	**01/Non SL /Grt**	Rosyid	Garut , Tahun 1960	Sukahaji, Desa Cisero, Kec. Ciserupa, Garut	Ibu Sobariah	6	Sewa : 4 patok (1600 m^2)
2.	**02/Non SL/Grt**	Mulyadin	Garut, 24 Novemver 1981	Kp. Ngamplang Rt 03 RW 01, Cikajang, Garut	Ibu Dewi Nirawati	3	Milik : 1 Ha Sewa : 1,5 Ha
3.	**03 /Non SL /Grt**	Sobar R	Garut , 3 Maret 1988	Karamat wangi, Garut	Belum menikah	8	Milik : 4 patok (1600 m^2)
4.	**04/Non SL/Bdg**	Hendar (cepna)	Bandung, 03 maret 1983	Jln Raya Cibeureum Kec. Kertasari Kab. Bandung	Single (belum menikah)	5	Milik : 20 Patok Sewa : 10 Patok
5.	**05/Non SL/Bdg**	H. Cece Wasmana	Bandung, 5 Mei 1949	Kp Lebaksari, Desa Cibeureum, Kertasari, Bandung	Hj. Uut Karwati	2	Milik Sendiri : 1 Hektar Sewa : 1 Hektar
6.	**06/Non SL/Bdg**	Ujang Tatang	Bandung, 09 September 1968	Kp Lebaksari, Desa Cibeureum, Kertasari, Bandung	Ibu Yati Sumiati	6	Milik Sendiri : 1,5 Hektar
7.	**07/Non SL/Bdg**	Ibu Imas R	Bandung, 28 Agustus 1973	Babakan, Kiara, Marga Mekar	M Kardin	4	1 Hektar
8.	**08/Non SL/Bdg**	Aris S	Bandung, 12 Agustus 1963	Babakan, Kiara, Marga Mekar	Ibu Nia	5	Sewa : 300 tombak Milik sendiri : 400 Tombak
9.	**09/Non SL/Bdg**	Suparman	Bandung,	Babakan, Kiara, Marga Mekar	Ibu Imas	3	800 Tombak (1,5 Ha)
10.	**10/Non SL/Bdg**	Jajang H Tayudin	Bandung,	Puncuk Raya, Kiara, Marga Mekar	Ibu Atikah	5	Milik sendiri : 1.000 m^2 Sewa : 1.200 m^2

No	Kode	Nama	Tempat / tgl lahir	Alamat	Nama suami / istri	Jumlah keluarga (orang)	Kepemilikan Lahan
11.	**11/Non SL/Bnjr**	Fahrul auton	Banjar negara, 1970	Batur	Ibu Siti rohmatun	4	1 H
12.	**12/Non SL/Bnjr**	Musto afif	Banjar negara, 11-11-1969	Pagondangan, wanaraja	Ibu Hamimah	4	0,5 Ha
13.	**13/Non SL/Bnjr**	Slamet	Banjar negara, 17 maret 1967	Beji	Ibu Tuminah	5	0,5 Ha
14.	**14/Non SL/Bnjr**	Suciono	Banjar negara, 17 maret 1967	Batur	Ibu Septiani	4	1,5 Ha
15.	**15/Non SL/Bnjr**	Tri setiyanto	Banjar negara, 1978	kasimpar	Ibu Karmia Sa,biah	5	1 Ha
16.	**16/Non SL/Bnjr**	Wahono	Banjar negara, 17 – 5-1977	Wanaraja RT 3/1 wanayasa	Ibu Wati	3	1 ,5 Ha
17.	**17/Non SL/Wnsb**	Budiyono	Tambi, 27 agustus 1983	Tambi, kejajar, wonosobo	Ibu Nur zaenah	3	¼ Ha
18.	**18/Non SL/Wnsb**	Kholil	Wonosobo/ 2 agustus 1982	Tieng RT 1 / 4 kecamatan kejajar	-	6	1 Ha
19.	**19/Non SL/Wnsb**	Miftahusshururi	Wonosobo/ 17 april 1987	Tieng RT 1 / 4 kecamatan kejajar	-	3	0,5 Ha
20.	**20/Non SL/Wnsb**	Suryadi	Mlandi / 7 Juni 1976	Mlandi RT 02 / 08 kecamatan Garung	Ibu Susilowati	5	Milik : 0,5 Ha,Sewa : 1 Ha
21.	**21/Non SL/NTB**	H. Ehi	Sembalun	Lebkoja	-	6	5 Ha
22.	**22/Non SL/NTB**	Sunarto	Tahun 1973	Sembalon Lawang	Rosilawati	4	Milik Sendiri
23.	**23/Non SL/NTB**	H. Anwar	17 Juni 1959	Sembalun Lawang	Hj. Rini	4	Milik Sendiri : 8 Ha
24.	**24/Non SL/NTB**	H. Wildan	12 januari 1951	L daya, Sembalun Lawang	Hj. Rohidi	2	Milik Sendiri
25.	**25/Non SL/NTB**	Sukriadi	Sembalun Lawang, 31 juli 1979	Sembalun Lawang	Ibu Karniati	4	Milik sendiri : 5 ha

