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Small research and development activity

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List of Abbreviations

Abbreviation	Full name	
	Indonesian	English
AUD		Australian dollar
Balitsa (IVEGRI)	Balai Penelitian Tanaman Sayuran	Indonesian Vegetable Research Institute
BBH	Balai Benih Hortikultura	Horticultural Seed Centre
BBI	Balai Benih Induk	Mother-seed Centre
BBK	Balai Benih Kentang	Potato Seed Centre
BD	Benih dasar	Basic seed
BEP		Break even price
BEY		Break even yield
BP	Benih pokok	Stock seed
BPBK	Balai Pengembangan Benih Kentang	Seed Potato Development Centre
BPS	Badan Pusat Statistik	Statistics Indonesia
BPSP	Balai Pengawasan dan Sertifikasi Benih	Seed Inspection and Certification Service
BPSBTPH	Balai Pengawasan dan Sertifikasi Benih Tanaman Pangan Hortikultura	Food and Horticulture Crops Seed Inspection and Certification Service
BS	Benih sebar	Extension seed
Cms		*Clavibacter michiganensis* subsp. *sepedonicus*
CV	Commanditaire Vennootschap	Limited liability partnership
EBIT		Earnings before interest and tax
ELISA		enzyme-linked immunosorbent assay
FFS	Sekolah lapangan	farmer Field School
FIL		farmer initiated learning
G		generation
G0		generation zero
GTZ		German Technical Agency
ICHORD	Pusat Penelitian dan Pengembangan Hortikultura	Indonesian Center for Horticultural Research and Development
IGCS		Indonesian government seed scheme
IKB	Instalasi Kebun Benih	Seed Garden Installation
IPB	Institut Pertanian Bogor	Bogor Agriculture Institute
IVEGRI (Balitsa)	Balai Penelitian Tanaman Sayuran	Indonesian Vegetable Research Institute
JICA		Japanese International cooperation Agency
KBH	Kebun Benih Hortikultura	
KIAT	Kelompok Intermediasi Alih Teknologi	Technology Transfer Intermediary Group
KT	kelompok tani	farmer group
LHS		left-hand side
NTB	Nusa Tenggara Barat	West Nusa Tenggara
PCN		potato cyst nematode

Abbreviation	Full name	
	Indonesian	English
PLRV		potato leafroll virus
PSS		partial seed scheme
PSTVd		potato spindle tuber viroid
PT	perseroan terbatas	Ltd (limited)
PVA		potato virus A
PVX		potato virus X
PVY		potato virus Y
Rp		Indonesian rupiah
SHA		screenhouse A
SHB		screenhouse B
SOP		standard operational procedure
SRA		small research activity
T		table
WA		Western Australia
ViCSPA		Victorian Certified Seed Potato Authority

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2 Executive summary

2.1 Objective 1: Identify industry and potential commercial partners priorities

Indonesian government seed potato policy attempts to encourage local seed production. Importation of seed potatoes requires a permit from the Director of Horticulture Seed. Currently permits are issued for seed of the crisp processing variety Atlantic. Import permits for the major variety, Granola for the fresh market, are not issued. This is done in an attempt to encourage local seed development by reducing competition to encourage new seed producers. This in turn increases seed availability and reduces the seed price. However, the local supply response has been very limited and the price of certified seed remains high.

A previous ACIAR project AGB/2005/167 found that the Sembalun Valley in Lombok was free from potato cyst nematode (PCN) and that the highland paddy soils provided good protection against this pest. A recommendation was that a partial seed scheme (PSS) combined with a participatory farmer learning program would be an appropriate way to improve the availability and affordability of quality seed potatoes free from PCN to the Indonesian potato industry. Imported Atlantic and Granola seed from PCN free areas of Australia would be multiplied once in the Sembalun Valley. This PSS will provide seed at a lower price than imported seed.

The project team of Terry Hill and Julie Warren discussed these issues and ideas with the Indonesian government stakeholders from 18 – 19 August 2014. Dr. Ir. Muhammad Prama Yufdy, M.Sc, ICHORD Director, Dr Yusdar Hilman, ICHORD Principal Researcher, Dr Liferdi, Head IVEGRI were supportive of the project. Head of Horticulture Seed, Mrs Sri Wijayanti Yusuf also gave verbal agreement for the testing of a PSS to go ahead at Sembalun. Mr Budi Dharmadi of PT Indofood, also gave support for the project.

Project members also held meetings with two major seed potato producers and exporters in Western Australia (WA) who indicated support for the development of a PSS to Indonesia. The larger WA potato industry also support development of seed potatoes to Indonesia with the peak seed grower group, WA Seed Potato Producer Inc. and the Potato Growers Association actively seeking ways to accelerate development of seed potato exports to Indonesia. In addition the Potato Marketing Corporation of WA commissioned, in 2014, an assessment of the opportunity to export WA seed and ware potatoes to Indonesia. This assessment endorsed the strategy to develop Atlantic and Granola seed exports, recognising that a relaxation of Indonesian import regulations would be required. The interest from the WA potato industry championing the development of a PSS with Indonesia is seen from export statistics that show from 2011 to 2013 WA exported 78% to 96% of Australian seed potatoes, with Indonesian being one of the main markets.

2.2 Objective 2: Describe market situation, research gaps and production and agribusiness development opportunities.

Indonesia experienced rapid potato industry growth from the early 1980s until 1996. Both production area and yield increased as did exports. From 1997 to 2012 growth slowed along with yield increases; exports declined markedly and imports increased. The Indonesian potato industry must improve its competitiveness in the face of relaxing regional trade liberalisation and major pests and diseases. High price of seed and disease status of seed potatoes are considered to be major constraints to production.

The Indonesian government certified seed (IGCS) scheme was established with the Japanese International Cooperation Agency (JICA) based on limited generations starting with pathogen tested seed and relying on a number of field bulkings without degeneration of seed stocks. The IGCS system is constrained because of the limited availability of suitable field bulking areas where low degeneration rates over several generations are possible. Recent changes in the Indonesian certified seed scheme have reduced the number of generations from five to three. This has been done to try and reduce seed degeneration. To maintain and bolster the supply of seed in a scheme with reduced generations, aeroponic minituber production is being relied upon to increase the supply of minituber Basic Seed. Farmer production of Basic Seed is also being encouraged to further increase supply.

Project team observations of aeroponic and early generation seed production show sub-optimal management of screenhouses. Screens were damaged and did not provide effective protection against insects and virus vectors. The aeroponic minituber production systems had widespread bacterial wilt contamination plus power failure problems and unsuitable water temperature. Footbaths were not being used and other hygiene measures were not adequate; soil sterilisation was not carried out properly and seed crop isolation requirements were not met. The longest established aeroponic seed production system, the cluster system in Sulawesi, has not been able to supply seed demand for a minor potato production area.

Seed potato costs remain high, the cost of IGCS was similar to the cost of imported seed, around Rp 13,000/kg. The Indonesia certified seed potato scheme does not produce sufficient quantities of seed potatoes to fulfil Indonesia's seed requirement.

Most seriously, the Indonesian certified seed potato scheme does not provide protection against some harmful soil-borne pests and diseases. The rotation requirement in the Indonesian certified seed scheme is just 9 months between seed crops. This will result in the seed, which is produced in areas where potato cyst nematode (PCN) (*Globodera rostochiensis*), bacterial wilt (*Ralstonia solanacearum*) and bacterial ring rot (*Clavibacter michiganensis* subsp. *sepedonicus)* (Cms) are found, spreading these pests and disease to uninfested areas.

A literature search found no convincing evidence that Indonesian farmers who use certified seed receive an immediate benefit in yield or profit. The lack of immediately obvious benefit from high quality potato seed is found globally; reports from Australia and the United States show these benefits could not be measured either. This lack of immediate benefit will affect seed buyer demand. Officials managing the seed scheme need to review these threats and introduce improved protection for IGCS.

2.3 Objective 3: Evaluate opportunities to increase seed potato production and agribusiness development

A rapid appraisal of potato production systems in Nusa Tenggara Barat (NTB) showed that the Atlantic crisp processing crops grown for PT Indofood with imported seed were more profitable than comparable enterprises in West Java. Atlantic crisp processing potatoes accounted for 84% of potato production at Sembalun. The NTB survey also showed that farmers used seed from many different sources. These included IGCS, imported seed, informal seed and seed produced in a PSS scheme based on tissue culture source seed from the Agricultural Institute in Bogor. Some farmer groups produced small amounts of Granola for the local fresh market. One farmer group bulked seed and French fry processing potatoes for a processor in Jakarta. The highest profits came from crops which had the highest fraction of seed sales.

A threat to the area was identified to be the potential for the introduction of PCN, bacterial wilt and bacterial ring rot into Sembalun through the importation of seed potatoes from Java. NTB has regulations designed to manage the threat of this seed by ensuring only high quality certified seed is allowed entry. However seed of unknown quality from Java is still being used by some farmers at Sembalun. An effective way to reduce this threat is to produce sufficient seed at Sembalun to meet local requirements. This means seed of both Atlantic and Granola varieties will have to be grown.

2.4 Objective 4: Develop detailed project proposal (Phase 1 & 2).

A draft Phase 1 plan for a project to commercialise the opportunity for a PSS based at Sembalun on the highland paddy soils was prepared and submitted separately to ACIAR. The PSS would provide certified potato seed free from PCN, bacterial wilt and bacterial ring rot at reduced prices compared with imported seed.

The incentive for Sembalun growers to participate was shown by an economic analysis. Currently, WA seed, free from PCN, bacterial wilt and Cms, is used to produce Atlantic crisp processing potatoes at Sembalun. This crop produces 85% chip stock and 14% seed which gives an income of Rp 113.8 million/ha. If this system is modified to produce a greater amount of seed, the chip stock fraction is assumed to decline to 49% while the seed fraction increases to 50%. This gives an income of Rp 149.8 million/ha and provide 12.5 tonnes of PCN free seed potatoes. The potential annual seed production at Sembalun using this system is estimated to be 6,000 tonnes based on 15 t/ha of seed grade from 400 ha of highland paddy fields. This is equivalent to 90% of the high quality seed used in 2013 in Indonesia which amounted to 6,686 tonnes, comprising 3,152 tonnes of Indonesian seed and 3,534 tonnes of imported seed.

The development of a PSS at Sembalun will require the following development work:

- Changes to seed policy and regulations
- Obtaining import permits for PCN, bacterial wilt and Cms free seed sources of Atlantic and Granola
- Obtaining approval for WA generation four seed to be multiplied once in the Indonesian seed scheme in NTB for use as Extension Seed in East Java.
- Determining the physiological age of seed exported from WA that will produce short maturing crops at Sembalun that have a high yield of seed grade tubers.
- Development of best management practices for multiplying seed at Sembalun developed, including:
    - Determining the physiological age of seed produced at Sembalun that have a high yield of seed grade tubers and good performance when replanted.
    - Measuring the degeneration rate of seed produced at Sembalun to enable the planning of an effective seed multiplication program.
    - A Farmer Initiated Learning (FIL) program to identify effective integrated crop management practices.
    - Improving seed storage facilities.
- Seed production training for NTB growers.
- Comparison of the performance of the seed produced against other seed sources in high yielding potato production districts in East Java. This comparison must include both financial and pest and disease risk analyses of all seed sources.
- Arranging finance sources for imported Granola and Atlantic seed.
- A FIL program to elucidate effective management of seed buyers' crops is needed to ensure the seed performs to its potential.
- Business plan developed for continuation of PSS after project ends

A successful demonstration of improved seed quality and reduced seed cost should enable the PSS to be adopted as an official Indonesia seed supply chain. This will enable the production of both Granola and Atlantic seed by this seed supply chain.

The potato crop provides employment opportunities for the rural poor. A PSS which improves seed quality and reduces seed cost, combined with a program of FIL to improve crop management, will increase the competitiveness of the potato industry and so help the poor.

3 Introduction

This SRA (AGB 2012/005) aimed to further investigate recommendations for development of seed potato supply chains in Indonesia identified in the ACIAR project AGB/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 West Nusa Tenggara*.

This SRA sought an alternative path to previous investments that attempted to introduce seed production schemes designed for temperate areas with low seed degeneration rates. These temperate areas' low degeneration rates are due to their isolation, capacity for soil sanitation (rotations or freezing) and low disease vector populations due to cold climate or prevailing on-shore winds. In the Philippines the Buguias Seed Farm was established through the German Technical Agency (GTZ) with the Philippine Bureau of Plant Industry in 1977. The establishment of this potato seed centre attracted commercial farmers to this previously isolated area; inevitably degeneration rates rose and the location was no longer suitable for seed production (Crissman 1989). Similarly the small supply of Indonesian government certified seed may be a symptom of the supply system being unsuited to Indonesian conditions. This scheme was established with the Japanese International Cooperation Agency (JICA) based on limited generations starting with pathogen tested seed and relying on a number of field bulkings without degeneration of seed stocks. The Indonesian system is constrained because of the limited availability of suitable field bulking areas where low degeneration rates over several generations are possible (Jayasinghe 2003). In Vietnam GTZ also ran a seed development program based on tissue cultured pathogen tested material multiplied in the field with little success (Dang 2008).

Project AGB/2005/167 recommended a partial seed scheme (PSS) combined with a participatory program of FIL would be an appropriate way to improve the availability and affordability of quality seed potatoes free from potato cyst nematode (PCN) to the Indonesian potato industry. Imported Atlantic and Granola seed from PCN free areas of Australia would be multiplied once in the Sembalun Valley. This PSS will provide seed at a lower price than imported seed.

This SRA (AGB 2012/005) investigated whether the introduction of a PSS in Indonesia would be the best future pathway for Indonesian seed potato development. This was done by collecting information to allow an economic and practical comparison of the potential PSS with other seed value chains including:

- Indonesian government certified seed (IGCS)
- private seed production using IGCS methods
- aeroponics based seed production
- informal seed, and
- imported seed.

This SRA identified the most feasible and economically cost efficient ways to increase Atlantic and Granola seed potato supply and farmer net income with special regard to poor farmers in eastern Indonesia. It consulted with government, research and leading private sector partners to collect information that will be used to develop a proposal for a larger project that will aim to develop production methods that would improve the availability and affordability of seed potatoes and benefit the 60,000 small holder potato farmers in Indonesia.

Planned project objectives and activities are shown in Table 3.1 which also indicates the sections in the report where their respective outcomes are discussed.

The schedule of field visits undertaken to achieve these outcomes is shown in Appendix 2.

Table 3.1. Planned activities for SRA AGB/2012/05 showing the sections of this report where outcomes are discussed.

No	Brief activity description	Outputs and location of results
Objective 1: Identify industry and potential commercial partners priorities		
1.1	Consultation and priority setting workshops / meetings with research, government and key private sector groups and potential partners in Indonesia	Consultation and workshops documented, priorities defined and industry partners identified. Results shown in Chapter 8 and Section 9.2.
1.2	Identify potential project champions in Australia, e.g. Landmark and lead farmers. Consult with potential Australian commercial partners to identify research and agribusiness development priorities.	Potential solution in Section 9.2.2
Objective 2: Describe market situation, research gaps and production and agribusiness development opportunities.		
2.1	Undertake market and production analysis to identify gaps, issues and opportunities for agribusiness development	Sections 5, 6, 7 & 8
2.2	Consult with the Indonesian Potato Seed Centre (BBK) to identify potential for technical assistance in quarantine and seed certification systems.	Sections 6.3 & 6.4 & 9.2 (Training)
Objective 3: Evaluate opportunities to increase seed potato production and agribusiness development		
3.1	Analysis of seed potato supply with particular focus on NTB and East Java; identification of priority issues, research gaps and agribusiness development opportunities, potential project champions, e.g. Governor NTB, and Horsela farmer group Sembalun.	Section 8. East Java Section 9. Note West Java and South Sulawesi added to improve seed scheme analysis.
3.2	Economic analysis of options and strategies to increase seed potato production and small holder famer income in selected chains.	Sections 8 & 9
Objective 4: Develop detailed project proposal (Phase 1 & 2).		
4.1	Phase 1 proposal	See Section 10.2.1
4.2	Arrange export of 1 tonne G4 seed potatoes from Australia. Target funding and support from commercial and other partners	Not undertaken due to changes in seed scheme regulations requiring more permits from this seed to be approved see Section 9.2.2. Add additional funding sources in Section 9.2.2
4.3	Phase 2 proposal	Draft prepared and submitted to ACIAR 8 October 2015. Phase 1 delayed due to changes to Indonesian government priorities. More info Section 9.2.
4.4	Final Report	

4 Indonesian Potato Industry

4.1 Indonesian potato production

Indonesian potato production is characterised by humid, mountainous areas with a vulnerability to climate shocks and pest and disease outbreaks and a concentration of poor communities which are physically isolated due to poor infrastructure (Ezeta 2008, p. 15). Potato production occurs year round in rotation with other vegetable crops. The potato is an important cash crop and employer for these communities as it uses intensive family and hired labour. Around 200 days of hired labour and 120 days of family labour is needed for each hectare of crop (Mattingley *et al.* 2011, p. 47). Economically it is an anchor for farmers in the intensive cool-weather horticultural systems (Ezeta 2008, p. 11). The main production area is Java followed by Sumatra. Average land area owned by farmers is 0.4 ha in Java and 0.7 ha elsewhere (Direktorat Jenderal Hortikultura, 2011, p. 7).

4.1.1 Potato use

In Indonesia the potato is used as a vegetable to vary the diet and improve nutrition, it is not consumed as a staple. Indonesian fruit and vegetable consumption grew from 61 kg per capita in 2005 to 73 kg per capita in 2009 (Direktorat Jenderal Hortikultura, 2011, p. 30) but this is only 50% of the FAO/WHO recommended intake for fruit and vegetables of 146 kg[1] per capita per year (FAO/WHO 2005). Potato consumption was 0.5kg/capita in 1968, but increased eightfold to 4 kg/capita by 1995 (Adiyoga *et al.* 1999, p. 1); however, in the last decade it is reported to have decreased to 2kg/capita (Pusat Data dan Sistem Informasi Pertanian 2009, p. 35). The big increase in fresh consumption occurred in the 1970s and 1980s, after which consumption of processed potatoes increased.

The potato also provides snacks and Western-style fast food for the growing urban middle classes. Potato production for processing made up just one percent of West Java production in 1995 but increased to 10 percent by 2005 (Natawidjaja *et al.* 2007, p. 32).

4.1.2 Varieties

Granola has been the dominant ware variety since 1989 (Adiyoga *et al.* 1999, p. 12) while Atlantic makes up only 10 percent of production and is grown for crisp processing. Granola is a German variety while Atlantic is from North America. Growers and potato industry stakeholders report that Atlantic is more prone to virus disease than Granola. According to the European Cultivated Potato Database (http://www.europotato.org/varietyindex.php):

- both varieties have low resistance to potato late blight (*Phytophthora infestans*)
- both are resistant to potato cyst nematode (PCN) (*Globodera rostochiensis*) race 1
- Granola has high resistance to potato virus A (PVA)
- Atlantic has high resistance to potato leafroll virus (PLRV)
- Granola has a very long dormancy while Atlantic has a medium dormancy.

The Granola sourced from the Indonesian Vegetable Research Institute (IVEGRI) (Balai Penelitian Tanaman Sayuran/Balitsa) at Lembang is known as Granola L where L stands for Lembang. In East Java, Granola Kembang (Granola K) is often grown; kembang means flower. Granola K has much longer growing period of 130 – 135 days compared with the 100 – 115 days of Granola L (Kosim 2014, pp. 100 & 105) and is listed as a mutant selection of Granola L by Kosim (2014, p. 105). Granola K may be a better selection of Granola L.

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[1] *Recommendation is 400 g/day of fruit and vegetables excluding potatoes and other starchy tubers.*

4.1.3 Indonesian potato production and consumption.

Indonesian potato production and yield for the period 1981 to 2012 is shown in Figure 4.1 along with moving 5 year averages, which smooth out annual fluctuations. 1981 is used as the starting point as this is the year from which Adiyoga *et al.* (1999) discuss Indonesian potato industry growth. The moving average clearly shows there was rapid growth in production from 1981 until 1996. Production from 1981 to 1996 rose from 216,713 tonnes to 1,109,560 tonnes, an increase of 512%[2] or an 11.5%[3] annual increase (Figure 4.1).

Yield over this period rose 222% from 7.2 t/ha to 15.9 t/ha or an annual increase of 5.5%[4]. From 1996 to 2012 growth in production was much reduced, being dwarfed by the annual fluctuation. Production from 1996 to 2012 fell 4%[5] to 1,068,800 tonnes, an annual growth rate of -0.2%[6]. However, the 5 year moving average shows an increase over this period of about 100,000 tonnes. From 1996 to 2012 yield increased from 15.9 t/ha to 16.6t/ha, an annual increase of 0.3%[7]. Total cropping area in 2012 was 65,218 ha (Badan Pusat Statistik 2012). The decline in production in 2001 is attributed to a fall in the price of potatoes from Rp 2,336/kg (2000) to Rp 1,628 (2001) (Rasmikayati & Nusrasiyah 2004).

This slowing of the rate of growth of the potato industry is also reported by Adiyoga (2009, p. 492) with 6.7% growth from 1989-98 declining to negative growth of -0.1% from 1999-2006. From 1969 he found that potato production increased steadily for 20 years due to an increase in area planted, the next 10 years growth was due to increased area as well as increased productivity while over the 8 years from 1999-2006, total production decreased but with a small gain in productivity.

4.1.4 Trends in potato imports and exports.

The high price of potatoes in Southeast Asia has enabled an international trade in potatoes despite their heavy weight making long distance transport costly (Ezeta 2008, p. 12). Indonesian potato exports grew quickly from the mid-1980s until the mid-1990s but then declined just as rapidly (Figure 4.2).

Major markets were Malaysia and Singapore. Indonesian vegetable exports were deregulated in 1990 (Adiyoga *et al.* 2001, p. 7). Potato exports peaked in 1995 at a level equal to 10% of domestic production or 40% of North Sumatran production, where most of the potatoes for the export market were grown (Adiyoga *et al.* 2001, p. 18). From 1998 to 2000 exports declined rapidly to around 31,000 tonnes and have since declined steadily to around 5,000 tonnes in 2012 (Figure 4.2). Exports for 2012 were close to 7,000 tonnes according to the Pusat Data dan Sistem Informasi Pertanian (2013) but this includes 1,500 tonnes of potato starch, plus some frozen product, which are probably re-exports. Until 1998 Indonesia was the main exporter of fresh potatoes to Malaysia, Singapore and Thailand but China and Australia have since become more price competitive (Ezeta 2008, p. 12) and more lately Bangladesh (Prabowo 2011). The decline in Indonesian exports is unlikely to be due to pesticide residues as no shipments of Indonesian potatoes have been rejected by

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[2] *512% calculated from 1996 production of 1 109 560t divided by 1981 production of 216 713t.*

[3] *11% calculated from compound interest formula FV = IV*(1+interest rate)^period where FV = final value, IV = initial value, interest rate = annual growth rate, period = number of years. This can be rearranged thus: annual growth rate (interest) = (FV/IV)^(1/years) – 1.*

[4] *Annual growth rate = (15.9t/ha/7.2t/ha)^1/15years) – 1.*

[5] *4% calculated from 2012 production of 1 068 800t divided by 1996 production of1 109 560t.*

[6] *-0.2% annual decline in production calculated as per footnote 2 above where annual growth rate = (FV/IV)^(1/16 years) – 1.*

[7] *Annual growth rate = (16.6t/ha/15.9t/ha)^1/16years) – 1.*

Singapore for this reason (Adiyoga *et al.*, 2001, p. 24). Regional free trade agreements will favour growth in potato trade among neighbouring countries (Ezeta 2008, p. 13).