No	Kode	Nama	Tempat / tgl lahir	Alamat	Nama suami / istri	Jumlah keluarga (orang)	Kepemilikan Lahan
26.	**26/Non SL/NTB**	H. Arfen	Sembalun Lawang, 20 Nopember 1947	L daya	Hj. Maeti	4	Milik Sendiri
27.	**27/Non SL/Sls**	Muh Ramli	Parangbodongia, 21 tahun	Kanrapea			Milik sendiri, 1 ha
28.	**28/Non SL/Sls**	Abdul khalik	Lembang Teko, 15-10-89	Bulluballea		6 orang	Milik sendiri
29.	**29/Non SL/Sls**	Aisyah	Pattapang, 01-07-76	Lemo-pemo	Budi	4 orang	Milik sendiri
30.	**30/Non SL/Sls**	Hasrullah	Gowa, 05-05-1985	Silanggaya	-	7 orang	Milik sendiri
31.	**31/Non SL/Sls**	Hamzah	Silanggaya, 13-04-89	Silanggaya	-	5 orang	Milik sendiri
32.	**32/Non SL/Sls**	Hasrullah	Silanggaya, 11-11-1986	Silanggaya	-	5 orang	Milik sendiri
33.	**33/Non SL/Sls**	Muh Arfah K	Tombolopao, 62 tahun	Bulluballea	Nur Adha	6 orang	Milik sendiri
34.	**34/Non SL/Sls**	Dg Usman	Bontomanas, 1985	Bulluballea	Puang Kasmah	7 orang	Milik sendiri

Keterangan :

a. Grt : Kabupaten Garut
b. Bdg : Kabupaten Bandung
c. Bnjr : Kabupaten Banjarnegara
d. Wnsb : Kabupaten Wonosobo
e. NTB : Nusa Tengara Barat
f. Sls : Sulawesi Selatan
g. Non SL : Petani Bukan Peserta Sekolah Lapang Pengelolaan Tanaman Terpadu (ICM FFS)
h. 1 ha sama dengan 25 patok