Frozen French fries are not produced in Indonesia and imports reached 23,000 tonnes in 1997, before the Asian Economic Crisis, after which they fell to 7,000 tonnes. Imports have steadily increased since, surpassing the 1997 level in 2001 and reaching 27,000 tonnes in 2012.

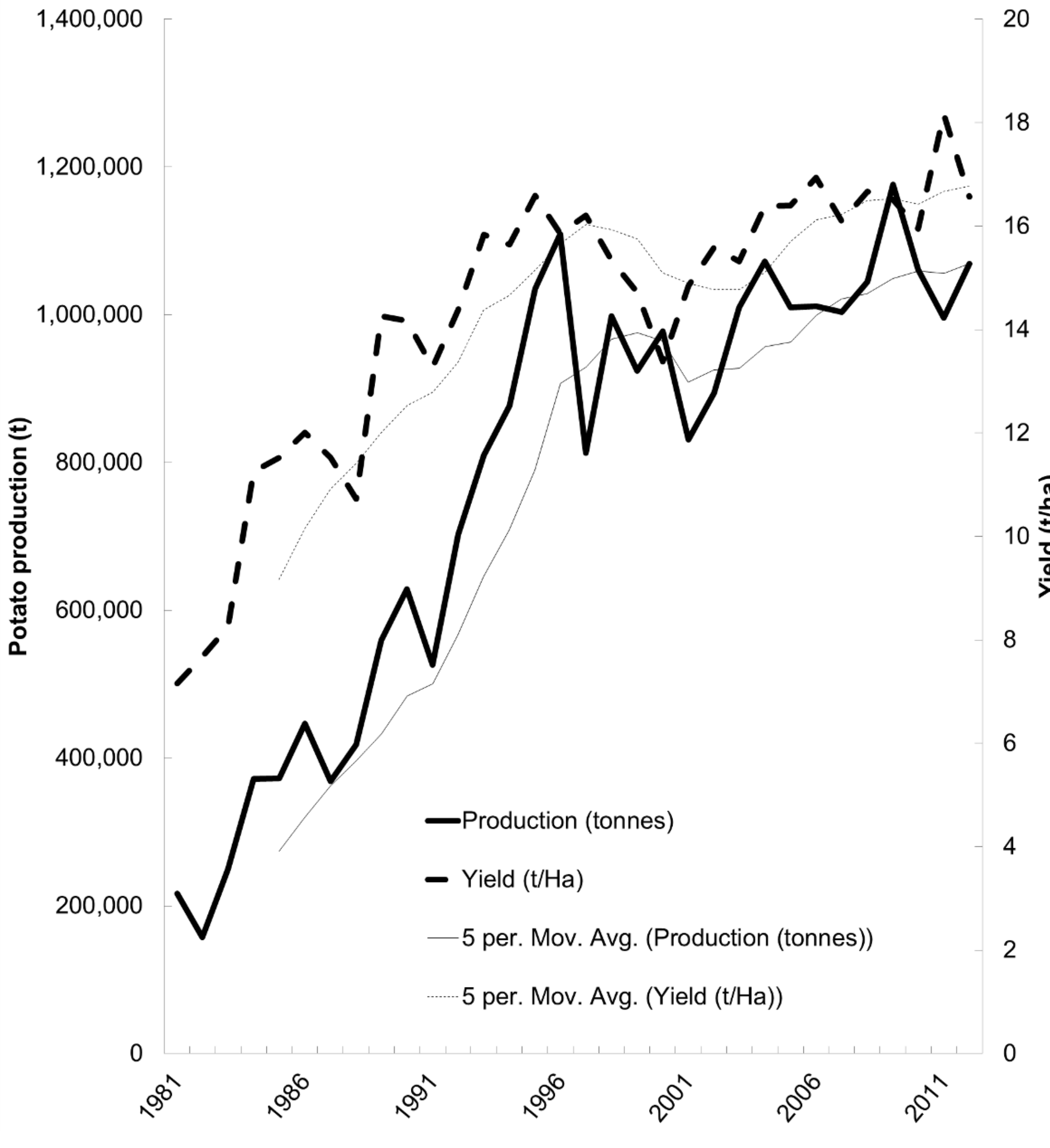

Figure 4.1. Indonesian potato production and yield from 1981 to 2012. Production shown as solid lines and yield as dashed lines. Actual data shown by bold lines with 5 year moving average shown as fine lines. Data from FAOSTAT.

Figure 4.2. Indonesian potato imports and exports from 1980 to 2011 (left axis) with domestic potato production (right axis). Note, the left and right axes have different scales; the domestic production scale is ten times greater than the import and export scale. Imports include fresh and frozen potatoes. Source FAO.

4.1.5 Constraints to potato production in Indonesia

Ezeta (2008, pp. 14-15) sets the scene; in Indonesia significant constraints to production are caused by potato late blight, bacterial wilt (*Ralstonia solanacearum)*, PCN, viruses and insect pests like leaf miner fly (*Liriomyza huidobrensis*) and potato tuber moth (*Phthorimaea operculella*). Pesticide use is high and soil erosion a significant risk. The lack of reliable and affordable quality potato seed is a major problem, as it is for most of the world (Singh 2008, p. 20). Poor quality seed imposes other constraints because important diseases are seed-borne (Ezeta 2008, p. 15).

Singh (2008, p. 20) summarises the reason for the lack of seed in the Asia-Pacific region:

- Potatoes have a low multiplication rate which is made worse by the low proportion of seed sized tubers.
    - A large quantity of seed is required which makes it difficult for most countries to fulfil their own seed needs.
- potatoes have a high production cost
- potatoes have a high rate of degeneration
- a high level of technical skill is required for seed production.

Maldonado *et al.* (1998) surveyed heads of National Potato Programs in Southeast Asia about principal constraints to potato production. The highest ranking constraints were high cost of seed, bacterial wilt, potato late blight and disease in seed, as shown in Table 4.1. Table 4.1 also shows the crop management priorities in East and Southeast Asia as surveyed by Fuglie (2007). He reported that potato late blight, lack of improved varieties, need for improved seed and control of virus and bacterial wilt were most important. The lack of new superior varieties as alternatives to Granola was recognised as a major problem around a decade earlier (Adiyoga *et al.* 1999, p. 12). Crissman (1989, p. 2) adds physiological age of seed as a limiting factor which needs to be considered as part of improving the supply of high quality seed, Fuglie's (2007) third priority.

Table 4.1. Main constraints to potato production in Southeast Asia* from Maldonado *et al.* (1998) and crop management priorities in East and Southeast Asia† from Fuglie (2007).

Maldonado *et al.* 1998 Constraint	Fuglie (2007) Crop management priority (>3.4 = high priority)
High cost of seed	Control of late blight (management & genotype)
Bacterial wilt	Improved varieties (marketable high yielding)
Potato late blight	Improved supply of quality seed
Disease in seed	Control of viruses through, vector control, seed production and crop management,
Lack of processing varieties	Control of bacterial wilt using genotypes & crop management

*Countries classified as Southeast Asia in this study were; Indonesia, Myanmar, New Caledonia, Thailand, Tonga and Samoa.

4.1.6 Farmer training

Singh (2008, p. 20) notes that technological solutions to constraints need to be adopted and benefit farming communities. It is suggested that Farmer Field Schools (FFS) would be an effective method.

Farmer training is a special challenge in Indonesia where individual potato enterprises number just under 120,000 {assuming an individual enterprise area of 0.55 ha (Direktorat Jenderal Hortikultura, 2011, p. 7) with a 2012 crop area of 65,218 (Badan Pusat Statistik 2012)}. Dawson *et al.* (2011, p. 7) found that FFS methodology, which compared an integrated crop management plot with a conventional plot, concurrently tested many disparate management techniques, made interpretation of the results difficult. This was in itself a constraint to potato production as the FFS farmer training method was ineffective. They modified the FFS investigations to allow the impact of a single management change to be investigated in a standardised way. These farmer group field investigations focussed on specific constraints which were supported by specially developed Technical Toolkits aimed at farmer guides and facilitators. The toolkits described how to undertake rigorous but simple experiments to test production constraints. The Technical Toolkits also contained information on standard operation procedures for managing potato crops. The standardisation of the simple experiments meant that collaborating farmer groups could add rigor to their results by pooling data to allow statistical analysis of their results. This modified FFS method allowed easier and more rigorous interpretation of the results. Farmer Initiated Learning (FIL) was the brand used by Dawson *et al.* p, 20) to differentiate this new method from previous highland vegetable FFS practice. FIL provides both a method of training farmers in new techniques as well as enabling farmer groups to find the best solutions for constraints for their specific location.

4.1.7 Conclusions about Indonesian potato production

Indonesia experienced a rapid rate of growth of its potato industry from the early 1980s until 1996. Both production area and yield increased as did exports. From 1997 to 2012 growth slowed along with yield increases and exports declined markedly. Imports have increased and the Indonesian potato industry needs to improve its competitiveness in the face of relaxing regional trade liberalisation and major pests and diseases. High price of seed and disease status of seed potatoes are considered to be major constraints to production.

5 Indonesia Potato Policy and Regulations

5.1 Rules and regulations

Rules and regulations concerning Indonesian Horticultural seed policy have changed frequently in the last decade. Current laws and regulations are shown in Table 5.1. The overarching law is Law 13 of 2010 about horticulture (UU 13/2010). Under this law it is illegal to plant a horticultural crop with uncertified seed. Article 32 of this law defines seed as an input and Article 35 states inputs must meet the quality standards with Article 126 prescribing punishment for anyone distributing horticultural inputs that do not meet quality standards.

5.1.1 Seed Production Technical Guide

The latest seed potato technical production guide is published as an attachment to Regulation of the Ministry of Agriculture 20/Kpts/SR.130/IV/2014. It allows for certification of Extension Seed produced in an open field from generation 0, 1 or 2 (G0, G1, or G2) seed only. This guide meets the requirements of Regulations of the Ministry of Agriculture (RMA) 48/2012, as amended by RMA 116/2013.

The previous certified seed potato certification system allowed certified Extension Seed to be generation 4. The production of certified seed from these generations 3 and 4 will no longer be valid after November 2015.

5.1.2 Inter-Provincial Seed Movement

In Indonesia there are regulations about the movement of seed potatoes between provinces. One example is the West Nusa Tenggara (NTB) Governor’s Regulation Number 17 of 2011 (Peraturan Gubernur NTB Nomor: 17 Tahun 2011 tentang Peredaran Benih Kentang). The regulation was introduced to ensure the availability of good quality potato seeds in the province. To gain entry to the province potato seed must be accompanied by a permit from the Head of The Food and Horticulture Crops of the Agriculture Service of NTB. The seed must be certified by the BPSB[8] from the area of production.

5.1.3 Intent of regulations

To assist the development of national seed industry.

Seed is seen as a key factor which leads to high productivity and quality. Seed laws and regulations have been revised to encourage the development of the national seed industry and to ensure that seed development benefits the Indonesian people. Seed industry development is required as production of certified seed does not meet demand.

The effect of the new laws and regulations with regard to seed import and export are summarised by Yusuf (2012a):

- The government encourages the national seed industry.
- New commercial varieties have to be registered and the seed has to be certified.
- The distribution of all commercial seed is to be supervised by certification services.
- Export and import of seed needs a permit from the Minister of Agriculture.
- 2 years after registration of an imported variety, all commercial seed sold in Indonesia has to be produced in Indonesia.

[8] *BPSB = Balai Pengawasan dan Sertifikasi Benih (Seed Inspection and Certification Service).*

Table 5.1. Indonesian laws and regulations concerning seed potatoes.

Number (short no.)	Description	Replaces
Laws (undang-undang, UU)		
UU 12/1992	Cultivation system	
UU 29/2000	Plant variety protection	
UU 13/2010	Concerning Horticulture (8 aims) • to develop optimal sustainable horticulture resources • meet community needs for horticultural products • increase production & competitiveness • increase prosperity	
Regulations of the Ministry of Agriculture (RMA)/Decrees of the Ministry of Agriculture (DMA)		
38/2011	Horticultural variety assessment & registration	RMA 37/2006*
01/Kpts/SR.130/12/2012		
01/2012	Technical Guide for Certification of Horticulture Seed	
05/2012	Export-import of horticultural seed	
05/Permentan/OT.140/2/2012		RMA 38/2006
05/2012	Export-import of horticultural seed	
48/Permentan/SR.120/8/2012		
(48/2012)	Horticultural seed production, certification and control	RMA 39/2006 RMA 40/2006
01/Kpts/SR.130/12/2012		
(01/2012)	Technical Guide for Horticultural Seed Certification includes Attachment II Vegetable crop seed certification that shows requirements for RMA 48/2012	
116/Permentan/SR.120/11/2013		
116/2013	Amendments to RMA 48/2012	
20/Kpts/SR.130/IV/2014		RMA 01/2012 after November 2015
(20/2014)	Attachment provides techniques of multiplication and certification of seed potato (see Kosim 2014) required for 48/2012 as amended by 116/2013	

* Regulation of the Ministry of Agriculture {Permentan (Peraturan Menteri) in bahasa Indonesia}

- The amount of exported and imported seed has to be reported to the Directorate General of Horticulture.
- Seed importers have to be seed producers in Indonesia.
- Foreign investment regulations for the seed industry:
    - Foreign companies have to partner with Indonesian companies and transfer technology.
    - The maximum amount of foreign investment in a horticultural business is 30%.
    - The establishment of a seed business needs a permit from the government.
- To obtain a permit the following is required:
    - plant quarantine requirements have to be met
    - the variety must be registered
    - seed must comply with national seed quality standards
    - domestic supply of the seed does not meet demand
    - quantity of imported seed must not exceed demand
    - genetically modified organisms must have a recommendation from the Indonesian GMO Commission.

The government's role is to:

- Encourage foreign investors to build up the capacity of Indonesia to produce quality seeds.
- provide seed policy and regulations conducive to seed development
- enforce the regulations.
- conduct annual meetings with seed stakeholders
- strengthen seed-related institutions
- provide technical guidelines for seed producers
- strengthen quality control
- promote the use of quality seeds because Indonesian farmers are still using 60%[9] of farm seeds.

The expected outcome is for self-sufficiency in quality seed supply and improved welfare of the community through the benefits of improved seed.

Government support for seed development will come through the Directorate General of Horticulture whose strategic plan (Direktorat Jenderal Hortikultura 2011, pp. 7-8) presents issues and challenges as well as a development strategy for seed revitalisation:

- Issues and challenges:
    - insufficient quality seed is produced due to lack if investment, including the private sector
    - seed system needs better support through improvements to:
        - variety development
        - the production and distribution system
        - the certification system.
    - The level of technology used by farmers needs to be increased.
- Development strategy (Direktorat Jenderal Hortikultura 2011, pp. 46 & 48):
    - Development of seed systems which are cheap, timely and within easy reach farmers.
    - Institutional strengthening of inspection and certification centres (BPSB) by:
        - improving staff competency
        - modernization of equipment
        - improvement of systems, standardization and accreditation processes, roles and functions
        - strengthening technology information systems.

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[9] *Includes all crops, not just potatoes.*

- Revitalization of seed production centres through:
  - improved seed supply sources and seed grower training
  - the development of seed grower associations
  - improving access to science and technology
  - improving access to capital markets
  - the development and implementation of seed standard operational procedures (SOP)
  - strengthening seed quality assurance (LSSM)[10]
  - increase the private sector's role in building the seed industry in the country through the ease of licensing, coaching process accreditation
  - simplifying regulation and release of varieties.

5.2 Effectiveness of Seed Potato Policy

A study of the effectiveness of Indonesian seed potato production policy makes the following comments about existing legal and regulatory framework (Sayaka *et al.* 2012):

- The limit on foreign ownership discourages foreign investors.
- There is a greater role for provincial governments in seed development, including seed import and export initiatives, and the establishment of seed production centres. Law UU 13/2010 Article 34 stipulates that local governments can provide regulated incentives to entrepreneurs to produce horticultural inputs ("sarana produksi") that cannot be produced locally.
- The seed potato production guidelines may be too technical (not suited to Indonesian conditions) to achieve the aim of self-sufficiency in seed.
- Article 126 of Law 13/2010 provides for a punishment of imprisonment for two years or a maximum fine of two billion rupiah for anyone providing horticultural inputs that do not meet quality standards. This is not enforced as most Indonesian potato growers are using "seed" that does not meet the quality standards. Seed standards have been developed by the Badan Standardisasi Nasional (2004a, b & c).
- Despite the regulations, adoption of certified seed is still low as there is a large price difference between certified seed and farmer's own seed without a great difference in productivity. Therefore there needs to be greater production of lower price seed available in all seasons.

An earlier study into policy development of seed potatoes suggested that limits on importing seed may encourage local seed development due to reduced competition which would encourage new entrants to seed production and so increase availability and reduce the price (Sayaka *et al.* 2009). However, despite a virtual ban on imports of Granola seed, the local supply response has been very limited and the high cost of certified seed remains a major issue.

[10] *LSSM = Lembaga Sertifikasi Sistem Mutu (Institute for Certification Quality System)*

6 Indonesian Government Certified Seed System

6.1 Characteristics of seed potatoes

Seed potatoes have a unique combination of characteristics which must to be considered when determining suitable propagation systems that can produce seed tubers of an acceptable quality. Quality concerns include:

- the spread of pests and diseases which have the greatest impact on yield and quality
- seed vigour, or physiological age, and
- physical damage.

Seed potatoes characteristics are summarised by Struik and Wiersema (1999, pp. 29-30):

1. Seed potatoes have a low multiplication rate (10 times by weight for seed crops, 20 times for commercial crops in high yielding areas), which means a large proportion, around 10%, of the production must be devoted to seed.
2. Seed potatoes are susceptible to degeneration through their ability to:
    a. transfer soil-borne diseases
    b. accumulate seed-borne diseases and other risk factors:
        i. viroids
        ii. viruses
        iii. bacteria
        iv. fungi
        v. nematodes
        vi. weeds.
3. Seed potatoes are perishable in storage.
4. Seed potatoes are susceptible to changes in performance due to seed storage:
    a. Growth is affected by tuber physiology.
    b. Dormancy after maturity means storage is required.
    c. Vigour varies with physiological state;
        i. there is a strong change in seed quality as seed ages.
5. Seed tuber performance varies with tuber size.
6. There is variation in performance of seed-lots, due to the factors above, which seed buyers must learn to manage.
7. Obtaining seed at the best stage for planting may be difficult where potatoes are grown at various times of the year.
8. Seed potatoes have a high price.
9. A wide range of techniques for propagation is available and the best technique should be selected on the basis of agro-ecological conditions of seed and commercial production.

Struik and Wiersema (1999) caution that some seed managerial requirements are often underestimated which leads to ineffective handling, management, quality control and certification of seed production schemes.

6.2 Seed scheme components

There are three stages of seed multiplication (Mateus-Rodriguez *et al.* 2013, p. 358) and others consider the fourth is essential to provide a sound foundation to a seed scheme:

1. Micro-propagation in laboratory to produces *in vitro* pathogen tested seedlings.
2. Basic Seed production (minitubers under protection or controlled environment).
3. Post minituber field production.
4. Variety development (Struik & Wiersema 1999, p. 275) through breeding; the starting point of any seed production system.

The micro-propagation stage is expensive and so the cost of the initial material is spread over a series of multiplications called generations. The main problems of maintaining the health standard of seed start when specialist growers transfer the Basic Seed to the field for large scale multiplication into later seed generations (Struik & Wiersema 1999, p. 272). During field multiplication the seed is exposed to; diseases, pests and their vectors and handling damage.

As seed potato crops are exposed to pests and diseases it is inevitable that the percentage of tubers within the crop that are infested or infected increases. The levels of pest and disease build up with increasing generations and, along with handling damage, impair the performance of seed. This reduction in seed performance is called degeneration. The rate at which degeneration occurs depends on the environmental conditions, the genetic material being propagated and the skills of the seed growers. Therefore to produce seed to specified pest and disease tolerances, the decline in seed quality over the generations must be monitored, controlled and contained.

Seed quality, or its degree of degeneration, is not easily assessable by visual observation of the tubers at time of purchase; therefore buyers must rely on other assessment methods. Seed quality assessment is usually performed by independent agencies through field monitoring tests. These tests are used to assign a quality classification to the seed according to the results of the seed scheme under which it is grown. Independent assessment of the actual level of quality decline is a crucial as well as an effective method to show the level of decline to both the seller and the buyer (Struik & Wiersema 1999, p. 274).

Degeneration rate can be managed by using two methods:
- shortening the duration of degeneration by limiting field multiplications, and
- reducing the rate of degeneration through protective measures.

Degeneration tests to determine the rate of decline in quality due to virus can be done for specific areas (Struik & Wiersema 1999, p. 301). This involves planting healthy seed tubers in the area being investigated. At harvest two tubers from each plant are harvested. One tuber is tested in the laboratory for the pest or disease of concern and the remaining tuber is stored and replanted at the location in the following season and at harvest two tubers per plant are again selected for testing and replanting. The procedure is repeated to cover the number of generations used in seed production.

6.3 Indonesian Government seed system

6.3.1 5 generation scheme, valid until November 2015

The government certified seed system began through a Japanese International Cooperation Agency (JICA) project in 1992 (Fuglie *et al.* 2005). The scheme is based on initial pathogen-tested tissue cultured material with relegation of generations to lower seed classes following each multiplication. The scheme began in the highlands of West Java based at the Potato Seed Development Centre (Balai Pengembangan Benih Kentang (BPBK)) at Pangalengan.

West Java is the largest potato producing province growing 24% of Indonesia's potatoes. West Java produced 261,966 tonnes of potatoes from 13,628 ha with an average yield of 19.2 t/ha in 2012 (Badan Pusat Statistik 2012).

The procedure used at BPBK Pangalengan up to 2015 is shown in Figure 6.1. Seed production encompasses five generations, from generation zero (G0) to generation four (G4). The first two generations were propagated in a protected laboratory or screenhouse environments. G0 minitubers are produced in screenhouse A from plants generated from pathogen tested tissue culture material. This produces the next generation, G1 or Basic Seed 1 (Benih Dasar 1), which itself is grown in screenhouse B to produce G2 or Basic Seed

2 (Benih Dasar 2). Basic Seed 2 is multiplied in the field to produce G3 Stock Seed (Benih Pokok). The final field multiplication produces G4 Extension Seed (Benih Sebar).

Breeder seed is monitored for virus infection using enzyme-linked immunosorbent assay (ELISA). After G1 production, subsequent generations of seed are grown in fields to the standards of the Food and Horticulture Crops Seed Inspection and Certification Service (BPSBTPH[11]). The later generations can also be produced by registered seed potato growers. Pre-planting soil tests for PCN are undertaken for all BPSBTPH supervised seed potato crops.

Government Seed Centres

Following the establishment of BPBK Pangalengan more seed potato centres were established to supply seed to other provinces and by 2012 there were seven seed potato centres (Yusuf 2012b);

- BPBK Pangalengan, West Java
- BBH (Balai Benih Hortikultura = Horticultural Seed Centre), Kledung, Central Java
- BBI (Balai Benih Induk = Mother Seed Centre)
  - BBI Kuta Gadung (North Sumatra)
  - BBI Kayu Aro (Jambi)
- BBK (Balai Benih Kentang = Potato Seed Centre)
  - BBK Alahan Panjang (West Sumatra)
  - BBK Tosari (East Java)
  - BBK Modoinding (North Sulawesi).

Amount of seed produced

Recent production of seed within this system in West Java by BPBK is shown in Table 6.1. The greatest amount was 75 tonnes of G2 produced in 2013. The resulting amount of Extension Seed produced in West Java was around 3,500 tonnes (Mr Dedi Ruswandi, Technical Manager for Seed Potato Inspection, BPSBTPH West Java, personal communication, 25 November 2014). Seed crop area inspected was 380 ha of which 2.5% failed to pass due mainly to bacterial wilt infection. Another source reports around 3,000 tonnes of Extension Seed was produced in 2013 (Table 6.2). The scheme also includes a pre-planting PCN soil test. The number of fields rejected due to PCN infestation is increasing in West Java according to BPSBTPH (Mr Dedi Ruswandi, personal communication, 25 November 2014).

Dinas Pertanian East Java report that seed availability in that province was just 2% of requirements in 2012, i.e. only 305 tonnes of certified seed was available but 13,684 tonnes was needed to plant the entire crop (Table 6.2). Mr Sugianto, Head of BBK Tosari, East Java, reports that annual production from that centre is 20 tonnes of G2. Two other horticultural seed centres in East Java multiply later generations, KBH Sapikerep at Probolinggo multiplies G2 to G3 on 6 ha while KBH Sarangsari at Magetan multiplies G3 to G4 on 10 ha. Seed growers also contribute to seed production with two seed producers at Malang, five at Probolinggo, seven at Pasuruan, two at Magetan, one each at Trenggalek, Lumajang and Madiun.

In 2008 Indonesian seed availability was 8,066 tonnes, or 8% of requirements, which included 2,785 tonnes of imported seed (Ranu 2010).

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[11] BPSBTPH = Balai Pengawasan dan Sertifikasi Benih Tanaman Pangan Hortikultura (Food and Horticulture Crops Seed Inspection and Certification Service).

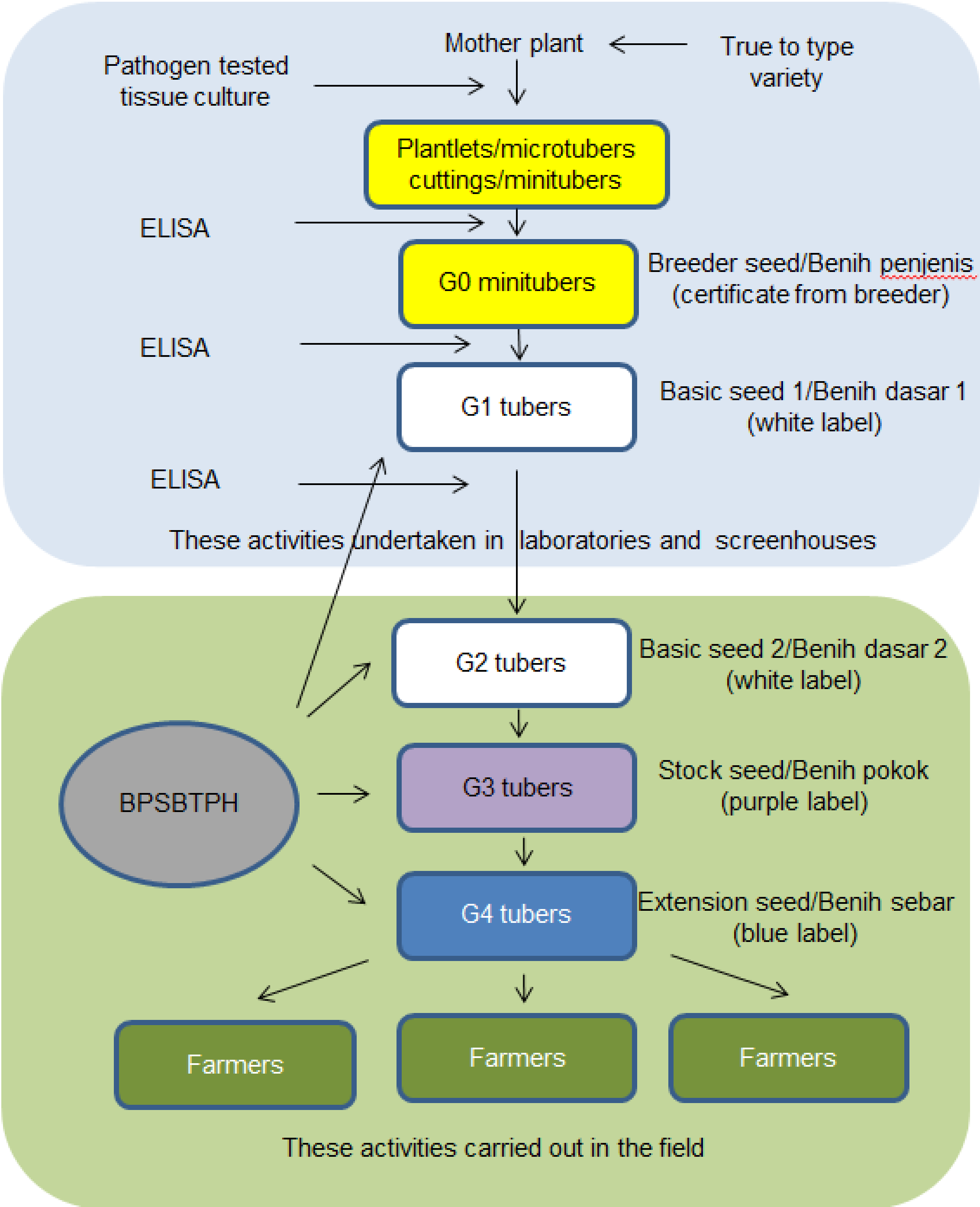

Figure 6.1. Seed potato multiplication flow concept for West Java. After Dinas Pertanian Jawa Barat (no date A).

Table 6.1. Seed potato production from BPBK Pangalengan

Year	Tuber			Area	Reference
	number	kg	weight (g/tuber)		
			G0 seed		
2003	272,790	2,249	8		Dinas Pertanian
2004	152,846	1,180	8		Tanaman Pangan
2005	200,455	1,610	8		(no date B)
2006	230,924	2,283	10		"
2007	216,562	1,999	9		"
2008	152,780	1,441	9		"
2009	191,872	1,548	8	11 SHA	Visit November 2014
2010	162,905	1,315	8	10 SHA	"
2011	157,949	1,848	12	7 SHA	"
2012	290,093	3,404	12	12 SHA	"
2013	141,840	1,665	12	9 SHA	"
			G1 seed		
2003	141,852	8,189	58		Dinas Pertanian
2004	143,184	8,377	59		Tanaman Pangan
2005	145,440	8,509	59		(no date B)
2006	149,657	9,128	61		"
2007	118,333	7,889	67		"
2008	165,049	11,003	67		"
2009	245,625	16,375	67	18 SHB	Visit November 2014
2010	197,347	13,156	67	14 SHB	"
2011	75,250	4,123	55	5 SHB	"
2012	185,724	10,196	55	12 SHB	"
2013	252,461	13,450	53	9 SHB	"
			G2 seed		
2003	793,478	36,500	46		Dinas Pertanian
2004	803,260	36,950	46		Tanaman Pangan
2006	818,478	37,650	46		(no date B)
2007	655,434	30,150	46		"
2008	1,086,955	50,000	46		"
			(t/ha)		
2009	1,101,675	50,675	12.7	4 ha	Data collected
2010		35,852	9.0	4 ha	during project
2011		27,175	13.6	2 ha	November 2014
2012		61,375	15.3	4 ha	field trip
2013		75,000	15.0	5 ha	"

Table 6.2. Seed potato availability, East and West Java.

Year	Potato Crop Area (Ha)	Seed Requirement (Tonne)*	Seed Availability	
			(Tonne)	(%)
		East Java		
2011	8,088	9,706	147	1.5
2012	11,403	13,684	305	2.2
2013	10,985	13,182	236	1.8
	West Java (Dinas Pertanian Tanaman Pangan, no date C)			
2013		39,587	2,916	7.4

*Based on 1.2 tonne seed/ha

6.3.2 Three generation scheme, phased in from 2013

On 13 November 2013 changes to the Indonesian certified seed potato scheme reduced the generations in the scheme to three; G0 Basic Seed (Benih Dasar), G1 Stock Seed (Benih Pokok) and G2 Extension Seed (Benih Sebar). G0 and G1 must be produced in screenhouses and G2 can be produced in the field. This means that the G3 and G4 of the five generation scheme will be phased out after November 2015 (Agricultural Ministry Decree number 20/Kpts/SR.130/IV/2014). This procedure, as now used at BPBK Pangalengan, is described below and in Figure 6.2 and Tables 6.3, 6.5 and 6.7.

Breeder Seed (Benih Penjenis)

Breeder Seed (Benih Penjenis) supplies the tissue culture plantlets used to begin seed multiplication. Producers of Breeder Seed (Benih Penjenis) must have legal delegation from the owner of the variety (Form SK 02 Delegasi Legalitas) and a Breeder Seed Certificate (Form SK 03 Surat Keterangan Benih Penjenis). The requirements for production of Breeder Seed are given by Kosim (2014, pp. 8-17).

The Breeder Seed is supplied by IVEGRI as bottles of tissue culture plantlets. IVEGRI has commissioned the private tissue culture company PT DaFa Teknoagro Mandiri[12] at Bogor to produce plantlets to increase the availability of Granola breeder seed that is needed to compensate for the removal of G3 and G5 seed from the seed scheme.

Three generation seed production at BPBK (Benih Penjenis)

Basic Seed (Benih Dasar) – Generation 0

BPBK Pangalengan obtains Breeder Seed from IVEGRI as bottles of tissue culture plantlets. Each bottle contains 10 plantlets rooted in agar. Each plantlet is cut above the first node and this stem is divided into single node cuttings, usually four per plantlet. These single node cutting are grown on agar in tissue culture jars. After this multiplication one tissue culture bottle has enabled the production of four new bottles plus the original bottle which is retained to grow out its rooted cutting “stumps”. The multiplication rate is 5.

At BPBK this procedure is repeated to result in a multiplication of around 5 x 5 = 25 times the original number of Breeder Seed plantlets. A 5% mortality rate of laboratory plantlets means the actual multiplication rate is 4.75 x 4.75 = 22.6 times.

After the second plantlet multiplication the plantlets are grown on agar until they have several nodes. These multi-node cuttings are potted into sterile soilless media (coco peat) and grown in the aphid proof Acclimatisation Screenhouse. The use of multi-node cuttings

[12] *website: www.dafataman.com*

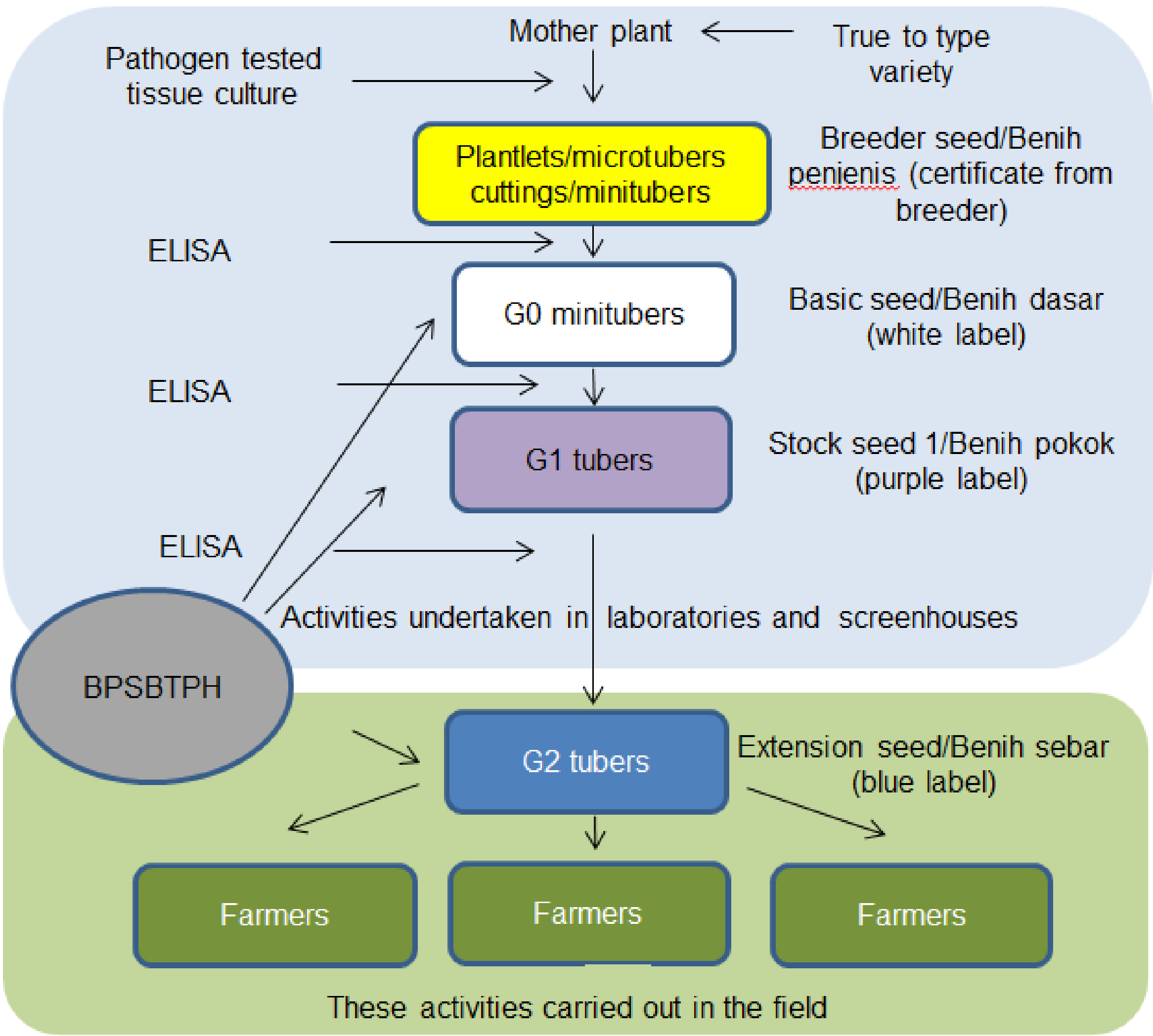

Figure 6.2. Revised three generation seed potato multiplication flow concept for West Java. After Dinas Pertanian Jawa Barat (no date A).

allows a couple of nodes to be buried to give strong root production. Failure rate in acclimatisation is around 7.5% so the final multiplication rate is around 21 times. The multiplication of plantlets from tissue culture bottles to plantlets in the Acclimatisation Glasshouse is as follows. 600 bottles of tissue culture plantlets are received twice a year from IVEGRI. This give an annual production of 250,444 acclimatised plantlets (Table 6.7 shows calculations).

The next multiplication is the production of G0 minitubers from the acclimatised plantlets. This is done in seedbeds in Screenhouses A (SHA). The capacity of this system, based on the infrastructure shown in Table 6.3, is as follows. Seedbeds hold 210 acclimatised plantlets. Each SHA has 80 seedbeds. The capacity to grow-out acclimatised plantlets is 16,800 plantlets/SHA per season but a 7.5% mortality rate results in 15,540 plantlets being harvested/SHA/season. There are six Screenhouses A. BPBK Pangalengan can therefore produce 6 lots of 15,540 plantlets/per season or twice this over one year. The result is 186,480 plantlets.

Table 6.3. BPBK Pangalengan Screenhouse A plantlet capacity. Dimensions from Fuglie *et al.,* 2005)

Item	Dimensions/capacity	Plantlets per	
		season	year
Seedbed			
dimensions	1.685m x 0.82 m		
planted capacity	210 plantlets		
number/screenhouse	80		
Plantlet capacity/screenhouse	210 x 80 =	16,800	
Plantlet mortality	7.5%	1,260	
Plantlets harvested/screenhouse		15,540	31,080
Screenhouse A			
dimensions	39 m x 6.5m		
number	6	93,240	186,480

Requirements that must be met to produce generation zero (G0) Basic Seed (Benih Dasar) are detailed in Kosim (2014). Competencies, infrastructure requirements and crop management practices are prescribed (Kosim 2014). Screenhouse specifications are given in Direktorat Jenderal Hortikultura (2013). The seed produced is graded according to size (Table 6.4).

Table 6.4. Seed grade sizes.

Seed type	Seed grade		
	Small	Medium (grams)	Large
Basic/Dasar (BD) (G0)	<5	5 - 20	> 0
Stock/Pokok (BP) (G1)	<40	40 - 90	90 - 120
Extension/Sebar (BS) (G2)	<40	40 - 90	90 - 120

Stock Seed (Benih Pokok) – Generation 1

After the G0 minitubers (Basic Seed/Benih Dasar) have been produced in SHA they are stored until dormancy is broken, then used to grow G1 (Stock Seed/Benih Pokok) in Screenhouse B (SHB). Requirements to produce G1 Stock Seed (Benih Pokok) are detailed in Kosim (2014). The minitubers must be planted in sterilised seedbeds using sterilised subsoil. SHB capacity at BPBK Pangalengan is shown in Table 6.5. SHA contains 19 rows averaging 285 plants which gives a capacity of around 5,500 plants/SHB/season. There are 14 SHB so 77,000 plants can be grown per season or 154,000 annually.

Extension Seed (Benih Sebar) – Generation 2

G1 Stock Seed is planted in the field and crops which meet the standards of the seed inspection by BPSBTPH produces G2 Extension Seed (Benih Sebar). Similarly G0 Basic Seed which is planted directly into the field, as opposed to a screenhouse, is relegated to produce G2 Extension Seed also.

Table 6.5. BPBK Pangalengan Screenhouse B plantlet capacity. Dimensions from Fuglie *et al.,* (2005)

Item	Dimensions/capacity	Plants per	
		season	year
Planting arrangement SHB			
row dimensions	37m x 0.65 m		
row number/SHB	19		
in row spacing	11.5 to 15cm		
Plants/SHB	210 x 80 =		
Plants/row	322 to 247 (average 285)		
Plant/screenhouse	~5,500	10,830	21,660
Seasonal/annual production			
dimensions	39m x 13m= 507m2		
number SHB	14		
number plants	= 14 x 5,500 =	77,000	154,000

G2 Extension Seed Production fields must:

- not be in an area prone to aphid proliferation
- not be in an area where bacterial wilt occurs
- pass a PCN laboratory soil test with samples taken on an 8 step grid
- have a rotation of 3 growing seasons (3 x 3 months) of non-Solanaceae crops
    - fallow for one growing season is counted as a non-Solanaceae crop
- isolation from:
    - consumption potato crops using a border crop higher than the potato crop for a 6m width
    - consumption potato crops or tobacco crops using an artificial barrier 1.5 m tall with 3m wide band of unplanted land from the seed crop
    - volunteer potato plants in the surrounding land
    - water flowing from surrounding Solanaceae crops.

Seed multiplication by other parties

Seed can be multiplied by registered seed growers who meet the requirements described above. Farmer seed growers are being encouraged to produce G0 Basic Seed from tissue culture to broaden the supplies of seed in the reduced generation seed scheme, an examples were seen during field visits; PT Labiota Indah at Malino, the Fanini brothers at Dieng and Muhammad Khudori at Garut and a partnership between IVEGRI and a grower group is described by Sofiari (2013). This shows that the government certified seed scheme and the private tissue culture seed production are merging under the new, three generation seed scheme.

Seed inspection and certification

Seed inspection and certification procedures are detailed by Kosim (2014). An application is submitted to the provincial inspection agency using form SK 03 for screenhouse and field inspections and SK 05 for tuber inspections.

Inspection stages

1. The application is vetted to ensure it complies with all requirements which include a correctly filled out application form, certificate of freedom from PCN, agreement between seed labels submitted and the amount of seed planted. Applications passing this stage are given an identification number.
2. Preliminary inspection includes the following checks:
    a. seed matches label and is appropriate for the class of seed to be produced

   b. isolation requirements are met
   c. condition of screenhouses conforms to requirements
   d. slope of land is less than 30°
   e. rotation requirements have been met.
3. Crop inspections are done to ensure that the crop meets the minimum technical requirements as shown in Table 6.6. A certification unit is 20,000 screenhouse plants or one hectare of field crop. Inspections are carried out comprise:
   a. First inspection 30 – 40 days after planting, all plants in screenhouses producing G0 Basic Seed and G1 Stock Seed are inspected and at least 1,000 plants for G2 Extension Seed plots.
   b. Second inspection takes place 50 – 70 days after planting.
   c. Tuber inspections are done on all G0 seed containers. For other seed at least 1,000 tubers from every 15 tonne lot are examined. The minimum technical requirements for tuber inspections are shown in Table 6.6.

Table 6.6. Minimum Technical Requirements Seed Potatoes

Parameter	Unit	Seed class produced		
		G0	G1	G2
Field inspection				
Other mixed varieties	%	0*	0.0	0.0
Disease (Maximum % of plants attacked by number)				
Virus (PLRV, PVX, PVY)	%	0*	0.0	0.1
Bacterial wilt (*Ralstonia solanacearum*)	%	0*	0.1	0.5
PCN (*Globodera* sp.)	%	0*	0*	0*
Field management **				
Tuber inspection in store				
Tuber health (Maximum % of tubers affected by number)				
Brown rot and soft rot	%	0*	0.0	0.3
Common scab, black scurf, powdery scab, late blight (mild infection)	%	0*	0.5	3.0
Dry rot	%	0*	0.1	1.0
Damage by tuber borers (*Phthorimaea operculella*)	%	0*	0.5	1.0
Root knot nematode (mild infection)	%	0*	0.5	3.0
Varietal mixture	%	0*	0.0	0.0
Mechanical damage	%	0*	0.5	3.0

0 * No (Nil visually) ** Management of field; see 1 & 2 below.
1. The crop fails if there are; many volunteers, weeds as a source of disease, roguing residues remaining, aphids not controlled or the land contains PCN.
Isolation from consumption potato crops or tobacco crops requires a border crop higher than the potato crop for a 6m width or an artificial barrier 1.5 m tall with 3m wide band of unplanted land from the seed crop. No water may flow from a consumption potato crop into the seed crop.
2. If inspection is not possible because leaf blight, leaf mechanical or chemical damage, heavy damage by insects, and/or wilting of plants, the inspection cannot continue.

BPBK West Java seed production based on conventional minituber production

Table 6.7 shows production of acclimatisation plantlets and the subsequent minituber (Basic Seed/Benih Dasar), Stock Seed (Benih Pokok) and Extension Seed (Benih Sebar). Note

Table 6.7. BPBK seed multiplication – traditional minituber production

Seed planted		Multiplication		Seed harvested	
		Rate	Notes	Number	Description
Breeder Seed/Benih Penjenis; laboratory and acclimatisation screen house					
1,200	bottle plantlets		From IVEGRI 600/season		
12,000	plantlets	4.75	x 5 with 5% losses	57,000	single node cuttings
57,000	cuttings	4.75	x 5 with 5% losses	270,750	single node cuttings
270,750	cuttings		x 1 with 7.5% losses	250,444	acclimatised plants
Breeder Seed/Benih Penjenis; screen house A (annual capacity 15,540 cuttings 6 houses x 2 seasons)					**Basic Seed (G0)**
15,540 x 6 x 2 = 186,480	cuttings	3.5	minitubers/cutting	652,680	minitubers
63,964	surplus cuttings				
G0 Basic Seed/Benih Dasar; screen house B					**Stock Seed (G1)**
5,500	plants/house		=14 x 5,500 x 2 = 154,000		
154,000	minitubers	9	G1 tubers†	1,386,000	G1 BPBK tubers
498,680	surplus minitubers			4,488,120	G1 tubers not BPBK
G1 Stock Seed/Benih Pokok; field planted					**Extension Seed (G2)**
138,600	BPBK G1 tubers	0.454	kg G2 seed/G1 tuber†	62,924	kg BPBK G2
	30,000/ha			63	tonnes BPBK G2
1,247,400	surplus G1 tubers				
4,488,120	non-BPBK G1 tubers				
5,735,520		0.454	kg G2 seed/G1 tuber†	2,603,926	kg non-BPBK G2
				2,604	tonnes non-BPBK G2

† The multiplication rate used is seed grower Dahlan from Tosari (personal communication, 5 June 2015).