11.1.3 PEMANDU

No	Kode	Nama	Tempat / tgl lahir	Alamat	Nama Kelompok Yang Difasilitasi	Status Keanggotaan Kelompok	Bulan/tahun masuk kelompok
1.	01/pmd/grt	Ayat H	Garut, 21 Januari 1952	Kp. Sukahaji, Ds. Cisero, cisurupan, garut	Sukahaji	Pemandu	Tahun 2007
2.	02/pmd/grt	Supanji	Garut, 25 April 1960	Kp. Nyamplang, Ds Cibodas, Cikajang, Garut	Tani Mekar	Pemandu	Desember 2009
3.	03/pmd/grt	Ending	Garut, 1954	Ngamplang, Desa Cibodas, Kec. Cikajang, Garut	Medal Sawargi	Pemandu Petani (pl 2)	Oktober 2007
4.	04/pmd/grt	Asep Rohiman	Bandung, 7 Maret 1963	Jl. Pasar valu no.22, Cikajang, Garut (hp :081395484127)	Medal Sawargi	Pengamat Hama Tanaman	Oktober 2007 – Februari 2008
5.	05/pmd/grt	Nandang	Cisurupan, 15 Desember 1960	Desa Cisurupan, Kec. Cisurupan	Tani Jaya	Pemandu	Oktober 2007 - April 2010
6.	06/pmd/bdg	Asep Budi DS	17 Mei 1975	Kp. Plered rt 04 / rw 15, Desa Cikembang,	Tunas Tani	Pemandu	Juni 2006 - Juni 2010
7.	07/pmd/bdg	Amang Tarya	Bandung, 2 Juni 1968	Lebaksari rt 03 / 16, Desa Cibereum, Kec. Kertasari, Bandung	Mekar sari	Pemandu petani	November 2007 - Maret 2010
8.	08 / pmd/ bnjr	Ahmad Nurholis	Banjar negara, 15 Nopember 1975	Batur		Ketua Kelompok	2008
9.	09 / pmd/ bnjr	Amin Didik Hartoji	Banjar negara,3 Juni 1978	Gembol	Sekar tani	Sekretaris kelompok	2007
10.	10/ pmd/ bnjr	Mahyat	Banjar negara,9 Mei 1968	Beji rt 1/1	Sumber rejeki	Pemandu	2007 - 2010

No	Kode	Nama	Tempat / tgl lahir	Alamat	Nama Kelompok Yang Difasilitasi	Status Keanggotaan Kelompok	Bulan/tahun masuk kelompok
11.	11 / pmd/ bnjr	Widodo	Magelang, 1 Juli 1959	Wanayasa	Bukit madu	Penyuluh pertanian	Oktober 2007
12.	12 / pmd/ wnsb	Sadilan, SP	Sleman, 3 Februari 1963	RT 01 RW V Kelurahan/Kecamatan Garung Wonosobo	Klakah Sari mulya	Penyuluh pertanian muda	Mei 2006 - Februari 2009
13.	13/pmd/ntb	Darwinti	Sembalun Lawang, 11 Desember 1968	Dusun Dasan Kodrat, Sembalun Lawang	Dayan Pansor	Pemandu	2007 - Oktober 2009
14.	14/pmd/ntb	Suhilwadi	04 Mei 1980	Sembalun Lawang	Horsela Lor Telaga	pemandu	juli 2009
15.	15/pmd/ntb	Rupnih	Sembalun Lawang, 22 Feb 1968	Sembalun Lawang, Lombok Timur, Ntb	Horsela (Or Sumur) Paok	Pemandu	Juli 2009
16.	16/pmd/ntb	Risdun	Sembalun Lawang, 1970	Sembalun Lawang	Orang Dayan Desa	Pemandu	Juli 2009
17.	17/pmd/sls	Halik Hasbi	Gowa, 21-06-75	Bulubalea, Pattapang		Petani Pemandu	Maret 2009
18.	18/pmd/sls	Abdul Jalil	Tamaona, 30-09-65	Buluballea, Pattapang		Petani Pemandu	Maret 2009
19.	19/pmd/sls	Syuaib	Silanggaya, 08-07-76	Silanggaya		Petani Pemandu	Juni 2009

Keterangan :