‡G1 seeding rate used by MAA (Sudarisman, personal communication,

that at each step BPBK produces more material than it has the capacity to propagate. It is assumed that this material is sold to seed potato growers and the expected outcome from these bulkings is also shown in Table 6.7. The result is almost 2,700 tonnes of G2 (Extension Seed/Benih Sebar) seed. That is four kilograms of G2 seed from every G0 minituber produced by BPBK Pangalengan. This is sufficient to plant 1,800ha or 13% of the 13,820ha of potatoes harvested in West Java in 2013 (Dinas Pertanian Tanaman Pangan, no date D). However, some of this seed may not meet seed size specifications (see Table 6.4) and so the seed supply may be less.

There are other registered seed producers who obtain Breeder Seed from tissue culture facilities and so the amount of seed produced will be greater than shown in Table 6.7. However, the greatest amount of seed, including Extension Seed, inspected by BPSBTPH in West Java is around 3,500 tonnes (Mr Dedi Ruswandi, personal communication, 25 November 2014) which is enough to plant 17% of West Java's 2012 requirements, i.e. 2,333ha of 13,628ha grown (Badan Pusat Statistik 2012).

Rotation

A rotation of 3 growing seasons (3 x 3 months = 9 months) is stipulated for field grown seed potatoes by the Ministry of Agriculture regulation number 01/Kpts/SR.130/12/2012.

For G0 Basic Seed/Benih Dasar production, which must be undertaken within a screenhouse, the non-soil planting media must be sterilised through steam or baking or chemicals. Heat treatments must have a minimum temperature of 90°C maintained for 3 – 5 hours (Kosim 2014). Chemical active ingredients are not listed by Kosim (2014) who states that treatments must adhere to label recommendations. A search of a list of registered pesticides in Indonesia shows cadusafos, an organophosphate nematicide is available for use with potatoes, while metham sodium is listed for tea seedling production (Tonny Moekasan, private communication, 21 January 2014). The recommended nematicide for root knot nematode (*Meloidogyne* spp) is Carbofuran 3G (1 – 3 kg a.i./ha) (Duriat *et al.,* 2006, p. 37).

For G1 Stock Seed/Benih Pokok production, which must be undertaken in a screenhouse, the planting media must be sterilised by steam or other heating or the use of chemicals. Growing media may contain sub-soil and the growing media must have no contact with topsoil but it may be in direct contact with the sub-soil. The planting media must be sterilised as for G0 seed.

6.3.3 Aeroponic minituber production

Aeroponic minituber production has the potential to produce much greater numbers of minitubers per plantlet compared with conventional minituber production. Under Indonesian experimental conditions this system can produce 28 minitubers per plant with an average weight of 12 g and average diameter of 37mm (Muhibuddin *et al.* 2009). The conventional approach using cuttings in coco-peat media produce 3 to 5 minitubers per plant with diameter of 5 to 25mm (Rukmana *et al.,* 2013).

Kosim (2014) lists the requirements for producers of aeroponic seed potatoes; these include a certificate of competency or a quality management system certificate plus connection to the national electricity grid plus a generator.

BPBK West Java seed production based on successful aeroponic minituber production

If the acclimatised plantlets produced at BPBK Pangalengan, as shown in Table 6.7, are grown aeroponically the increased minituber production is as follows. Around 30 minitubers will be produced per plantlet, instead of 3.5 from conventional with production, increasing the

Table 6.8. BPBK seed multiplication – potential aeroponic minituber production

Seed planted		Multiplication		Seed harvested	
		Rate	Notes	Number	Description
Breeder Seed					
12,000	plantlets	4.75	x 5 with 5% losses	57,000	single node cuttings
57,000	cuttings	4.75	x 5 with 5% losses	270,750	single node cuttings
270,750	cuttings		x 1 with 7.5% losses	250,444	acclimatised plants
Breeder Seed; screen house A					Basic Seed (G0)
250,4440	cuttings	30	minitubers/cutting	7,513,313	minitubers
Basic Seed (G0)					Stock Seed (G1)
7,513,313	minitubers	9	G1 tubers†	67,619,813	G1 tubers
Stock Seed (G1)					Extension Seed (G2)
67,619,813	tubers	0.454	kg G2 seed/G1 tuber†	30,736,278	kg G2
				30,736	tonnes G2

† The multiplication rate used is seed grower Dahlan from Tosari.

number of minitubers to 7,513,313 (Table 6.8). Using the same G0 to G2 multiplication rate as in Table 6.7 (4 kg G2 from each minituber) then a much greater proportion of seed requirement is met. The amount of G2 increases eleven fold to 30,053,252 kg or 30,053 tonnes. 20,035 ha of commercial crops could be planted with G2 Extension Seed at a seeding rate of 1.5t/ha, i.e. enough for the 13,820 ha West Java crop plus sufficient for an additional 6,215 ha elsewhere.

South Sulawesi aeroponic minituber production experience

In 2012 South Sulawesi produced 23,444 tonnes of potatoes from 1,816 ha with an average yield of 12.9 t/ha (Badan Pusat Statistik 2012. South Sulawesi is a minor potato area producing just 2% of Indonesia's potatoes. Malino is the main potato production area of South Sulawesi located in the highlands 60 km east of Makassar.

Indonesian aeroponic minituber production was pioneered by Professor Baharuddin at the Agricultural Biotechnology Laboratory at Hasanuddin University, Makassar, South Sulawesi from 2004 (Baharuddin *et al.* 2011). His aim was to overcome the poor supply of quality seed potatoes through increasing the supply of local G0 seed. A management package was also developed to help farmer groups produce potatoes efficiently (Baharuddin *et al.* 2011).

Tissue culture propagation of Breeder Seed/Benih Penjenis is done by the Agricultural Biotechnology Laboratory at Hasanuddin University, Makassar. The tissue culture is propagated by single node cuttings by PT Labiota Indah at Malino, a Technology Transfer Intermediary Group {Kelompok Intermediasi Alih Teknologi (KIAT)}. KIAT institutions are designed to extend applied technology from universities to farmers. The cuttings are acclimatised and produce minitubers in an aeroponic system. The G0 Basic Seed (Benih Dasar) is propagated in screenhouses. Potato farmers in the region were able to obtain Rp 7.2 billion (≅ AUD $720,000) from the local government for six screenhouses and 24 seed stores. They also formed 38 seed production enterprises for the clustered approach which is shown in Figure 6.3.

The G0 seed is grown by the *Veteran* farmer group at Malino, and other experienced seed producer groups elsewhere. The G0 seed is planted direct to the field and so relegated directly to G2 according to the seed scheme rules. This avoids the costly SHB stage at the expense of the loss of one available generation through relegation. The costs saved are those required for screenhouse infrastructure and production costs and for soil sterilisation. This strategy to reduce seed production costs at the expense of accelerated relegation is advocated by others (Wattimena 2012, p. 8, Sudarisman Suyoko, MAA, personal communication 28 February 2015). These G2 seed production groups recruit growers in each locality to bulk subsequent generations. The farmer group responsible for G2 seed production fosters G3 production by four other farmer groups who in turn each foster three farmer groups to produce G4 which is called a clustered approach (Baharuddin *et al.* 2011) (Figure 6.3).

The *Veteran* farmer group has produced 19,800 G0 minitubers (Baharuddin *et al.,* 2011). The group's capacity is 6 screenhouses 8 x 15m which can each produce 50,000 G0 minitubers/season assuming 25 minitubers per aeroponic plant.

It has been predicted that the seed production potential through the system based at PT Labiota Indah could be 4,400 tonnes of G4 seed as shown in Table 6.9 (Baharuddin *et al.*, 2011). This is 162% of South Sulawesi's annual potato seed requirement based on 1,816 ha (Badan Pusat Statistik 2012) and a seeding rate of 1.5 t/ha.

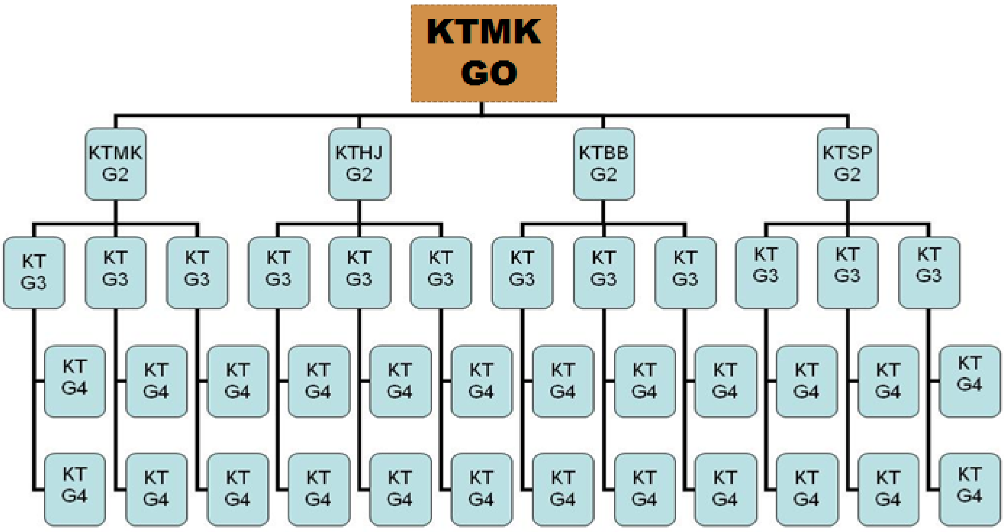

Figure 6.3. Seed flow or cluster model at farmer group level proposed for South Sulawesi (after Baharuddin *et al.* 2011). (KT = kelompok tani)

The cluster seed system established in South Sulawesi was reviewed in late 2012 by Rukmana *et al.* (2013). They found that:

- The Agricultural Biotechnology Laboratory at Hasanuddin University could not supply sufficient Breeder Seed as they are a research facility, rather than a production facility.
- Problems for potato farmers were:
    - scarcity of capital and labour
    - high seed and labour costs resulting in farmers using informal seed
    - lack of quality seed in sufficient quantity and quality
    - lack of seed production technology transfer to farmers.
- Farmer seed growers had not been able to produce quality seed in large numbers.
    - KIAT PT Labiota Indah produced 52,000 minitubers in 2012 from 6 screenhouses, less than 3% of the two million minitubers needed for South Sulawesi. IKB Enrekang (Instalasi Kebun Benih/Seed Garden Installation, Engrekang; equivalent to Malino's PT Labiota Indah) produced 9,777 minitubers in 2012.
- There were no financial institutions in the seed supply chain to help farmers access potato seed and labour.
- The local agribusiness sub-terminal (wholesale market) did not operate effectively.
- Farmers were buying seed from outside the province, from West Java and North Sulawesi.

Rukmana *et al.* (2013) recommended that:

- A regional company (Perusahaan Daerah/Perusda) or Agricultural Co-operative (Koptan) needed to be involved to provide funds for farmers.
- The agribusiness sub-terminal needed to be improved to become a venue for transactions and market information sharing.

The review by Rukmana *et al.* (2013) shows that seed production expectations have not been met.

Table 6.9. Prediction of seed potato production and its economic value (after Baharuddin *et al.,* 2011)

Seed class	Source & production notes	Production Target		Unit Price		Value
		Amount	Unit	Value	Rp/unit	(Rp '000,000)
Breeder Seed	Hasanuddin University tissue culture	1,000	bottle	25,000	Rp/bottle	25
G0 seed*	KIAT Labiota Indah from 500m2 screen house	100,000	tuber	2,500	Rp/knol	250
G1 seed†	seed grower from 3,000 m2 screen house	500,000	tuber	1,500	Rp/knol	750
G2 seed†	10ha grown by seed grower produces seed	100	tonne	15,000	Rp/kg	1,500
	10ha grown by seed grower produces consumption	150	tonne			
G3 seed†	66ha grown by seed grower produces seed	660	tonne	12,500	Rp/kg	8,250
	66ha grown by seed grower produces consumption	990	tonne			
G4 Extension Seed†	440ha grown by seed grower produces seed	4,400	tonne	10,000	Rp/kg	44,000
	440ha grown by seed grower produces consumption	6,600	tonne			
Consumption potatoes‡	farmers from 2,000 ha	58,000	tonne	2,500	Rp/kg	1,450,000
Total Value						1,504,750

*Seed rates used; G0 needs 40,000 seeds per hectare while G2, G3 and G4 need 1.5 tonnes per hectare
†Each field multiplication of seed will produce 10 tonnes of seed and 15 tonnes of consumption potatoes.
‡In 2012 South Sulawesi produced 23,444 tonnes of potatoes from 1,816 ha with an average yield of 12.9 t/ha, it is the 8th largest potato province producing 2% of Indonesia's potatoes (Badan Pusat Statistik 2012).

A project team, Andrew Taylor and Dr Nigel Crump, General Manager ViCSPA[13], visited South Sulawesi seed potato production stakeholders in December 2014. This included the Agricultural Biotechnology Laboratory at Hasanuddin University, PT Labiota Indah and seed growers. Their observations show some of the problems that have prevented the seed supply chain from fulfilling its expectations.

At the Agricultural Biotechnology Laboratory at Hasanuddin University they discussed with Professor Baharuddin the cluster seed system production shown in Figure 6.3 and the seed production predictions shown in Table 6.9. They were informed that the production figures in Table 6.9 were "best bet" scenarios rather than actual outputs.

In their visit to PT Labiota Indah the team observed that:

- Minituber production at PT Labiota Indah had increased to 200,000 G0 minitubers, twice the predictions in Table 6.9. The increase in minituber numbers was necessary due to the recent reduction in the number of generations in the seed scheme from five to three.
- Screenhouse netting had large holes and did not provide effective protection against insects:
    - The potato plantlets were infested with white fly (Figure 6.4).
- Acclimatisation losses of plantlets were 50%.
- An aeroponic minituber production system was installed but it was not being used due to failures caused by:
    - power cuts (Figure 6.5) and
    - bacterial wilt contamination of the untreated water supply (Figures 6.6 and 6.7). The project team found bacterial wilt has contaminated all five aeroponic facilities they visited across Java and South Sulawesi.
- Hygiene measures were not adequate:
    - Soil sterilisation equipment was not sufficient (Figure 6.8) being merely a LPG gas burner under a 20 litre bucket of soil.
    - Foot dipping stations were either bypassed or not used.
    - Plantlet trays were placed directly onto the soil surface (Figure 6.6.).
        - Scab symptoms were seen on G0 minitubers (Figure 6.10).
        - Wilt disease symptoms were seen in screenhouse plants.
    - Commercial crops were grown at the facility next to low generation seed crops (Figure 6.11). The commercial crop showed symptoms of virus, bacterial wilt and potato late blight. The prescribed isolation requirements from consumption potato crops of a border crop higher than the potato crop for a 6m width, or an artificial barrier 1.5 m tall with 3m wide band of unplanted land from the seed crop (Kosim 2014) were not implemented.
    - Cull piles were found close to seed crops.

The team's observations indicate that the G0 production system is not being managed adequately which contributes to the failure of the system to produce seed as predicted in Table 6.9. Management failures included; poor screenhouse maintenance, no prescribed back-up electricity supply for the aeroponic system (Kosim 2014, p. 18) and no water treatment for bacterial wilt.

[1313] ViCSPA: Victorian Certified Seed Potato Authority

Figure 6.4. Infestation of white fly in PT Labiota Indah screenhouse enabled by damaged screenhouse mesh.

Figure 6.5. Aeroponic system failure due to power cuts. Seed rules prescribe back up generator sets (Kosim 2014, p. 18).

Figure 6.6. Aeroponic water supply holding tank containing unsterilsied stream water.

Figure 6.7. Bacterial symptoms in aeroponic mintuber. Infection occurred due to use of contaminated water. Note this photo was from another aeroponics instalation.

Figure 6.8. Soil sterilisation system used at PT Labiota Indah, Malino South Sulawesi. This technolgy bridge installation should be using better suited equipment such as a steam generator.

Figure 6.9. Plantlet seedbed directly on soil surface. Seed rules do not permit direct contact with soil (Kosim 2014, p. 19).

Figure 6.10. Scab disease on G0 seed produced by PT Labiota Indah, Malino South Sulawesi.

Figure 6.11. Isolation requirements for a seed crop (background) from a commercial crop (foreground) were not met. The commercial crop had high levels of virus.

Farmers told the project team that seed purchased from other provinces was often affected by rot. The farmers believed that the seed tuber inspection by BPSPTPH could not have been done properly as the threshold is 1.3% (soft rot and dry rot, Table 6.6). One 14 tonne consignment valued at Rp 300 million (Rp 21,429/kg) was completely lost. Rukmana *et al.,* (2013) report that farmers obtain seed from Pangalengan, West Java, and Manado, North Sulawesi. The need to obtain seed from external sources is also shown by attempts in 2012 and 2013 by a Malino farmer group to import Granola seed from Australia. The importation of seed did not go ahead due to the failure of the farmer group to obtain an import permit (Kon Peos, personal communication 16 September 2013). This information shows that Extension seed requirements are not being met as there is still a need for farmers to obtain seed from outside the province.

6.4 Gaps in Indonesian Certified Seed Potato Scheme

6.4.1 Protection of seed against major risks

Under Section 6.1 *Characteristics of seed potatoes*, the need for seed quality to address the management of major pests and diseases which have the greatest impact on yield and quality was introduced.

The Indonesian seed potato scheme appears to emphasise protection against virus disease with little emphasis on other threats. Virus certainly is a threat as seed areas are not isolated from production areas and aphids are always present. According to Duriat (2009, p. 86) “there is no location or month free from aphids”; most aphids being trapped from July to September, the peak dry season. Seed areas are not safe as the catch of green peach aphid, the major vector of potato virus, was 30 - 42% higher at Pangalengan, the main seed growing area, compared with 15% in other areas (Duriat 2009, p. 86). The Indonesian certified seed scheme’s efforts to reduce virus impact are highlighted by the reduction in the number of field generations in the three generation scheme revision. This scheme is based on pathogen tested tissue culture with generation 0 and generation 1 produced under insect vector proof screenhouses with just the final G2 Extension Seed generation produced in the field. In Indonesia virus levels in G2 seed were observed to be 1% (Duriat 2009, p. 84).

Virus may be the major focus of the Indonesian seed scheme due to the observation that:

> “Patogen virus tidak memiliki racun antinya yang dapat digunakan secara teknis di lapangan, seperti fungisida untuk cendawan, bakterisida untuk bakteri, atau nematisida untuk nematoda.” (Duriat 2009, p. 89).

> For pathogenic virus there are no antidotes that can be applied in the field by farmers unlike fungicides for fungus, bactericides for bacteria, or nematicides for nematodes.

In other words, in dealing with a vegetatively propagated crop which allows intergenerational spread of virus, one must start with seed material low in virus as farmers do not have any other means of control.

By relying on the use of pesticides to manage other threats, the Indonesian certified seed scheme does not give adequate protection against the spread of some major pests and diseases. It is vitally important to control pests and diseases which have the ability to survive for long periods in the soil because, once an area is affected, pest and disease impact will have a long term effect on production.

The Indonesian potato industry has great scope for development and it is important that areas suitable for future growth are kept pest and disease free. The scope for growth of the Indonesian potato industry is assured due to the potential for increased consumption as well as the availability of suitable new land. Indonesian *per capita* potato consumption is only 2 to 4 kg (Adiyoga *et al.* 1999, p. 1, Pusat Data dan Sistem Informasi Pertanian 2009, p. 35) compared with Australia's per capita consumption of 42 kg comprising 21 kg each of fresh and processed potatoes (Stride Consulting 2012, pp. 5 & 23).

The area in Indonesian suitable for new potato production has been estimated to be 11.3 million ha, of which 65% or 7.4 million ha is outside the current main production areas in Java (Wattimena 2012[14]). The 2012 potato production was harvested from 65,218 ha (Badan Pusat Statistik 2012). For potato production development to proceed efficiently, it is important that these areas remain uncontaminated.

PCN risk

An example which shows the weakness in protection of seed from major threats is PCN. This is because the rotation prescribed in the seed scheme is not sufficient to give protection against this pest which occurs in East, Central and West Java.

If a field is cropped every year with potatoes and one PCN cyst is introduced at year zero, the population of cysts will increase exponentially as shown in Figure 6.12 (Spears 1968). Note, Spear's 10 fold multiplication is conservative compared with rates of 10 to 70 for a clay soil given by Struik and Wiersema (1999, p. 170).

One seed potato crop is permitted to be grown every year on the same site under the Indonesian seed potato scheme (Ministry of Agriculture regulation number 01/Kpts/SR.130/12/2012, Kosim 2014, p. 31). Annual cropping of the same plot even occurs at the Indonesian seed potato centres (Aris Munandar Head of Potato Seed Production BBH Kledung, personal communication, June 2010). Once a PCN cyst is introduced to the field it can multiple over four years of cropping and remain undetectable even though the cyst population will reach 10,000 cysts/acre (25,000 cysts/ha) (Figure 6.12). Only after five crops will cysts be detected reliably with a soil test (Figure 6.12). This means that if PCN is introduced to a seed production field that is cropped annually, cysts will be spread in soil or on tubers with the movement of seed, before the pest is detected.

PCN was first identified in East Java in 2004 (Indarti *et al.* 2004) and in 2006 was found at Pangalengan (Simamora unpub.), the main seed potato production area in Indonesia. The establishment of PCN at Pangalengan has also been confirmed by Dawson *et al*. (2011, p. 79) and Mr Dedi Ruswandi, Technical Manager for Seed Potato Inspection, BPSBTPH West Java (personal communication, 25 November 2014). Fields for seed potato crops must have a negative soil test result before the crop can be planted. Mr Dedi Ruswandi reported to the

[14] We consider this is a generous estimate as it includes land down to 700m elevations.

project team of Andrew Taylor and Dr Nigel Crump that the number of PCN infested fields is increasing in West Java (personal communication, 25 November 2014). This shows that PCN has been found in fields selected for seed potato production and certainly means that some infested seed production fields would have produced certified seed crops due to the field passing the PCN test while the cyst population was at undetectable levels. The spread goes unnoticed because it is not until seven crops have been grown in succession that symptoms begin to appear in small areas of the crop (Figure 6.12). This problem is confounded as in crop PCN symptoms can be mistaken for bacterial wilt disease (*Ralstonia solanacearum*), which is common; in East Java it occurs in 72% of potato crops (Soesanto *et al.* 2011). It is not until the tenth crop is grown that complete crop failure may occur (Figure 6.12).

The Indonesian certified seed potato system has a real risk of introducing PCN to uninfested areas due to inadequate rotation provisions combined with a PCN test that fails to detect the pest until five seed crops have been grown on an infested site.