1. pmd : Pemandu
2. grt : Kabupaten Garut
3. bdg : Kabupaten Bandung

11.1.4 DINAS TERKAIT/LEMBAGA TERKAIT.

No	Kode	Nama	Instansi	Alamat Kantor	Jabatan	Alamat Rumah
20.	01/dinas/grt	Wawan S	Dinas Tanaman Pangan & Holtikultura Kabupaten Garut	Jalan Cimanuk 183, Kab. Garut, Jawa Barat	Kasi Pasca Panen dan Pengelolaan Hasil Pertanian	Jalan Cimanuk RT 3, RW 07, Kec. Pateruman
21.	02/dinas/bdg	Pepen Effendi	Dinas Pertanian, UPTB BPTPH Propinsi Jawa Barat	Jalan Ciganitri II, Bojong Soang, Bandung	Pengamat Organisme Pengganggu Tanaman (POPT)	Taman Kebon kopi B 64, Margamulya, Pangalengan
22.	03/dinas/bnjr	Ir. Suhari	Bintan kannak, Kabupaten Banjarnegara	Jl. Pemuda No 78 Banjar Negara	Pengawas benih	Jln sunan giri no 4 banjarnegara
23.	04/dinas/wnsb	Mufrodin , SP	Dinas Pertanian Tanaman Pangan Kabupaten Wonosobo	Jl. Sindoro No 3 telp (0286) 321 036	Kasi Pengembangan buah-buahan	Sari agung RT 02 RW X wonosobo
24.	05/dinas/ntb	Jayadi, Sp	BP3K, Kec. Sembalun, Kab. Lombok Timur	Sembalun	Kepala Bp3k Kec. Sembalun	Selong
25.	06/dns/sls	Muhamad Asaad	BPTP, Sulawesi Selatan	Jalan Perintis Kemerdekaan Km. 17,5 , Sudiang , Makassar, Sulawesi Selatan	Peneliti	Makasar
26.	07/dns/sls	Ir. Hilda Tahir	Dinas Pertanian Tanaman Pangan Dan Hortikultura, Sulawesi Selatan	Jalan Amirullah 1, Makasar	Kasi Tanaman Padi , Palawija dan Umbi-umbian	Makasar

Keterangan :

1. dns : Dinas
2. grt : Kabupaten Garut
3. bdg : Kabupaten Bandung
4. bnjr : Kabupaten Banjarnegara
5. wnsb : Kabupaten Wonosobo
6. ntb : Propinsi Nusa Tenggara Barat
7. sls : Propinsi Sulawesi Selatan

11.2 Farmer Groups and number of participants by gender.

JAWA BARAT, JAWA TENGAH, SULAWESI SELATAN DAN NTB

No	Propinsi	Kabupaten	Kecamatan	Kelompok	Anggota
1	Jawa Barat	Bandung	Kertasari	Mekar Tani Muda	18 lk, 5 pi
				Mekartani II	20 lk
			Pangalengan	Sauyunan	22 lk , 3 pi
				Mitra mukti	20 lk
		Garut	Cisurupan	Sukahaji.	19 lk, 1 pi
				Karya Mandiri	20 lk
			Cikajang	Medalsawargi	20 lk
				Perjuangan Tani Mukti	18 lk ,2 pi
			Pasir wangi	Mukti Tani	20 lk
				Barokah tani	20 lk
2	Jawa Tengah	Banjarnegara	Wanayasa	Ngudi luhur	20 lk
				Bukit Madu	20 lk
			Batur	Trubus	20 lk
				Tunas Harapan jaya	20 lk
			Pajawaran	Sekar Tani,	23 lk
				Sumber rejeki	20 lk
		Wonosobo	Garung	Tempelsari	20 lk
				Sri rejeki	18 lk,2 pi
			Kejajar	Klakah Sarimulyo	24 lk
				Manunggal	25 lk
3	Sulawesi Selatan	Goa	Tinggi Moncong	Veteran	20 lk
				Kayu Putea/ Gemah baru	17 lk, 3 pi
				Ta'ca'la	20 lk
				Lemo-lemo	17 lk, 3 pi
			Tombolo pao	Taruna Tani, Silanggaya	15 lk, 5 pi
				Bonto ganjeng	20 lk
4	NTB	Lombok timur	Sembalun Lawang	Orong Tenjong	16 lk
				Orong Lendang Luar	16 lk
				Orong Paok + Kekoro	16 lk
				Orong Ronggak +Telaga	16 lk
				Orong Dayan Pangsor, Serut	16 lk
				Orong Dayan Desa + Buatan	16 lk
	Jumlah	6 kab.	13 Kec.	32 Klmpk	636 org