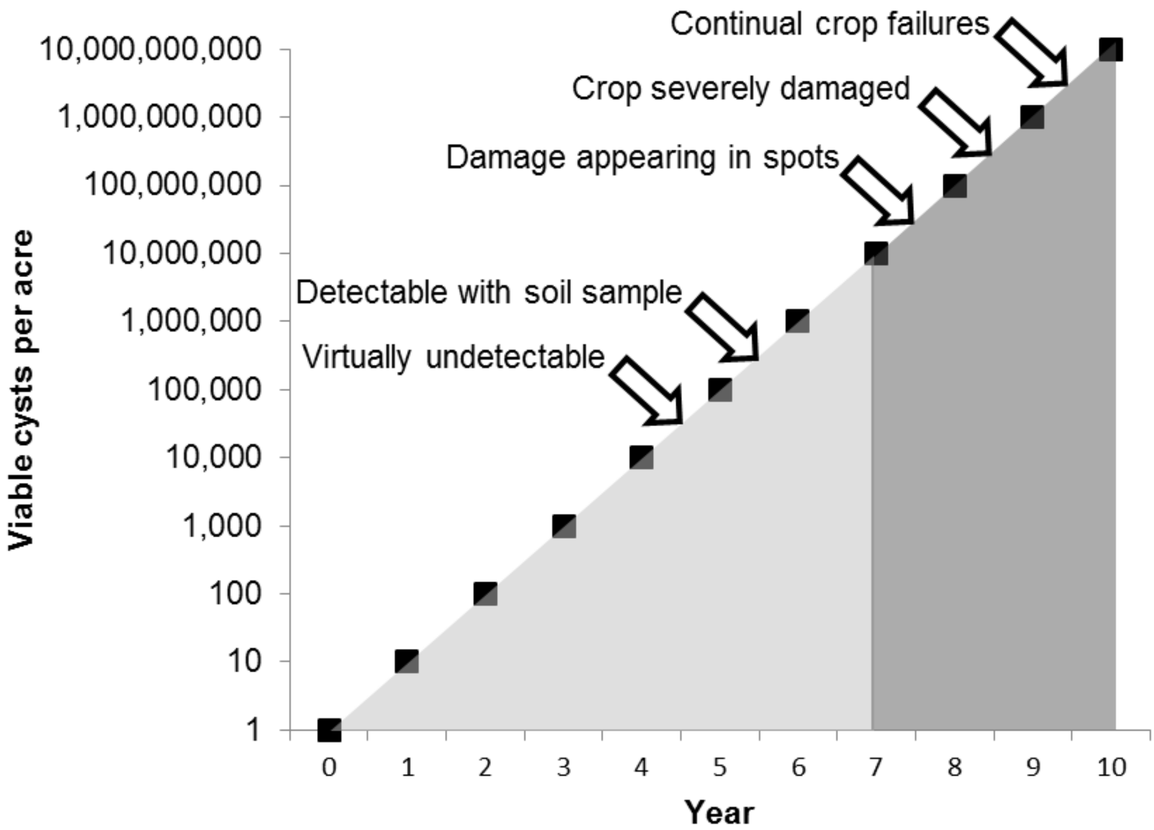

Figure 6.12. Increase in potato cyst nematode populations in a field planted with one crop of potatoes each year. A crop is grown between each marker on the trend-line. A 10 fold increase is assumed after each crop. Note the exponential vertical axis with area in acres. Multiply the vertical axis number by 2.5 to get cysts/ha. After Spears (1968).

Other soil-borne risks

Two other examples of soil-borne threats to potato crops are bacterial wilt (*Ralstonia solanacearum*) and bacterial ring rot (*Clavibacter michiganensis* subsp. *sepedonicus*) (Cms).

Bacterial wilt was found in 72% of samples taken from potato fields in East Java (Soesanto *et al.,* 2011). The short rotation used in the Indonesian seed potato scheme will result in spread of this pathogen. Bacterial wilt is known to survive for years in soils and is found in irrigation water, particularly if host weeds or volunteer potato plants are present surrounding the water course (van Elsas *et al*. 2000, Elphinstone *et al*. 1998). Of particular concern to the project team was the detection of bacterial wilt in G0 production facilities, which suggests early generations of seed may be contaminated and performance of the seed is limited by this disease. This may be compounded by latent infections of tubers with bacterial wilt that are asymptomatic.

Bacterial ring rot (Cms), a listed exotic disease in Indonesia, was found in up to 25% of crops in South Sulawesi (Sulastrini *et al.* 2012). They also reported that this exotic disease has been found in Pangalengan, Indonesia's main seed potato production area. Cms survives in volunteer plants, cull piles and crop debris (Wale *et al.* 2008, p. 19) and so the short rotation of the Indonesian seed potato scheme will again result in spread of this pathogen.

The soil-borne pest and disease risk is not confined to field produced seed as common scab (*Streptomyces* spp.) was seen by the project team on G1 tubers from the seed scheme produced in soil-less sterilised media in screenhouses. This disease was seen at Malino, South Sulawesi, and at BBH Kledung by the project team. Common scab on G1 tubers produced at BBH Kledung had also been seen on previous visits (Andrew Taylor, personal communication, February 2008).

The occurrence of soil-borne disease in screenhouse production in soil-less, sterilised planting media indicates that either hygiene measures or soil sterilisation techniques are lacking. The tolerance for these diseases in G1 seed tubers is 0.5% (Table 6.6) which shows these diseases must commonly be found in G1 screenhouse crops. The lack of hygiene and sterilisation techniques was also shown by the presence of bacterial wilt in the aeroponic facilities visited by the project team in November 2014. At BBH Kledung the pesticide Puanmur 50 SP (chlorobromoisosianuric A / CBIA 50%) was used to sterilise potting mixture. At Garut, screenhouse potting mixture was re-used and treated with Resol (lysol) as a chemical sterilant.

The high cost of soil sterilisation may result in the new, three generation seed scheme becoming a two generation scheme as seed growers plant minitubers direct to the field to avoid sterilisation costs as well as screenhouse infrastructure costs. Wattimena (2012, p. 9) considers the high expense of the SHB stage is the main obstacle to increased seed production. The greatest expense is for soil sterilisation. Steam sterilisation uses 1,775 L of kerosene (minyak tanah) per SHB (507m^2). SHB is also bypassed, by other seed growers, e.g. MAA (Sudarisman Suyoko, MAA, personal communication 28 February 2015).

Rotation periods used in other seed potato schemes

The prescribed rotation period of 9 months (Section 6.3.2) for Indonesian certified seed is very short compared with other seed potato schemes. For example Canada requires certified seed potato fields to be free of potatoes for two years before replanting, Western Australia requires three years free of potatoes before producing G5 certified seed while Scotland requires a five year rotation (Dawson and Lancaster 2015).

Conclusions about scheme's protection against threats

The Indonesian certified seed potato scheme does not provide adequate protection against the spread of several important soil-borne pests and diseases. A longer rotation is required to improve protection against pests and diseases like PCN and bacterial wilt.

6.4.2 Seed Availability

Only a fraction of Indonesia's seed potato requirement was fulfilled by the five generation seed system which ran from 1992 until 2015 (Table 6.10). The greatest seed fulfilment occurred in 2008 with 8,066 tonnes, or 8% of requirements being met. This included 2,785 tonnes of imported seed (Ranu 2010). The inability to supply sufficient seed is confirmed by

Liferdi (2013, p. 6) who says that the use of quality seed potatoes, including imports, is from 10 - 15% of requirements. He also states that data about seed potato use is not properly recorded and this data needs to be verified in order to properly design potato seed supply.

Table 6.10. Recent potato seed requirement and supply for Indonesia.

Year	Annual potato seed need (tonnes)	Potato seed		Potato seed supply (% of need)	Reference
		produced (tonnes)	source or location		
1992 JICA system established					
2003		700	West Java	2.3*	JICA 2003
2004	108,426	4,703 2,951 1,752	total domestic import	4.3 2.7 1.6	Sayaka *et al.* (2012, p. 32)
2004				3.5	Rasmikayati & Nurasiyah (2004)
2004	108,428	4,955 2,951 2,004	total domestic import	4.6	Dirjen Hortikultura (2007) cited in Direktorat Kredit, BPR dan UMKM (2012, p. 20)
2005				4.8	Sayaka *et al.* (2012, p. 32)
2005		5,493 3,364 2,129	total domestic import	4.8	Dirjen Hortikultura (2008) cited in Direktorat Kredit, BPR dan UMKM (2012, p. 20)
2006				4.1	Sayaka *et al.* (2012, p. 32)
2006	121,784	6,020 4,491 1,529	total domestic import	4.9	Dirjen Hortikultura (2008) cited in Direktorat Kredit, BPR dan UMKM (2012, p. 20)
2007	30,000	1500		5	Sayaka *et al.* (2012, p. 32)
2007	128,613	7,680 4,940 2,740	total domestic import	6.0	Dirjen Hortikultura (2008) cited in Direktorat Kredit, BPR dan UMKM (2011, p. 20)
2007			West Java	5.8	Irawan *et al.* (2007, p. 29)
2008	92,277	2,785 8,066	imported total	 8.3	(Ranu 2010) Ditjen Hortikultura (2010) cited in Jufri (2011)
2010	100,000	1,900 1,000 900	total domestic imports	1.9†	Sayaka *et al.* (2012, p. 32)
2010		5,401	import		International Trade Centre
2010	25,294	1,690	West Java	6.7‡	Sujitno (2011, p. i)
2012			domestic imports	12.5	Sofiari (2013, p. 7)
2012		3,724	import		International Trade Centre
2013		potato and garlic		17	Direktorat Jenderal Hortikultura (2013, p. 19)
2013		3,534	import		International Trade Centre

*Based on 20,146 ha (Badan Pusat Statistik 2012) requiring 1.5 tonnes of seed per hectare.
†Based on 66,531 ha requiring 1.5 tonnes of seed per hectare
‡Based on 15,809 ha requiring 1.6 tonnes of seed per hectare

It is argued that in order to increase Indonesian potato seed supply, the number of generations must be reduced to enable Extension Seed to be produced more rapidly (Liferdi 2013, p. 6). He advocates a jump start system with generations G0, G2 and G4. The argument that current seed requirements can be better met with a reduced generation seed scheme that requires shorter time to produce the end product is difficult to understand considering that the five generation system has been in operation since 1992 and so the end product should have been available since 1997, five years after the scheme started.

A clear benefit will be achieved by the new system if minituber production is cheaper and the reduced generations provide seed at a lower price. Potato producers at Sembalun were concerned that the new system would not provide cheaper seed as G2 seed is more expensive than G4 seed. The three generation scheme was only introduced in 2014 and it is too early to determine the likelihood of success (Mr Dedi Ruswandi, Technical Manager for Seed Potato Inspection, BPSBTPH West Java, June 11 2015).

Potential for aeroponic seed to increase seed supply

Aeroponic production of G0 minitubers is considered to enable an increase of seed supply from the new three generation certified seed scheme compared with the five generation system using conventional minituber production. This is because aeroponics has the potential to increase minituber production from plantlets by a factor or 10. The calculations presented in Table 6.8 show that BPBK Pangalengan could produce enough minitubers to fulfil seed requirements for the three generation certified seed scheme. However inspection of the subsequent multiplication of G0 and G1 seed from the aeroponic systems established in South Sulawesi show that there are other problems which prevent the potential of the system being achieved. Remember that the project team found that aeroponic seed installations and their subsequent generation bulking facilities had the following problems:

- damaged screenhouse netting did not provide effective protection against insects
- acclimatisation losses of plantlets were 50%
- aeroponic minituber production systems had:
    - widespread problems with bacterial wilt contamination
    - some other problems due to power supply failure and water temperature
- hygiene measures were not adequate:
    - Soil sterilisation was not adequate
    - Isolation requirements were not met

The project team found that even the most advanced seed institution had problems with aeroponic production. At BPBK Pangalengan minituber production had been affected by high water temperatures in the aeroponic chambers. Water temperatures can be high due to geothermal activity or due to the screenhouses being too warm. At IVEGRI bacterial wilt contamination of the aeroponic water supply had occurred. The widespread failures in other aeroponic systems caused by bacterial wilt contamination and power outages shows that the system has reliability problems. The use of aeroponics to increase the supply of minitubers for a three generation seed scheme means that there will be increasing reliance on minitubers supplied by seed farmers rather than government seed institutions. Government institutions can be affected by budget constraints which can affect production targets. For example the G1 seed section of Table 6.1 shows that at BPBK Pangalengan, the main seed potato production facility for a high priority crop where seed supply is considered a major constraint was not using all 14 SHB available. At IVEGRI there is only 500m^2 of suitable screenhouse is available for minituber production (Sofiari 2013, p. 10).

The question that has to be asked is whether this technologically advanced seed multiplication system based on aeroponics is appropriate for seed potato production in a developing country? Singh (2008, p. 20) considered that the high level of technical skill required for conventional seed production was a constraint (Section 4.1.5) and Ezeta (2008, p. 15) reminds us of the poor infrastructure in rural areas of Indonesia (Section 4.1). The seed potato production guidelines were thought to be too technical and unsuited to Indonesian conditions by (Sayaka *et al.* 2012). The management skills required for seed production are often underestimated and this leads to ineffective quality control and certification in seed production schemes (Struik and Wiersema, 1999). The management of early generation seed production enterprises observed by the project team confirms that the seed system in Indonesia will be difficult to implement according to the prescribed requirements of the scheme.

6.4.3 Yield benefit of seed not being realised.

The use of certified seed of high health is assumed to be accompanied by yield and profit increases. A search of the literature, presented in the following chapter, failed to find convincing evidence that this occurs in Indonesia. This is probably due to other constraints, like disease control and low soil moisture, preventing the potential of the seed to be harnessed. If farmers do not experience increase in profits with certified seed they will choose cheaper alternatives. This will provide them better short term returns.

One benefit of certified seed is protection against exotic threats. In the US the effective control of pathogens such as potato spindle tuber viroid (PSTVd) and bacterial ring rot has been achieved through the production of a high health seed supply and certification (Frost *et al*., 2013). If Indonesian farmers in PCN free areas can be assured of the supply of pest free seed they may demand this seed because of its long term sustainability benefits. However, without appropriate assessment and reporting, certified seed in Indonesia has a risk of spreading PCN and cannot provide this benefit. The only assured source of PCN free seed is seed from known PCN free areas. The only area known to be free of PCN in Indonesia is Sembalun which was tested in 2008 (Dawson *et al.,* 2011).

For high quality seed to perform to its potential other constraints to production must be overcome. For example, water stress in a dry season crop will not be overcome with improved seed. Similarly high quality seed will not provide protection from the air-borne inoculum of potato late blight disease in wet season crops. This spread of the disease must be managed with an effective fungicide program. The use of high quality seed must be accompanied with improved crop management in order to give the seed the best chance of realising its potential.

6.4.4 Seed storage and physiological age.

Most potato seed is stored under ambient conditions. Only the largest seed producers have limited amounts of cool storage. This means that seed losses are high in storage which adds to the cost of seed. An example of seed in storage is shown in Figure 6.13.

Figure 6.13. Shrivelled seed tubers in storage at BBI Kledung.

7 Seed Potato Demand in Indonesia

7.1 Factors influencing seed demand

Potato seed demand in Indonesia is calculated as the area of potato production multiplied by the seeding rate, for example in 2010 the then Head of the Horticulture Seed Division of the Ministry of Agriculture reported seed demand was 96,227 tonnes for 64,151ha based on a seed rate of 1.5 t/ha (Ranu 2010). Using the same method the 2012 seed requirement was 97,827 tonnes based on potato production of 65,218ha (Badan Pusat Statistik 2012) with a 1.5 t/ha seed rate.

The certified seed requirement calculated this way has a legal standing in Indonesia because Article 32 of the law concerning horticulture (Law 13 of 2010) defines seed as an input and Article 35 states inputs must meet the quality standards with Article 126 prescribing punishment for anyone distributing horticultural inputs that do not meet quality standards.

Only 8% of the calculated seed requirement of 96,227 tonnes was fulfilled from 8,066 tonne of local and imported certified seed (Ranu 2010).

The amount of seed farmers are willing to buy may vary considerably from the above calculation. For example farmers' seed demand will be less if the seed is:

- too expensive
- not considered to offer value for money
- not providing the quality farmers require.

Not every farmer wants to use certified seed, so to determine farmers' actual certified seed demand the calculation must be multiplied by the proportion of farmers who want to use certified seed at its current cost. Unless farmers' demand is taken into account the true seed demand cannot be determined. Until farmers' demand is determined the percentage of seed demand fulfilled cannot also be determined.

7.1.1 Farmers' demand for seed

Use of certified seed in Australia illustrates that farmer demand is less than demand calculated from cropping area and seed rate. In Australia not all potato crops are planted with certified seed; the remainder use 'farm-produced seed' or 'one-off seed' (Mulcahy 2015, p. 3). 82% of respondents to a survey reported using certified each year for some or all of their production (Mulcahy 2015, p. 24). 22% of the survey respondents claimed they experienced few advantages from certified seed while 11% believed there was no advantage (Mulcahy 2015, p. 25). Some respondents reported having both good and bad experiences with certified and non-certified seed which may indicate that factors other than seed may be more important in crop performance. One reason for using 'one-off seed' may be that it may not degenerate noticeably if grown under low degeneration conditions, meaning that one-off seed that is "apparently" disease free has the potential to perform to the equivalent of certified seed with the same disease status. There also may be commercial need to produce one-off seed that has the appropriate physiological age to align with the commercial production needs not met by certified seed.

Mulcahy (2015,14) concluded that it is not possible to determine a precise financial advantage from using certified seed because other factors not related to certification influence crop performance. In another Australian survey when respondents were asked whether certified seed lowered the cost of production, 40% agreed, 30% disagreed and 25% did not know (Crump and Shovelton 2012). The positive responses mostly came from seed growers while the negative and "don't know" responses came from commercial growers. This shows that people's perception of the benefits of certified seed may be quite subjective, and emphasises the need for education across the supply chain in understanding the benefits of seed certification programs. This survey was also unable to place a financial value of certified potato seed benefits. It was argued that the value of certification is the prevention of transmission of important seed borne diseases and improved biosecurity against exotic pests such as PCN.

7.2 Benefits of certified seed

The seed potato literature with emphasis on Indonesian publications was reviewed to determine factors influencing Indonesian seed demand.

Certified seed is considered vital for obtaining high yields and quality. Struik and Wiersema (1999, p. 272) support this assertion by showing a positive linear relationship between the proportion of a country's crop planted with certified seed and that country's yield (Figure 7.1).

Struik and Wiersema caution that there are factors other than seed that contribute to this yield relationship such as:

- Areas with a low use of certified seed are often less environmentally suitable for potato production.
- Superior cultivation practices are more frequently used in areas with increased certified seed use.

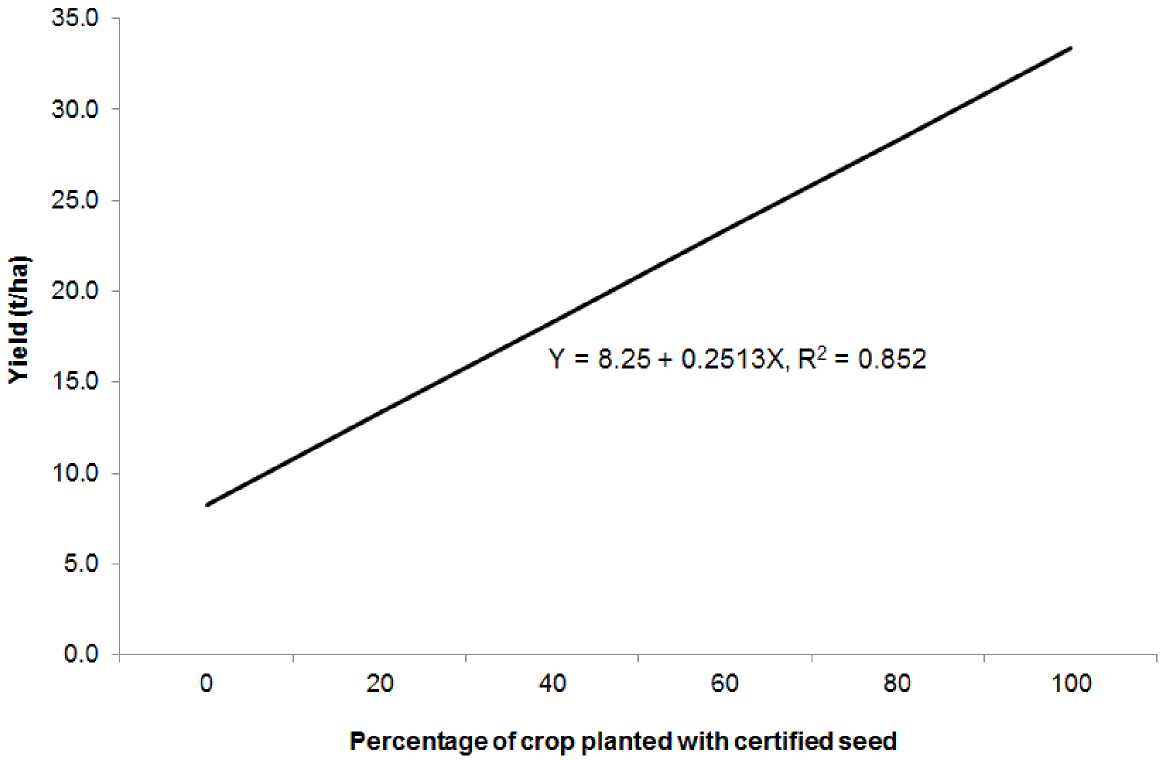

Figure 7.1. Relationship of proportion of potato crop planted with certified seed and yield (Struik & Wiersema 1999, p. 272).

7.2.1 Seed type effect on potato yield and gross margin

Other examples of yield increase with the use of certified seed are claimed by Ridwan *et al.* (2010) and Sayaka and Hestina (2011) who present improved budget outcomes for Indonesian crops grown from certified G4 seed compared with non-certified seed.

West Java

Standardised gross margin budgets for West Java potato crops prepared by Ridwan *et al.* (2010, p. 204) are shown in Table 7.1. Standardisation of budgets is explained in Appendix 3. Ridwan *et al.* used a non-random survey of Indonesian potato growers from various locations who used either certified seed or non-certified seed. Financial information on crop production was collected and budgets for crops grown with certified seed and non-certified seed were compiled. The authors used a t-test to compare differences in seed.

Ridwan *et al.* (2010, p. 199) claimed that in West Java there were significant differences in cost of production and income between farmers who used certified and non-certified seed according to t-tests. However, there was not a significant difference in gross margin between certified seed and non-certified seed use. The use of t-tests to determine significance is not appropriate as the assumptions on which this test is based were probably not met. The t-test must have:

- independent samples
- samples are randomly drawn from the normally distributed populations with unknown population means and
- the population variances of the two groups are equal.

The limited survey of 18 respondents in total would have not been randomly selected from the population due to the low use of certified seed as reported by Sayaka and Hestina (2011, p. 32). Therefore sample variances may have not been equal as crop management by the two groups would have differed as shown by the difference in other costs between the West Java comparisons. Therefore Ridwan *et al.'s* conclusion that differences were statistically significant is not valid.

Ridwan *et al.* (2010, p. 199) report that in Pangalengan, users of certified seed did so because of reduced virus levels due to inspection by BPSBTPH, affordable price and high productivity. Half the respondent farmers using non-certified seed did so because of its cheaper price, ready availability and trusty performance while the other half said they did not have enough funds for certified seed and that their own seed was of good quality. These farmers reported that after certified G4 seed was regrown as non-certified seed, yield peaked at G5 with a noticeable decline after G7.

Ridwan *et al.* (2010, p. 205) concluded that higher yield and profit was obtained by farmers who used certified seed. They concluded that in order to convince farmers that the use of certified G4 seed potatoes is beneficial, there needs to be a quality guarantee from all seed growers about their seed's high production capacity, resistance [sic] to pests and diseases and low input requirements and this could be done through a quality assurance program.

From this study the yield improvements might have been due to other factors apart from seed. There would have been many differences in the crops apart from sources of seed. The use of certified seed may be associated with better educated farmers with greater access to capital resulting in improved management practices which also contributed to higher yield. Crop growth is influenced by cultivation techniques, pest and disease management, nutrition, environmental conditions, seed size (Ridwan *et al.* 2010, pp. 197 & 200) as well as farming scale. Adiyoga *et al.* (1999, p. 7) found that although medium scale (0.5 – 2 ha) farmers had higher costs (due to better quality of inputs) they also produced higher yields compared with small scale (< 0.5 ha) farmers, earning much higher net income as a result.

Sayaka and Hestina (2011) presented budgets by Sayaka *et al*. (2009)[15] comparing crops grown from certified G4 seed and non-certified seed (Table 7.2). The budgets show that in West Java farmers who used certified seed had much higher yields than users of non-certified seed, 21 t/ha versus 13 t/ha (Table 7.2). The higher yield produced by users of certified seed outweighed their greater seed costs of Rp 20 million/ha which was double that

Table 7.1. Gross margin per hectare analysis of potato enterprises growing Granola from certified G4 and non-certified seed in West and Central Java in 2008 (after Ridwan *et al.* 2010). Fixed costs of land rent, equipment depreciation and interest have not been included.

Item	West Java - Pangalengan		Central Java - Batur	
	Certified	Non-certified	Certified	Non-certified
	n = 9	n = 9	n = 15	n = 14
Amount of seed (kg)	1,705	1,359	1,427	1,421
Seed price (Rp/kg)	8,034	6,936	7,212	6,145
Seed cost (Rp)	13,698,683	9,426,388	10,291,973	8,731,836
Seed cost (% costs)	40	35	45	41
Other costs (Rp)	20,926,159	17,753,592	12,450,280	12,826,997
Total variable costs (Rp)	34,624,842	27,179,980	22,742,253	21,558,833
Yield (kg)	26,364	22,002	16,976	14,031
Sale price (Rp/kg)†	2,671	2,433	3,954	3,659
Income (Rp)	70,417,354	53,529,785	67,130,010	51,388,645
Gross margin (Rp)	35,792,512	26,349,805	44,387,757	29,779,812
B/C‡	1.03	0.97	1.95	1.33

†calculated from yield and income ‡B/C = benefit/cost = (gross margin/variable costs)

of non-certified seed. The result was a gross margin of 22 Rp million/ha for certified seed users compared to Rp 10 million/ha for non-certified seed users.

Reasons provided by West Java respondents for the use of less profitable non-certified seed were:

- certified seed is too expensive / insufficient capital
- limited availability
- lack of awareness of the benefits of certified seed and
- the use of non-certified seed gives acceptable yield.

Central Java

A survey of 29 respondents in Batur in Central Java found the average total cost of potato production with G4 certified seed was Rp 22,742,253 /ha/season, of which 45% was for seed (Table 7.1) (Ridwan *et al.* 2010, p. 203). Costs for potatoes grown with non-certified seed were similar at Rp 21,558,833 /ha/season where seed costs were 41% (Table 7.1) (Ridwan *et al.* 2010, p. 203). Crops grown with G4 certified seed yielded 17 t/ha while uncertified seed produced a yield of 14 t/ha which gave a gross margin of Rp 44 million/ha for certified seed, 49% higher than the gross margin for non-certified seed. The use of certified seed was associated with a significantly higher gross margin but the improved yield may not be due solely to seed but to other management factors associated with users of certified seed.

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[15] Although Sayaka and Hestina (2011) cite Sayaka et al. (2009) they omitted it from their reference section. Another paper where Sayaka is lead author (Sayaka et al. 2012) does include the reference details of Sayaka et al. (2009) which have been used in the reference section of this review. However this paper contains none of the budget details cited by Sayaka and Hestina (2011).

East Java

For East Java, certified seed is obtained from West Java (Hikmah farms, Puncak Biotek) and Central Java (BBH Kledung). In East Java, farmers who used certified seed had much higher yields than users of non-certified seed;16 t/ha versus 10 t/ha (Table 7.2). The higher yield produced by users of certified seed easily compensated for the greater seed costs of Rp 19 million/ha, which was triple that of non-certified seed. The result was a gross margin of 18 Rp million/ha for certified seed users compared to Rp 9 million for non-certified seed users. Reasons provided by East Java farmers for the use of less profitable non-certified seed were similar to those given by West Java farmers; certified seed was thought to be too expensive or they had insufficient capital.

South Sulawesi and Nusa Tenggara Barat

In South Sulawesi Sayaka and Hestina (2011) report that Sayaka *et al.* (2009) found certified seed is sourced from West Java (Hikmah farms, Puncak Biotek) and from local propagation of low generation material. Certified seed was Rp 10,000/kg, twice the price of non-certified seed, but respondents using certified seed produced 20 t/ha compared with 12 t/ha produced by users of non-certified seed (Table 7.3). The gross margin for growers using certified seed was Rp 26 million/ha, more than twice the Rp 11 million/ha gross margin obtained when non-certified seed was used.

In Nusa Tenggara Barat (NTB), on the island of Lombok, potato farmers grow Atlantic for the crisp processor PT Indofood. Imported certified Atlantic seed is provided by the company at Rp 10,500 /kg and yields 21.5 t/ha which gives a gross margin of Rp 36 million/ha. Non-certified seed, saved from previous crop, costs Rp 7,000/kg and yields 10 t/ha to give a gross margin of Rp 11 million/ha. If Granola is used Indonesian G4 certified seed costs Rp 15,000/kg which is more expensive that imported Atlantic seed (Rp 10,500/kg) and non-certified seed Rp 7,000/kg.

Combined national results

Despite Sayaka and Hestina (2011) finding that use of certified seed is associated with increased yields and gross margins, they report that use of certified seed potatoes is rare and confined to:

- commercial farmers that have sufficient liquidity to afford the seed as well as access to a distributor or retailer of seed, or
- processing farmers who are contracted to the processor PT Indofood.

Sayaka & Hestina (2011) report the lack of adoption of certified seed is due to its high price and limited availability. This is supported by Ramdiani (2007) who reported the price of certified seed is too high for farmers who also preferred imported seed to local certified seed.

Ramdiani reported farmers had concerns about the quality of local certified seed probably due to the existence of counterfeit certified seed documentation.

A summary of the previous comparisons of certified and non-certified seed use is given in Table 7.4. The consistently higher yield of crops grown with certified seed, between 120 and 167 percent of crops grown with non-certified seed, is claimed to show that certified seed has clear advantages over non-certified seed with a concomitant increase in gross margin from 136 percent to 239 percent. However, the differences found in these limited surveys cannot be attributed to seed type alone, but also reflect other differences in crop management between the samples.

Table 7.2. Gross margin per hectare analysis of potato enterprises growing Granola from certified G4 and non-certified seed in Central and East Java in 2009 after Sayaka *et al.*, (2009) cited in Sayaka and Hestina (2011).

Item	West Java		East Java	
	Certified	Non-certified	Certified	Non-certified
	n = ?	n = ?	n = ?	n = ?
Amount of seed (kg)	2,000	2,000	1,500	1,500
Seed price (Rp/kg)	10,000	5,000	12,467	4,000
Seed cost (Rp)	20,000,000	10,000,000	18,700,000	6,000,000
Seed cost (% costs)	49	34	49	23
Other costs (Rp)	21,237,500	19,252,500	19,426,000	19,899,700
Total variable costs (Rp)	41,237,500	29,252,500	38,126,000	25,899,700
Yield (kg)	21,000	13,000	16,000	10,000
Sale price (Rp/kg)1)	3,000	3,000	3,500	3,500
Income (Rp)	63,000,000	39,000,000	56,000,000	35,000,000
Gross margin (Rp)	21,762,500	9,747,500	17,874,000	9,100,300
B/C	0.53	0.33	0.47	0.35

[1] Calculated from yield and income [2] B/C = benefit/cost = (gross margin/variable costs

Table 7.3. Gross margin per hectare analysis of potato enterprises using certified and non-certified Granola seed in South Sulawesi and certified and non-certified Atlantic seed in Nusa Tenggara Barat in 2009 after Sayaka *et al.* (2009) cited in Sayaka and Hestina (2011).

Item	South Sulawesi		Nusa Tenggara Barat	
	Certified	Non-certified	Certified	Non-certified
	Granola		Atlantic	
Amount of seed (kg)	1,500	1,500	2,000	2,000
Seed price (Rp/kg)	10,000	5,000	10,500	7,000
Seed cost (Rp)	15,000,000	7,500,000	21,000,000	14,000,000
Seed cost (% costs)	45	30	46	36
Other costs (Rp)	18,730,000	17,513,000	24,990,000	24,706,500
Total variable costs (Rp)	33,730,000	25,013,000	45,990,000	38,706,500
Yield (kg)	20,000	12,000	21,500	10,000
Sale price (Rp/kg)1)	3,000	3,000	3,800	5,000
Income (Rp)	60,000,000	36,000,000	81,700,000	50,000,000
Gross margin (Rp)	26,270,000	10,987,000	35,710,000	11,293,500
B/C			0.78	0.29

[1] calculated from yield and income [2] B/C = benefit/cost = (gross margin/variable costs)

Table 7.4. Average yield and gross margin from a survey of crops grown certified and non-certified seed in Indonesia.

Location	Seed used				Ratio: Certified/non-certified	
	Certified		Non-certified			
	Yield (t/ha)	Gross margin (Rp million/ha)	Yield (t/ha)	Gross margin Rp million/ha)	Yield (%)	Gross margin (%)
Granola						
West Java	21.0	21.8	13.0	9.7	162%	223%
Pangalengan	26.4	35.8	22.0	26.3	120%	136%
Batur	17.0	44.4	14.0	29.8	121%	149%
East Java	16.0	17.9	10.0	9.1	160%	196%
South Sulawesi	20.0	26.3	12.0	11.0	167%	239%
Atlantic						
NTB	21.5	35.7	10.0	11.3	215%	316%

7.2.2 Seed versus non-seed factors on crop yield

Experimental Evidence

McPharlin and Taylor (2012, Annex 1, p. 41) report on experiments comparing three sources of Granola seed; Indonesian certified G4, Indonesian non-certified seed and imported G4 seed. The experiment was repeated by 10 farmer groups. The design of the experiment and the treatments was the same at all sites. This meant that each site could be used as a replicate and the results could be analysed statistically using analysis of variance. Yield results are shown in Table 7.5. There is a much larger difference in yields between sites than seed-related differences within sites. For example, the lowest yielding site averaged 10t /ha where Indonesian certified seed produced 12.9 t/ha, non-certified produced 12.7 t/ha and imported seed produced 5.4 t/ha. At the highest yielding site, yield averaged 52.2 t/ha with Indonesian certified seed producing 50.3 t/ha, non-certified producing 46.3 t/ha and imported seed producing 60.1 t/ha. The highest yielding site had an average yield which was over twice the average yield of all sites. Statistical analysis of yield showed there was no significant difference in yield between seed types at the 5% probability level. This suggests the non-seed yield effect of agro-climatic conditions and crop management may be far greater than the effect of seed.

Experimental yield response to different seed sources was also reported by Gunadi *et al.* 2011. They compared various generations of seed potatoes (G2 to G7) from four sources in a March planting at IVEGRI. They found that virus level increased with generation but there was no significant difference in yield between the seed sources. This experiment would have been confounded by the large difference in physiological age between the seed sources, some of which were harvested six months earlier than others. Also the yield grand mean in the experiment was 19.4 t/ha which is not a high yield. The time of planting of this experiment, before the end of the wet season, may have meant that potato late blight disease, which seed schemes can't prevent, may have had a greater influence than seed quality. The result may show that seed quality alone will not result in yield increases unless other management factors are non-limiting.

Table 7.5. Yield of seed treatments for West Java farmer experimental plots (2008/2009) (McPharlin & Taylor 2011).

Farmer Group	Seed treatment	Total yield (t/ha)	Notes	Farmer Group means (t/ha)
Karya Mandiri	Indonesian certified	12.9		
	" non-certified	12.7	lowest result	10.3
	Imported certified	5.4	lowest result	
Muda Tani	Indonesian certified	15.3		
	" non-certified	13.4		13.0
	Imported certified	10.3		
Tunas Tani	Indonesian certified	16.7		
	" non-certified	14.3		16.2
	Imported certified	17.7		
Gapura	Indonesian certified	10.3	lowest result	
	" non-certified	28.7		16.6
	Imported certified	11.0		
Suka Haji	Indonesian certified	27.8		
	" non-certified	20.1		19.7
	Imported certified	11.2		
Barokah Tani	Indonesian certified	25.3		
	" non-certified	23.1		20.5
	Imported certified	13.1		
Perjuangan Tani M	Indonesian certified	27.2		
	" non-certified	15.0		20.5
	Imported certified	19.3		
Mukti Tani	Indonesian certified	25.9		
	" non-certified	19.2		20.6
	Imported certified	16.8		
Wargi Mandiri	Indonesian certified	25.5		
	" non-certified	16.4		22.3
	Imported certified	25.0		
Mekar Sari	Indonesian certified	50.3	highest result	
	" non-certified	46.3	highest result	52.2
	Imported certified	60.1	highest result	
Means	Indonesian certified	23.7		
	" non-certified	20.9		
	Imported certified	19.0		
Significance		ns		
LSD (P = 0.05)		5.7		

Partitioning seed and non-seed potato yield effects

The effect of management and seed quality on yield can also be seen if we revisit Struik and Wiersema's (1999) relationship between percentage of crop planted with certified seed and yield. This relationship is repeated below in Figure 7.2. Note the rising yield associated with increased certified seed use is due both to the effects of improved seed and to other factors such as improved agronomy and better environmental conditions associated with areas that have high use of certified seed (Struik & Wiersema 1999). The following discussion partitions seed and non-seed effects to show their respective importance. Reestman's (1970) equation estimates crop yield according to the potential yield, percentage of virus infection and the compensating effects of neighbouring healthy plants. This equation can be used to add curves to Figure 7.2 showing the expected yield reduction due to virus levels.

The data on which these curves are based are also shown in Table 7.6. When 100 percent certified seed is used, half a percent of plants infected with virus can be expected as the permitted level is usually 1%. Half a percent virus level results in no yield reduction according to Reestman (1970) and so the yield will be 33.4 t/ha (Table 7.6), the same as the maximum yield in the relationship reported by Struik and Wiersema (1999). If the non-certified seed fraction is assumed to be planted with potatoes that are 50 percent infected by PLRV then, when 80 percent certified seed is used in a crop, the 20 percent balance of non-certified seed (remember it has 50 percent PLRV infection) will result in the entire crop having 10 percent of plants infected. Here Reestman (1970) calculates yield reduction will be 2.6% to give a predicted yield of 32.5 t/ha (Table 7.6). When certified seed use is 60 percent the 40 percent of non-certified seed used with 50 percent PLRV infection results in a crop having 20 percent of plants infected with virus. This gives a yield reduction of 5.6%, resulting in 31.5 t/ha (Table 7.6). When no certified seed is used, that is the entire crop is planted with non-certified seed which has 50 percent PLRV incidence, the potential yield of 33.4 t/ha will be reduced 17% to 27.8 t/ha (Table 7.6 and grey dashed vertical arrow in Figure 7.2). When yield reductions are determined for each of the points on the x axis in Figure 7.2 due to the use of non-certified seed with 50 percent PLRV infection, the grey dashed curve is the result. The dotted curve shows the expected yield reduction if the non-certified seed had an 80 percent level of PLRV (Table 7.6 and dotted vertical arrow in Figure 7.2).

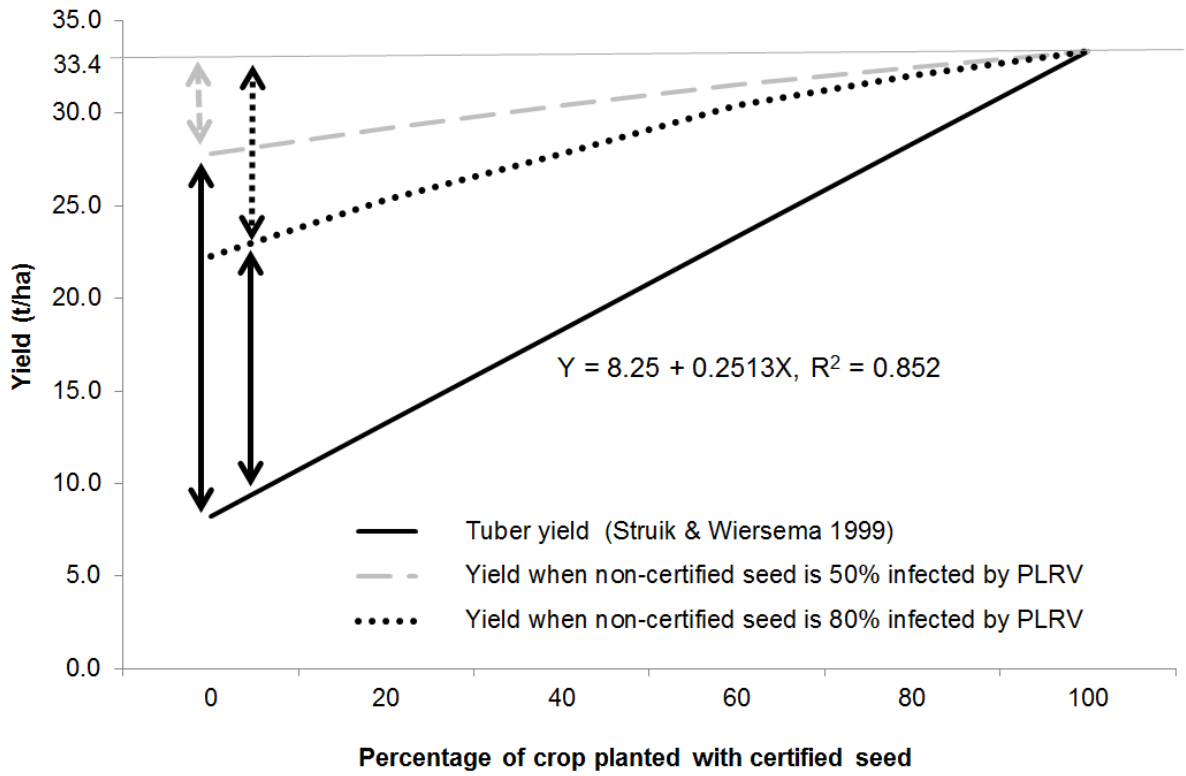

Figure 7.2. Percent of potato crop planted with certified seed and expected yield. Yield reductions due to viral infection are shown by the dashed curves while yield reductions due to general conditions are shown by the solid line and regression. After Struik & Wiersema (1999, p. 272) and Reestman (1970). Vertical dotted arrows indicate yield effects due to seed having specified virus infection levels. Vertical solid arrows indicate yield effects due to non-seed factors.

One interpretation of this data is that the yield loss due to seed quality (seed with 50 percent PLRV infection) is 17 percent while the yield loss due to both seed quality and non-seed factors, e.g. environmental suitability and superior cultivation practices is 75%, calculated from the yield loss shown by Struik and Wiersema (1999) between crops using all certified seed and those using no certified seed, i.e.;

{(33.4t /ha – 8.25t /ha)/33.4 t/ha x 100}. = 75%

Assuming seed effects and crop management effects are additive, the yield loss due to non-seed quality can be determined by subtracting the 17 percent loss due to seed quality from the 75 percent loss due to both seed and other effects which gives a yield reduction due to non-seed factors of 58 percent. If the non-certified seed had an increased level of PLRV infection of 80 percent then the yield loss due to non-seed factors is 42 percent (calculated by subtracting 33 percent yield reduction due to disease (Table 7.6, last row) from 75 percent.

Table 7.6. Potato yield loss expected when a potato crop is planted with varying percent of certified and non-certified seed (0 to 100%) and with varying levels of PLRV infection (after Reestman,1970). Expected yield decline from both seed and non-seed effects according to the regression in Struik and Wiersema (1999) are also shown with estimates of non-seed effect yield reduction.

Type of seed used		Seed effect on yield			Seed & non-seed effect on yield	Non-seed yield loss effect
certified (%)	non-certified (%)	PLRV infected plants (%)	Predicted effect on yield (% yield loss) A	Predicted effect on yield achieved (t/ha)	(% yield loss) B	(%) B - A
	50% PLRV assumed					
100	0	0.5	0	33.4	0	
80	20	10	3	32.5	15	
60	40	20	6	31.5	30	
40	60	30	9	30.4	45	
20	80	40	13	29.2	60	
0	100	50	17	27.8	75	59
	80% PLRV assumed					
0	100	80	33	22.3	75	42

Non-seed effects and seed effects on potato yield

Yield reduction due to seed effects when a crop is planted entirely with non-certified seed with 50% PLRV is 17% according to Reestman (Table 7.6, column "A") and yield reduction due to non-seed effects might be 59% (Table 7.6, last column "B - A") and the longer vertical black arrow in Figure 7.2).

Yield reduction due to seed effects when a crop is planted entirely with non-certified seed with 80% PLRV is 33% according to Reestman and yield reduction due to non-seed effects might be 42% (Table 7.6 and shorter vertical black arrow in Figure 7.2).

Therefore non-seed effects may be more important to potato yield than seed quality. This means that grower surveys which ostensibly investigate the effect of seed on yield must separate the effects of other management changes before a yield effect is attributed to seed. The studies by Ridwan (2010) and Sayaka and Hestina (2011) do not do this and so their results deserve re-interpretation.

Until management factors that affect yield are identified and overcome, improving yield through supply of superior seed will only **partially** solve the problem of low yield.

Observed effect of virus on yield of Indonesia potato crops

The preceding discussion shows that a high virus infection is required to have a substantial effect on potato crop yield. It is important to consider what the yield impact is of the virus levels found in Indonesian seed potatoes.

Duriat *et al.* (2009, Table 1, p. 215) quoted virus levels found in two surveys of different generations of seed potatoes. The highest level in G4 was 7% and for non-certified seed it was 42% (Table 7.7). The level of 7% in G4 seed could be expected to produce a yield reduction of less than 2% according to Reestman (1970) which would reduce the average yielding crop of 16.6 t/ha to 16.3 t/ha. The 42% virus level in non-certified seed could be expected to result in a yield loss of 13.3% which would reduce the average yielding crop of 16.6 t/ha to 14.4 t/ha. This difference in yield would be difficult to pick up in farmers' crops.

In a more recent survey Sulastrini *et al.* (2012) found levels of virus in South Sulawesi potato crops (seed class and generation not specified) ranged from 2% to 40%, with potato virus Y (PVY) the most frequent followed by PLRV.

In an experiment Gunadi *et al.* (2011) observed that virus levels increased with generation of Granola seed. The 13% virus level found in G6 seed could be expected to give a yield loss of 3.5% which would reduce the average treatment yield in this experiment from 19.4 t/ha to 18.7 t/ha. The 24% virus level found in G7 seed could be expected to give a yield loss of 7% which is a yield reduction from 19.4 t/ha to 18.1 t/ha.

These estimated yield reductions are not great and so the reduction in virus in G2 certified Extension Seed (Benih Sebar) under the new Indonesian certified seed potato regulation, may not provide the expected benefits in yield compared with G4 certified seed of the former scheme.

Table 7.7. Virus levels reported in Indonesia certified seed generations and non-certified seed.

Seed generation	Virus level		Source
	(%)	Type	
G2	1	PLRV, PVY, PVX	Pradjatinata (2005)*
G3	4		
G4	7		
Non-certified seed	40		
G2	0.2	PVY	Mulyana (2005)*
G3	0.4	PVY	
G4	4.0	PVY	
Non-certified seed	42.3	PVY	
G2	1.3	PVY symptoms	Gunadi *et al.* (2011)
G3	1.8	PVY symptoms	
G4	2.5	PVY symptoms	
G5	12.2	PVY symptoms	
G6	12.8	PVY symptoms	
G7	24.3	PVY symptoms	

*Quoted by Duriat *et al.* (2009)

Non-seed effects and seed effects on potato yield in Australia

In the high yielding potato production area of Tasmania commercial crop yield and marketable size grade could not be linked to seed factors (Brown 2006, p. 28). The factors driving yield and marketable grade were more closely linked to the management of the commercial crop rather than seed factors (Brown 2006, p. 28). The average yield in these experiments ranged from 62 t/ha to 72 t/ha (Brown 2006, Fig 11). However it shouldn't be concluded that seed quality has no effect on potato crop performance. The potato yield per hectare in Australia has continued to increase since the implementation of seed certification schemes around 1938 (Crump 2014) and a portion of this increase can be attributed to seed quality.