11.3 Impact study questionnaire. Pertanyaan untuk petani anggota kelompok

Tanggal Wawancara: ___________________________

Pewawancara: _____________________________

KOMPONEN	JAWABAN
Informasi umum responden:	
Nama	
Tempat/tgl lahir	
Alamat	
Nama suami/istri	
Jumlah keluarga	
Kepemilikan Lahan	
Nama Kelompok	
Status Keanggotaan Kelompok	
Bulan/tahun masuk kelompok	Bulan: _________Tahun _________s/d Bulan _______tahun ______

1. Sebelum ada SLPTT:

11.4 Impact study questionnaire. Pertanyaan untuk petani bukan anggota kelompok.

Tanggal Wawancara :______________________________

Pewawancara :______________________________

KOMPONEN	JAWABAN
Informasi umum responden:	
Nama	
Tempat/tgl lahir	
Alamat	
Nama suami/istri	
Jumlah keluarga	
Kepemilikan Lahan (Luasan lahan yg dikerjakan – milik, sewa)	

a. Apakah anda tahu bahwa di desa ini ada kelompok SLPTT?	
b. Menurut anda apa yang dinamakan SLPTT itu?	
c. Apakah SLPTT tersebut dapat diterima oleh semua petani di sini?	
d. Bagaimana cara memilih anggota peserta belajar dari SLPTT? (pendapat dr luar peserta)	
e. Apa perbedaan cara bertani dari anggota kelompok SLPTT dengan yang bukan?	
f. Menurut saudara, apa yang masih harus diperbaiki dari cara	

bertanam petani anggota SLPTT? (*apakah cara bertani anggota kelompok SLPTT itu cukup baik? Apa alasannya?)*	
g. Apakah bapak atau petani di sini juga mencontoh apa yang dilakukan oleh petani anggota SLPTT dalam kegiatan bertani? Apa alasannnya.	
h. Kira-kira berapa orang petani yang mencontoh apa yang dilakukan oleh petani anggota SLPTT?	
i. Apa manfaat bagi petani di wilayah hamparan/desa ini	
j. Apa saran anda untuk memperbaiki kelompok SLPTT yang ada	

11.5 Impact study questionnaire. Pertanyaan untuk Dinas/lembaga Terkait.

Tanggal Wawancara:______________

Pewawancara:____________________

KOMPONEN	JAWABAN
Informasi umum responden:	
Nama	
Alamat Rumah	
Instansi/lembaga	
Jabatan	
Alamat Kantor	

a. Peran apa saja yang dilakukan oleh Instansi atau lembaga dalam mendukung kelompok belajar masyarakat?

b. Bagaimana upaya instansi atau lembaga untuk menjaga keberlangsungan kelompok belajar masyarakat?

11.6 Impact study questionnaire. Pertanyaan untuk Pemandu.

Tanggal Wawancara:______________

Pewawancara:____________________

KOMPONEN	JAWABAN
Informasi umum responden:	
Nama	
Tempat/tgl lahir	
Alamat	
Jabatan	
Nama Kelompok yang difasilitasi	
Bulan/tahun memfasilitasi Kelompok	Bulan:______Tahun ____s/d Bulan______tahun _____

a. Apa yang mendasari munculnya kelompok ini	
b. Bagaimana bapak/ibu memfasilitasi pembentukan kelompok	
c. Bagaimana cara yang bapak/ibu gunakan dalam mendinamisir kelompok belajar	
d. Apakah ilmu pengetahuan tersebut juga anda praktekkan kepada diri sendiri?	
e. Bagaimana model pendampingan kelompok belajar	
f. Bagian mana yang dirasa masih kurang dan perlu diperbaiki	

g. Apa kelebihan dan kekurangan pada kelompok belajar tersebut	
h. Kendala apa saja yang dihadapi dalam membangun kelompok belajar	
i. Faktor pendukung apa saja yang digunakan sebagai pertimbangan pembentukan kelompok belajar	
j. Saran dan masukan apa saja yang diperlukan untuk pembentukan kelompok belajar masyarakat	