7.3 Conclusions

7.3.1 Yield benefit of seed not being realised.

The use of certified seed is often assumed to be accompanied by yield and profit increases. A search of the literature failed to find convincing evidence that seed quality leads to increased crop profitability in Indonesia. This is probably due to other constraints, like sub-optimal disease control and soil moisture stress preventing the potential of the seed being realised. Surveys of Australian seed users also did not provide convincing evidence of increased yield and profits associated with certified seed use (Crump and Shovelton 2012, Mulcahy 2015). An explanation of why is it difficult to place a true value on certified seed as given in a review of US seed by Frost *et al.* (2013), “the value of seed certification would result from the difference in expected value of yield given the probability of the different disease incidence that would occur with and without the existence of the seed certification program.” They concluded that the *losses due to plant diseases occurring with and without a seed certification are difficult to obtain*. This study also stated “*to value a seed program based only on the value of yield increase due to the provision of pathogen free planting materials ignores other values of the program.”* Two of these other values were:

- improved protection against new pest and disease incursions
- insurance to the industry through protection against the occurrence of catastrophic, but low probability events.

If farmers do not realise increase in profits when using certified seed they will choose cheaper alternatives which are perceived to provide better short term return. Therefore farmers’ seed demand will fall far short of seed demand calculated from cropping area and seed rate.

There is a need to improve productivity of Indonesian potatoes through elucidation of best practises for each area. Effective solutions to other production constraints, e.g. Table 4.1, need to be determined. An appropriate method is through FIL (Section 4.1.6). Unless yield can be increased, demand for seed may not increase as farmers will not see immediate benefits from its use.

7.3.2 Indonesian seed poses biosecurity threat

One benefit of certified seed is protection against exotic threats. If farmers in areas currently free of PCN, bacterial wilt and bacterial ring rot (Cms) can be assured of the supply of pest free seed they may demand this seed because of its long term sustainability benefits. However, certified seed in Indonesia has a risk of spreading these pests and diseases as it does not provide adequate biosecurity against these problems. A longer rotation is required to improve protection against these threats. The only assured source of PCN, bacterial wilt and Cms free seed is seed imported from known disease free areas, which includes domestic and imported seed. Farmers need to be made aware of sources of seed which provides this protection and the longer term benefits of its use in preventing the introduction of important pests and diseases.

7.3.3 Is low demand the reason expected seed quantities are not being produced?

This chapter began by suggesting farmer seed demand is less than seed demand calculated from crop area and seed rate. This reduced demand by farmers is most likely caused by the farmers not experiencing short term yield benefits from certified seed and so they make do with informal seed. Consequently seed growers only produce enough seed they know they can sell, which is well short of the demand calculated from planted area and seeding rate. In 2012 Hikmah Farms, the largest private producer of certified seed potatoes in Indonesia, reduced their seed production from 300ha to 130ha due to the decline is seed demand following the importation of consumption potatoes from Bangladesh and China. Hikmah Farms had to dump seed worth Rp 3 billion due to the fall in demand (Wildan Mustofa, personal communication, 21 September 2013). Therefore, in planning seed development it is important to ensure that the supply does not exceed the saleable demand.

There is a need for greater farmer awareness of the importance of maintaining seed stocks with high plant health and the promotion of the benefit this provides to the entire supply chain. For example seed free from PCN, bacterial wilt and Cms, combined with strict on-farm biosecurity practices will provide protection against these problems in new potato production areas of Indonesia.

8 NTB Seed Potato Supply Chains

8.1 Introduction

The SRA examined seed supply systems used in East Lombok District of Nusa Tenggara Barat Province (NTB) during a field visit in March 2015.

8.2 Methods

Mapping tools described by MP4 (2008) were used as a guide for undertaking a rapid appraisal and comparative analysis of each seed potato supply chain. A participatory characterisation and mapping of representative seed potato value chains in NTB was undertaken which included analysis of costs and margins and income and throughout the chains. Three farmer groups were studied. They arranged for 10 farmers from their group to attend the supply chain mapping workshop. The 10 farmers were asked to compile a cropping calendar, a best bet average gross margin budget and a supply chain map (Appendix 1). A questionnaire was used to guide the collection of information about the supply chain map (Appendix 1). The information was collected by staff of BPTP NTB.

The seed value chain analyses will be used to estimate their potential to increase income and sustainability of potato farmers by:

- increasing yield output;
- reducing cost of production,
- improving sustainability (pest and disease preventions) and;
- Improving the competitiveness at the transport, accumulation, trading, wholesaling, processing and marketing stages of the product chain.

The benefits of the seed value chains combined with improved production efficiency expected will also be estimated.

8.3 Seed potato supply systems

8.3.1 Imported seed for crisp processing crops

Crisp potato crops are grown for the processor PT Indofood Fritolay Makmur (PT Indofood). The Sembalun valley is an important supplier as it is one of the few areas that can reliably supply processing potatoes to PT Indofood at the end of the dry season in September and October. This is because the potatoes are grown on irrigated land that was established for highland paddy rice fields.

This supply chain for PT Indofood was reviewed by Adnan *et al.* (2013) who list the main features of the co-operative production:

- The Horsela farmer group (Horsela) produces Atlantic chip stock for PT Indofood factories. Horsela is short for Hortikultura Sembalun Lawang (Sembalun Lawang Horticulture).
- The cooperation began in 2006 with a written agreement between both parties. The commitments of both parties are as follows:
    - The company provides loans for seed, fertilizer and pesticides as well as production advice from expert farmers from the farmer group.
    - PT Sarana Tani Indonesia Makmur is a financial institution used by PT Indofood to finance the production inputs needed by farmers.
    - CV Cintani is the local distributor of fertilizers and pesticides designated by PT Sarana Tani Indonesia Makmur to provide production inputs to the farmer partners.

- Horsela is the grower umbrella organisation as supplier to the company that manages the receipt and distribution of the production inputs needed by the farmer group members.
- Horsela coordinates production and deliveries of farmer members to PT Indofood.
- PT Indofood ensures suitable market price for potatoes production with the contract price agreed between the farmer group and PT Indofood.
- The price received by farmers is lower than the contract price agreed between Horsela and PT Indofood Fritolay Makmur.
  - Horsela pays farmers the standard base agreed price.
  - The difference between contract price to the farmer group and the base price farmers receive is to finance off-farm activities including:
    - harvest costs
    - transport from the field to the storage shed
    - loading and unloading in the warehouse
    - storage costs
    - transportation costs from the warehouse to transit shipping
    - loading and unloading costs at the location of transit
    - transportation costs from transit to the factory warehouse
    - unloading costs at the company warehouse
    - packaging costs
    - incentives farmer groups and
    - shrinkage that occurs during storage or during delivery to the processor's storehouse.
- Repayment of loans for production inputs (seeds, fertilizers and pesticides) by farmers is through direct deductions from farmer payments through the Horsela's account.

Since the review of Adnan *et al.* (2013) PT Indofood has developed partnerships with some other farmer groups at Sembalun.

The cropping calendar for this system is shown in Figure 8.1. Imported seed arrives each year in June, the beginning of the dry season. Some is planted immediately and the remainder is shed stored until planting is finished at the end of July. The crops are harvested from September to October. In October the first rains of the wet season begin.

A supply chain map of this crop system is shown in Figure 8.2. The imported seed is sent from Jakarta to Horsela in Sembalun by PT Indofood. Horsela plans the cropping program and distributes the seed to its members. Horsela coordinates harvest and delivery to the factory at Semarang, central Java or Tangerang in Jakarta. Some potatoes are sold to the local market in Sembalun.

In one previous year, seed-size tubers were graded from the crop and sent to PT Indofood's cool store in Surabaya. The farmers reported that this was inefficient and so it has not been repeated. However PT Indofood provided further information that the Sembalun seed can be re-used successfully but the inefficiency was due to the seed harvest occurring when soils were already wet after the first rains in October (Budi Dharmadi, personal communication, 15 June 2015). The harvest and storage of wet tubers resulted in high wastage due to rots. Imported seed is planted at Sembalun at a rate of 2 t/ha which produces 13 t/ha of chip stock and 1.5 t/ha of seed. This yield is substantially lower than the yield reported by farmers. PT Indofood have stored the seed at 3 – 5°C but after grading out rots only one tonne remains. The seed rate for replanting this local once-grown seed is 1.5 t/ha as it is smaller size than imported seed.

Seed scheme	: Imported seed	Variety	: Atlantic
Farmer group	: Horsela	Location	: Sembalun, East Lombok, NTB
Survey day/ date	: Tuesday, 3 March 2015	Elevation	: 1,100m a.s.l.
Year of potato crop in question	: 2014	Informant	: Minardi / HP : 085239728722
Agro-ecosystem	: Paddy fields	Enumerator	: Sudjudi

Suggested order of filling the table is shown in the first column.

Cross the appropriate cells starting in the current year, then work back and forward as needed:

			Don't	2013												2014												2015											
		Month:	know	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1	Rain	Heavy		■	■	■										■	■	■										■	■	■									
2		Light					■	■											■																				
	Potato crop 1			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
9	Previous crop harvest	What? Paddy, local variety		■	■	■	■	■	■							■	■	■	■	■	■							■	■	■									
10		When harvested							■	■											■	■																	
7		Pre-plant seed storage							■	■											■	■																	
3		Main planting months							■	■											■	■																	
4	% annual production	Main harvest months										■	■											■	■														
8	20-30 t/ha (50%)	Post-harvest seed storage												▨	▨	▨	▨	▨	▨	▨																			
5		Late blight arrives							■	■											■	■																	
6		Insect pests arrive																																					
11	Following crop	What? Fallow/cabbages																																					
12		When planted?											■																										
13	Fallow or grazing												■																										
				J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D

Notes: production is from potatoes grown in the paddy fields with the cropping pattern local rice-potato-fallow/cabbages).
What occurs every year is seed arrives from Indofood 2 - 4 weeks before planting time. Diagonal shading indicates the storage of yield for seed for the following year that is cool stored for 6 months in Surabaya, and stored at Sembalun 1 month (until short sprouts are produced). This situation has only occurred just one year because it is inefficient.
Of the total potato production in Sembalun 30% comes from the paddy fields which have a cropping pattern of local rice – potato - fallow/cabbages with an average yield of 20-30t/ha while 20% comes from paddy fields with a cropping pattern of vegetables-potato-vegetables with a yield of 16-20t/ha and 20% comes from dry land (lahan tegalan tadah hujan) with only one cropping time i.e. potato mono-culture or potato that is planted together with corn or other vegetables but planted in different plots (not companion planting) with a yield of 12-15t/ha. Yield of potato on dry land is far lower than potato grown in paddy fields but the costs of higher for dry land. This is because control of disease in the rainy season is very high, i.e. at least 2 hr spent spraying 25-30 times during the season. The area of the crisp potato cropping partnership with Indofood in 2014 was only 75 ha because the seed didn't arrive in time (arrived too early so that much of the seed was spoiled) and many farmers were bankrupt. Usually around 200 ha of processing crop are grown.

Figure 8.1. Cropping calender for Atlantic crisp processing potatoes grown using imported seed for PT Indofood.

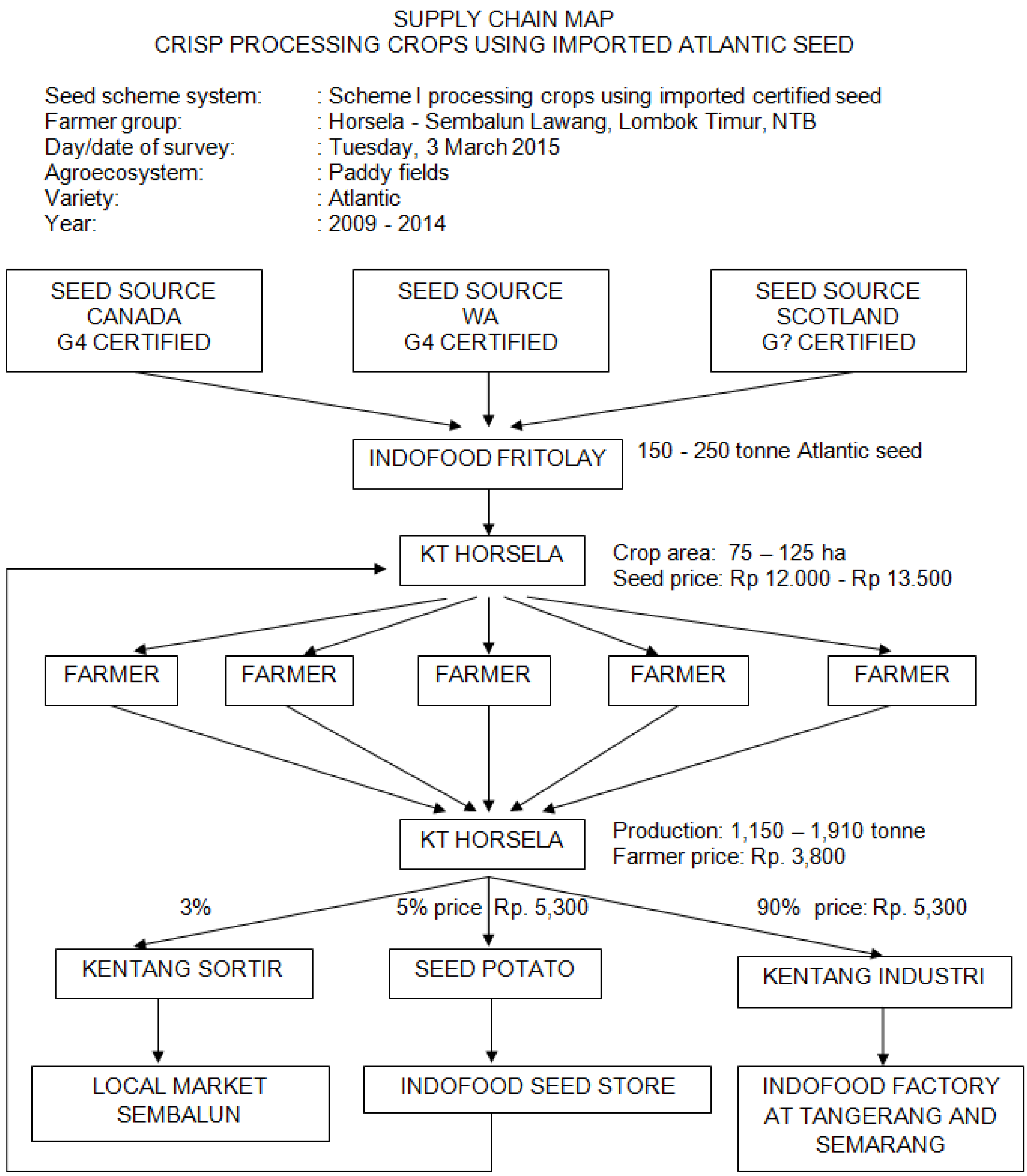

Figure 8.2. Seed and production supply chain map for Atlantic crisp processing potatoes grown from PT Indofood by the Horsela farmer group.

Seed supply in 2013 and 2014 was unusual. There was a shortage of seed from Western Australia and alternative supplies were sourced from Scotland. The Scottish seed arrived at Sembalun in February and was shed stored until June. The prolonged shed storage resulted in much of the seed rotting and there was only enough seed to plant 75ha compared to 150ha production in 2009 (Adnan *et al.,* 2013).

Ten members of Horsela compiled an average enterprise budget for this crop which is shown in Table 8.1. The cost of imported seed amounts to Rp 26.2 million/ha which is 49% of variable costs. Seed is Rp 13,100/kg and seed rate is 2,000 kg/ha. Fertiliser costs were 10% of variable costs, pesticides were 11% and labour was 31%. Total yield was 25 t/ha of which 85% was sold as chip stock, 14% was sold as seed and 1% was waste. Income was Rp 99 million which gave a gross margin of Rp 45.2 million/ha. Fixed costs were 9.2 million to give an enterprise profit of Rp 36 million/ha.

Table 8.1. Horsela crisp processing crop budget; imported seed, paddy field production

Item	Grade by %	Amount (kg/ha)	Price (Rp/kg)	Total (Rp/ha)	% costs
Income					
Variety and market	Atlantic, Indofood				
Processing/table potatoes	85%	21,250	4,000	85,000,000	
Waste potatoes	1%	250	0	0	
Seed	14%	3,500	4,000	14,000,000	
Total or average		25,000	3,960	99,000,000	
Variable costs (VC)					
Seed		2,000	13,100	26,200,000	49
Fertiliser				5,225,000	10
Support inputs				0	0
Pesticides				5,665,000	11
Labour & contractors					
Tractor (cultivation)				3,000,000	
Crop management				7,500,000	
Harvest		25,000	250	6,250,000	
Post-harvest					
Total labour				16,750,000	31
Other				0	0
Total VC				53,840,000	100
Gross margin				45,160,000	
Income/VC				1.84	
Break even price (BEP) (Rp/kg) {% av price}				2,154	{54}
Break even yield (BEY) (t/ha)				13,596	
Fixed costs					
Depreciation				96,000	
Land rent				8,000,000	
Water costs		250	4,000	1,000,000	
other					
Land tax				100,000	
Development tax					
Store hire					
Total Costs				63,036,000	
Enterprise profit				35,964,000	

The farmers' budget potato sale price is Rp 4,000/kg. The price of Rp 5,300/kg paid to Horsela by PT Indofood is higher to enable the group to pay for harvest costs, transport from the field to the storage shed, etc. as detailed earlier by Adnan *et al.* (2013). The supply chain map (Figure 8.2) assumes a farmer price of Rp 3,800 which is less than the Rp 4,000/kg farmer price shown in the budget.

Atlantic crisp processing crops profitable in Sembalun

The financial outcome of this crop compares favourably with other recent budget analyses of crisp processing crops grown for PT Indofood (Figure 8.3).

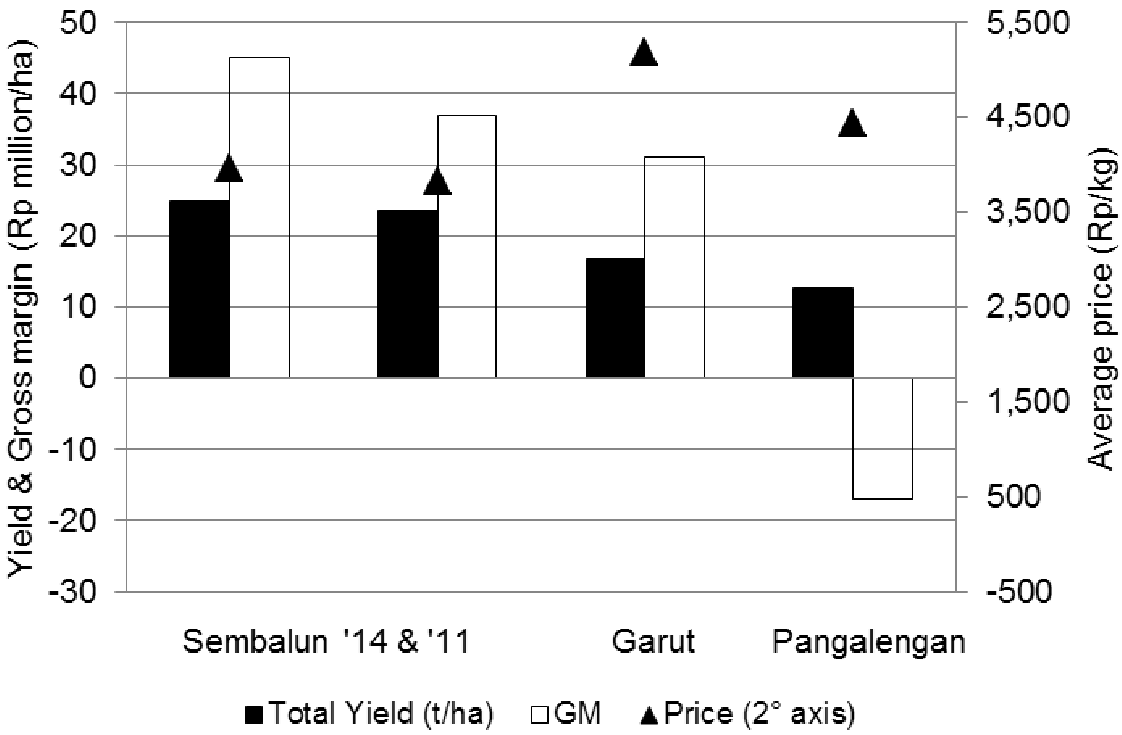

Figure 8.3. Comparison of recent financial analyses of crisp processing crops grown for PT Indofood at three locations in Indonesia.

Adnan *et al.'s* (2013) financial analysis for a 2011 Sembalun grown crisp processing crop (Sembalun '11 in Fig. 2) shows similar marketable yield, 23.5 t/ha, similar variable costs, Rp 52 million/ha and a gross margin of Rp 37 million/ha (Figure 8.3). Seed costs were also 49% of variable costs. Fixed costs were Rp 3 million/ha which resulted in an enterprise profit of Rp 34 million/ha. The outcome was much better than Atlantic crisp processing crops grown at Garut and Pangalengan in West Java using imported seed (de Putter *et al.,* 2014). At Garut yield of 17t/ha was lower than Sembalun, average price was higher due to 12% of yield sold as seed at a price of Rp 10,000/kg. Garut variable costs were Rp 56 million/ha (35% for seed) and gross margin was Rp 31 million/ha (Figure 8.3). At Pangalengan the crop was unprofitable; yield was the lowest at 12.7 t/ha, 94% of the crop sold at Rp 4,400/kg which gave an income of Rp 56 million/ha. Pangalengan variable costs were Rp 73 million/ha which gave a negative gross margin of Rp -17 million/ha. Seed costs were 34% of variable costs, a lower percentage than the other budgets due to higher costs of fertiliser (15%) and pesticides (18%).

Another less profitable financial analysis of Atlantic crisp processing crops for PT Indofood in West Java is given by Bank Indonesia (Direktorat Kredit, BPR dan UMKM, 2011). Total yield was 15.0 t/ha with 98% of the crop sold at Rp 4,950/kg. Income was Rp 74 million/ha, variable costs were Rp 59 million/ha which gave a gross margin of Rp 14.5 million/ha.

The crisp processing crops at Sembalun have a higher profitability than the crisp processing crops in West Java and so the crop is more attractive to farmers, resulting in more reliable supply to PT Indofood than supply from other areas.

The area cropped under this system was 75ha in 2014 which was less than usual due to the seed shortage. The Horsela group report their cropping area can range from 75 to 125ha. Adnan *et al.* (2013) show the crisp processing crop area has previously reached 150ha. Given the profitability this has the potential to increase to 150ha with a value of approximately Rp 5.5 billion (AUD $550,000)[16].

Problems with seed has been quality, size and price. Growers need reliable supply of smaller seed with average diameter of 50mm with a range of 35 - 65mm, this corresponds to a weight of 20 - 35g/tuber to give a seed rate of 1,900 - 2,100kg/ha.

These recent financial analyses indicate Sembalun has higher yields and lower costs resulting in a greater profitability than either Garut or Pangalengan.

8.3.2 Partial seed for French fry processing crops

The Koang Londe farmer group have developed the production of French fry potatoes based on G0 seed from Biotek IPB in Bogor with subsequent generation multiplied at Sembalun. This is a closed loop marketing system with seed of a propriety variety Jala Ipam owned by IPB (Institut Pertanian Bogor). Jala means net and Ipam is an acronym for IPB Amanah. Amanah being short for PT Amanah Prima, the potato processor at Tangerang in Jakarta. The variety appears to be a selection of Russet Burbank as its breeders are listed as Luther Burbank and GA Wattimena (Kosim 2014, p. 129). The Koang Londe farmer group could not provide details about the final processed product of this supply chain.

A supply chain map is shown in Figure 8.4. The growers consider this to be an informal partial seed scheme where high quality seed is brought into the area and bulked for a limited number of generations. G0 minituber seed is planted directly in dryland fields or paddy fields at Sembalun. 6,000 minitubers each produce 317g of G1 informal seed, the total is 1,900 kg from 0.25ha which is a yield of 7.6 t/ha. 65% of the yield is seed grade bought by the group for Rp 14,000/kg and stored for the next crop. The remaining 35% (700kg) is sold to the processor. Transport to Tangerang takes 48 hours and bruising losses are 5%. The processing grade is sold for Rp 4,000/kg, the same price as crisp processing potatoes at Sembalun.

The G1[17] seed is stored for later use by the farmer group. The cost of this seed is Rp 15,000/kg, the price increase covers storage costs and losses. After dormancy is broken the 1,200kg of seed is planted on 0.6ha which produces 13 tonnes (21.6t/ha). 30% of this is saved as G2[18] seed (3,900kg) and the remaining 70% (9,100kg) is sold to the processor as before.

A budget for this crop G1 planted crop was compiled by the farmer group is shown in Table 8.2. Note that two crops a year are grown as shown by the cropping calendar (Figure 8.5). The crops alternate between dryland and paddy field areas according to the season. The budget is for the paddy field area which produces higher yields than dryland crops. The

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[16] Exchange rate used Rp 10,000/AUD

[17] This seed would be classified as G2 if grown in the certified seed scheme as it was grown in the field, not a screenhouse.

[18] This seed would not be classified as G2 in the certified seed scheme as it was grown from G1 seed which would have been relegated to G2 (see footnote above).

budget has income of Rp 197 million/ha from a marketable yield of 30.0 t/ha. Processing sales are Rp 84 million/ha while seed sales were Rp 113 million/ha. Variable costs were Rp 65 million/ha giving a gross margin of Rp 132 million/ha. Seed costs comprised 31% of variable costs. Fixed costs were Rp 17 million which included 5 million storage costs. This resulted in an enterprise profit of Rp 114 million/ha. The seed sales component is responsible for the high income.

The G2 seed is again stored and planted for the final time. 95% of this crop is sold to the processor in Tangerang and 5% is sold to local processing.

The right hand side of Table 8.2 shows a modification to the budget to represent the third crop in the cycle which produces only processing potatoes, not seed. Seed grading and storage costs have been omitted. The result is that income falls from Rp 197 million/ha to Rp 100 million/ha, variable costs fall slightly less as there is no seed grading, and the gross margin becomes Rp 36 million/ha. The enterprise profit after fixed costs are deducted becomes Rp 24 million/ha, less than for crisp processing crops (Table 8.1). This shows that the seed grade component of the crop has very high value compared with processing production.

By including seed sales of 8.7 tonnes/ha in the enterprise mix, the Koang Londe farmer group have increased enterprise profit by Rp 90 million/ha (375%).

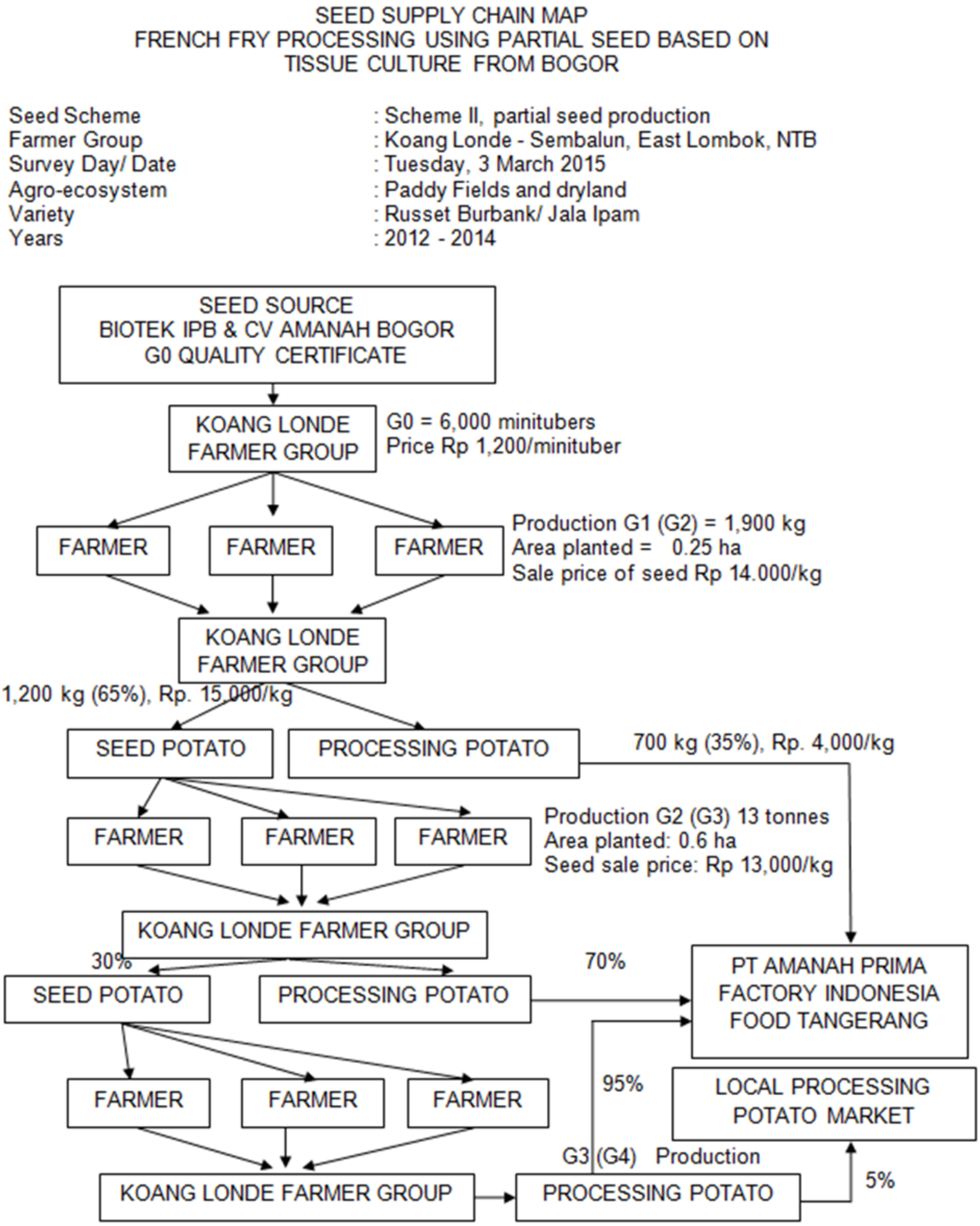

Figure 8.4. Seed and production supply chain map for Jala Ipam French fry processing potatoes grown for PT Amanah Prima by the Koang Londe farmer group. Generations shown in brackets indicate relegation that would occur if the seed was grown within the Indonesian certified seed scheme. In this scheme if G1 is not produced in a screenhouse it is relegated from G1 to G2.

Seed scheme	: Scheme II partial seed scheme	Variety	: Russet Burbank / Jala Ipam
Farmer group	: Koang Londe - Sembalun, East Lombok, NTB	Lokasi	: Sembalun, East Lombok, NTB
Survey day/ date	: Tuesday, 3 March 2015	Elevation	: 1,100 m a.s.l.
Year of potato crop in question	: 2014	Informant	: A Leo/ Murtadi / mobile : 081 917 992 282
Agro-ecosystem	: Paddy and dryland	Enumerator	: Sudjudi

Suggested order of filling the table is shown in the first column.

Cross the appropriate cells starting in the current year, then work back and forward as needed:

			Don't know	2013												2014												2015											
				Month																																			
		Month:		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1	Rain	Heavy		■	■	■										■	■	■										■	■	■									
2		Light					■												■												■								
		Wet season crop		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
9	Pervious crop harvested	What? *(Padi)*																																					
10		When harvested																																					
3	**Potato crop 1**	Main planting months												■												■													
4	% annual production	Main harvest months															100												100										
5		Late blight arrives						■	■	■										■	■	■	■																
6		Insect pests arrive							■	■	■												■	■															
7		Pre-plant seed storage								■								■																					
8		Post-harvest seed storage									■	■	■	■	■										■	■	■	■	■										
11	Following crop	What?																																					
12		When planted?																																					
13	Fallow or grazing																																						
		Dry season crop		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
20	Previous crop harvest	What																																					
21		When harvested																																					
14	**Potato crop 2**	Main planting months															■	■											■	■									
15		Main harvest months																			50	50																	
16		Late blight arrives																																					
17		Insect pests arrive																																					
18		Pre-plant seed storage																																					
19		Post-harvest seed storage										■	■	■	■	■									■	■	■	■	■										
11	Following crop	What? *(carrot, broccoli, celery) 60 % area*																																					
12		When planted?											■	■	■	■									■	■	■	■											
13	Fallow or grazing	40 % area												■	■											■	■												
22	Other information: area grown by the farmer group is 2 ha, the average yield is 25-30 tonne/ha																																						

Figure 8.5. French fry processing crops grown at Sembalun based on partial seed from tissue culture seed.

Table 8.2. French fry processing and seed on paddy field and French fry processing only on dryland both using partial seed, Koang Londe farmer group.

Item	French fry & seed, paddy field					French fry only, dryland				
	Grade by %	Amount (kg/ha)	Price (Rp/kg)	Total (Rp/ha)	% costs	Grade by %	Amount (kg/ha)	Price (Rp/kg)	Total (Rp/ha)	% costs
Income										
Processing/table potatoes	70%	21,000	4,000	84,000,000		95%	23,750	4,000	95,000,000	
Lower grades	1%	300	0	0		0%	0	0	0	
Seed	29%	8,700	13,000	113,000,000		5%	1,250	4,000	5,000,000	
Total or average		30,000	6,570	197,000,000			25,000	4,000	100,000,00	
Variable costs (VC)										
Seed		1,500	13,500	20,250,000	31		1,500	13,500	20,250,000	31
Fertiliser				6,120,000	9				6,120,000	9
Support inputs				380,000	1				380,000	1
Pesticides				8,050,000	12				8,050,000	12
Seed grading labour				1,740,000	3				0	
Other labour				28,890,000	44				28,890,000	44
Total VC				65,430,000	100				63,690,000	100
Gross margin				131,670,000					36,310,000	
Income/VC				3.01					1.57	
BEP (Rp/kg) {% av price}				2,181	33				2,548	64
BEY (t/ha)				9,959					15,923	
Fixed costs										
Seed store hire				5,000,000						
Depreciation, land rent etc.				12,202,667					12,202,667	
Enterprise profit				114,467,333					24,107,333	

8.3.3 Informal seed for Granola fresh potato crops

Horsela farmer group

The Horsela farmer group also grow Granola crops for the local fresh potato market. The seed originates either from tissue culture material or informal seed from Central or East Java.

The regulations prohibiting the movement of uncertified seed into NTB (Section 5.1.2) are not being effectively enforced.

The tissue culture seed is multiplied several times outside the certified seed scheme so it is classified as informal seed. The seed fraction decreases from 40% at G3 to 20% at G5 (Figure 8.6). The seed from each crop is saved for the next alternating between paddy and dryland crops. There is one crop each year grown in paddy fields while two crops are grown in the dryland areas (Figure 8.7). These are planted early and late in the wet season, i.e. November and March respectively, to avoid emerging plants being affected by the heaviest rain.

Granola production in the paddy fields has a cropping pattern of local rice – potato - fallow/cabbages with an average yield of 25 t/ha while another cropping pattern is vegetables-potato-vegetables with a yield of 18t/ha. This paddy field rotation does not have the 3 month flooding that occurs with rice production. On dryland there is only one cropping time where potato that is planted together with corn or other vegetables but planted in different plots with a yield of 13.5 t/ha. Farmers reported that yield of potatoes on dry land is far lower than potato grown in paddy fields while dryland cost of production is higher. This is because control of disease in the rainy season is very high because at least 2 hours is spent spraying 25-30 times during the season.

The paddy field crop has a higher gross margin than the dryland crops due to higher yield of 23 t/ha versus 20 t/ha (Table 8.3). Income from the paddy field crop was Rp 113 million/ha comprising 20 t/ha fresh potatoes sold at Rp 5,000/kg and 2.3 t/ha of seed also sold at Rp 5,000/kg. Income from the dryland crop was Rp 98 million/ha comprising 17.5 t/ha fresh potatoes and 2.1t/ha of seed both sold for Rp 5,000/kg. Variable costs for the paddy field crop are higher than the dryland crop due increased labour needed to harvest the higher yield. The farmers' comment from the previous paragraph about dryland (wet season) cost of production being greater than paddy field production costs was not apparent from the budget. Gross margin for the paddy field crop was Rp 69 million/ha while for the dryland crop it was Rp 55 million/ha. The difference in enterprise profit between the two crops was less than the difference in gross margin due to the higher fixed costs for paddy fields which included Rp 8 million/ha for land rent while dryland rent was Rp 3 million/ha. Both crops had higher gross margins and enterprise profit than the crisp processing crops (Table 8.1) however the scale of production is much smaller for the fresh market Granola crops for the local NTB market, the farmer group report the annual production is 10ha from the paddy fields and 10ha from the dryland area.

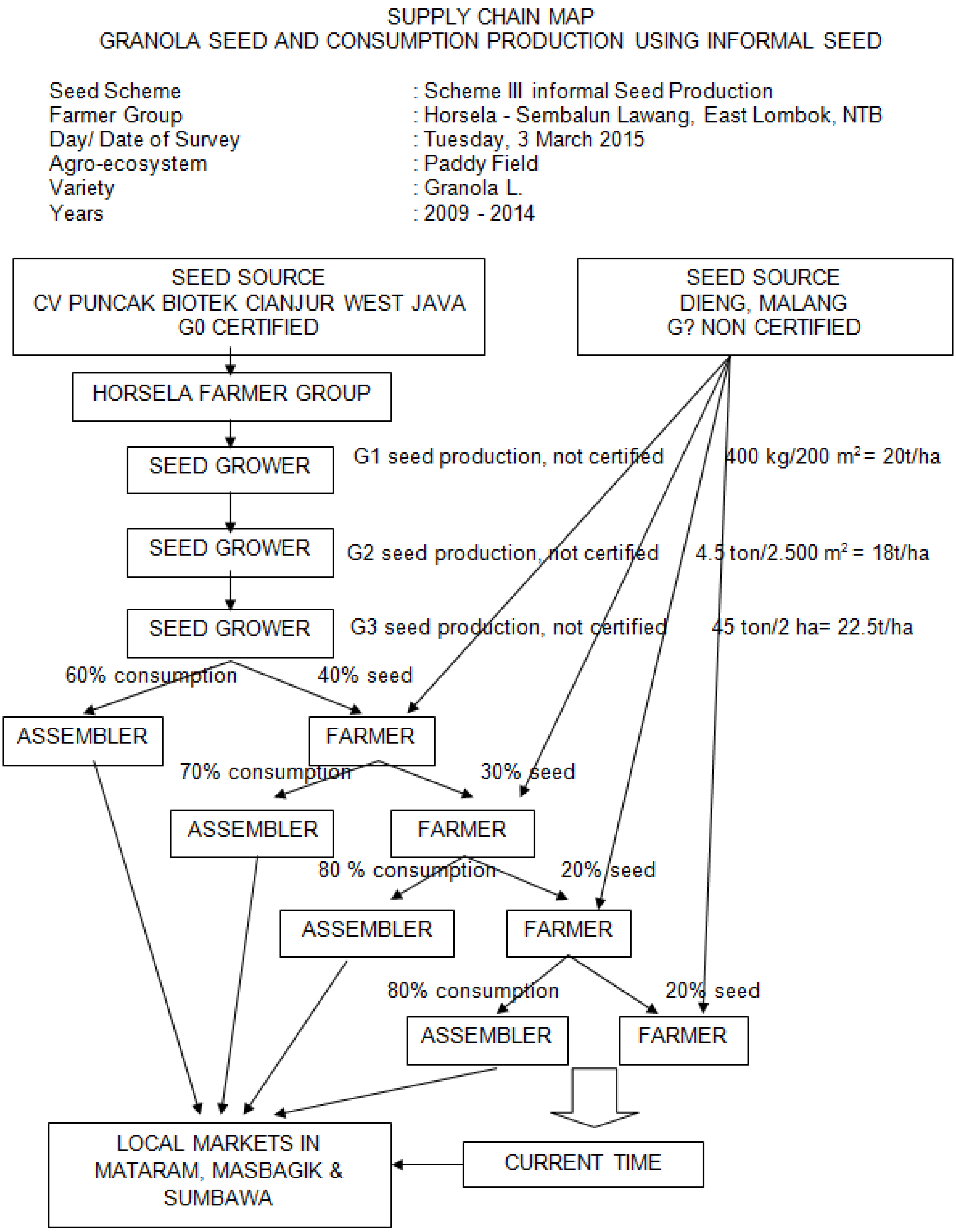

Figure 8.6. Seed and production supply chain map for Granola fresh potatoes grown for the local market by the Horsela farmer group. Generations shown are for informal seed production, not official Indonesian certified seed.

Seed scheme	: Informal Seed	Varietas	: Granola
Farmer group	: Horsela	Location	: Sembalun Lawang, Lombok Timur, NTB
Survey day/Date	: Tuesday, 3 March 2015	Elevation	: 1,100 m a.s.l.
Year of potato crop in question	: 2014	Informant	: Ruspino / HP : 087 763 140 050
Agro-ecosystem	: Paddy fields and dryland	Enumerator	: Sudjudi

Suggested order of filling the table is shown in the first column.

Cross the appropriate cells starting in the current year, then work back and forward as needed:

			2013												2014												2015											
		Month:	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1	Rain	Heavy	■	■	■										■	■	■										■	■	■									
2		Light				■												■																				
	Potato crop 1 paddy field		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
9	Previous crop harvest	What? *(Rice)*	■	■											■	■											■	■										
		When harvested?					■	■											■	■											■	■						
7		Pre-plant seed storage			■	■	■										■	■	■																			
3		Main planting months						■	■	■										■	■	■																
4		Main harvest months									30	40	40										30	40	40													
8		Post-harvest seed storage										■	■	■	■	■								■	■	■	■	■										
5		Late blight arrives								■	■											■	■															
6		Pests arrive									■												■															
11	Following crop	What? *(Fallow)(40% area)*											■	■											■	■												
12		When planted?																																				
	Potato crop 2 dryland		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
7		Pre-plant seed storage		■												■																						
3		Main planting months			■												■												■									
4		Main harvest months						75												75																		
8		Post-harvest seed storage							■	■	■										■	■	■															
5		Late blight arrives				■	■							■	■			■	■							■	■											
6		Pests arrive				■	■							■	■			■	■							■	■											
11	Following crop	What? *(Fallow)*																																				
12		When planted?										■	■	■	■									■	■	■	■											
	Potato crop 3 dryland		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
18		Pre-plant seed storage										■												■														
14		Main planting months											■												■													
15		Main harvest months														25												25										
19		Post-harvest seed storage															■	■	■	■																		
11	Previous & following crop	What? *(fallow)*																																				

Notes: Area planted by KT Horsela : 1 ha, average yield 25 ton/ha.
In Sembalun production of Granola using informal seed comes from the paddy fields which have a cropping pattern of local rice – potato - fallow/cabbages with an average yield of 20-30 t/ha while others comes from paddy fields with a cropping pattern of vegetables-potato-vegetables with a yield of 16-20 t/ha and other are grown on dryland (lahan tegalan tadah hujan) with only one cropping time i.e. potato mono-culture or potato that is planted together with corn or other vegetables but planted in different plots (not companion planting) with a yield of 12-15 t/ha. Yield of potato on dry land is far lower than potato grown in paddy fields and the cost is higher for dryland. This is because control of disease in the rainy season is very high, i.e. at least 2 hr spent spraying 25-30 times during the season.

Figure 8.7. Granola fresh market crops grown at Sembalun by the Horsela farmer group using informal seed.

Table 8.3. Granola seed and consumption production using informal seed, Horsela farmer group, paddy field and dryland production

Item	Paddy field					Dryland				
	Grade by %	Amount (kg/ha)	Price (Rp/kg)	Total (Rp/ha)	% cost	Grade by %	Amount (kg/ha)	Price (Rp/kg)	Total (Rp/ha)	% costs
Income										
Table potatoes	88%	20,240	5,000	101,200,00		87.5%	17,500	5,000	87,500,000	
Waste	2%	460	0	0		2.0%	400	0	0	
Seed	10%	2,300	5,000	11,500,000		10.5%	2,100	5,000	10,500,000	
Total or average		23,000	4,900	112,700,00			20,000	4,900	98,000,000	
Variable costs (VC)										
Seed		2,100	7,000	14,700,000	34		2,000	8,000	16,000,000	38
Fertiliser				4,220,000	10				5,260,000	12
Support inputs				0					0	
Pesticides				4,545,000	10				3,942,000	9
Total labour				20,075,000	46				17,325,000	
Total VC				43,540,000	100				42,527,000	
Gross margin				69,160,000					55,473,000	
Income/VC				2.59					2.30	
BEP (Rp/kg) {% average price}				1,893	39				2,126	{43}
BEY (t/ha)				8,886					8,679	
Fixed costs										
Land rent				8,000,000					3,000,000	
Water costs				1,150,000					1,000,000	
Depreciation, land rent etc.				213,804					188,804	
Total costs				52,903,804					46,715,804	
Enterprise profit				59,796,196					51,284,196	

Lendang Luar farmer group

Granola production for the local fresh market using informal seed is also undertaken by the Lendang Luar farmer group. The seed originates from certified seed growers from Malang in East Java and from Pangalengan in West Java or from uncertified seed growers in Malang as well as from Dieng in Central Java (Figure 8.8). The seed is has so far been multiplied three times outside the certified seed scheme so it is classified as informal seed.

Again the regulations prohibiting the movement of uncertified seed into (Section 5.1.2) are not being effectively enforced.

This crop is a minor planting, using 5 ha of paddy fields and 5 ha of dryland. The paddy field crop pattern is shown in Figure 8.9. Sales comprise 80% of yield as fresh potatoes for local NTB markets and 20% (Figure 8.8). Sales price for both grades is Rp 5,000/kg. Note that there is probably some variation in the amount of seed sold from each crop as the budget compiled for this cropping system shows seed fraction of 10% (Table 8.4). Seed is saved from each crop to plant the next crop which alternates between paddy fields and dryland areas.

Granola yield from the paddy fields is 23.5 t/ha and from drylang it is 20 t/ha (Table 8.4). The paddy field crop has a higher gross margin than the dryland crops as variable costs of both crops are similar. Gross margin for the paddy field crop was Rp 69 million/ha and for the dryland crop it was Rp 53 million/ha (Table 8.4). The difference in enterprise profit between the two crops was less than the gross margin difference due to the higher fixed costs for paddy fields where land rent was Rp 8 million/ha while for dryland it was Rp 3 million/ha. These budgets are very similar to the Granola budgets from informal seed reported by Horsela in the previous section.

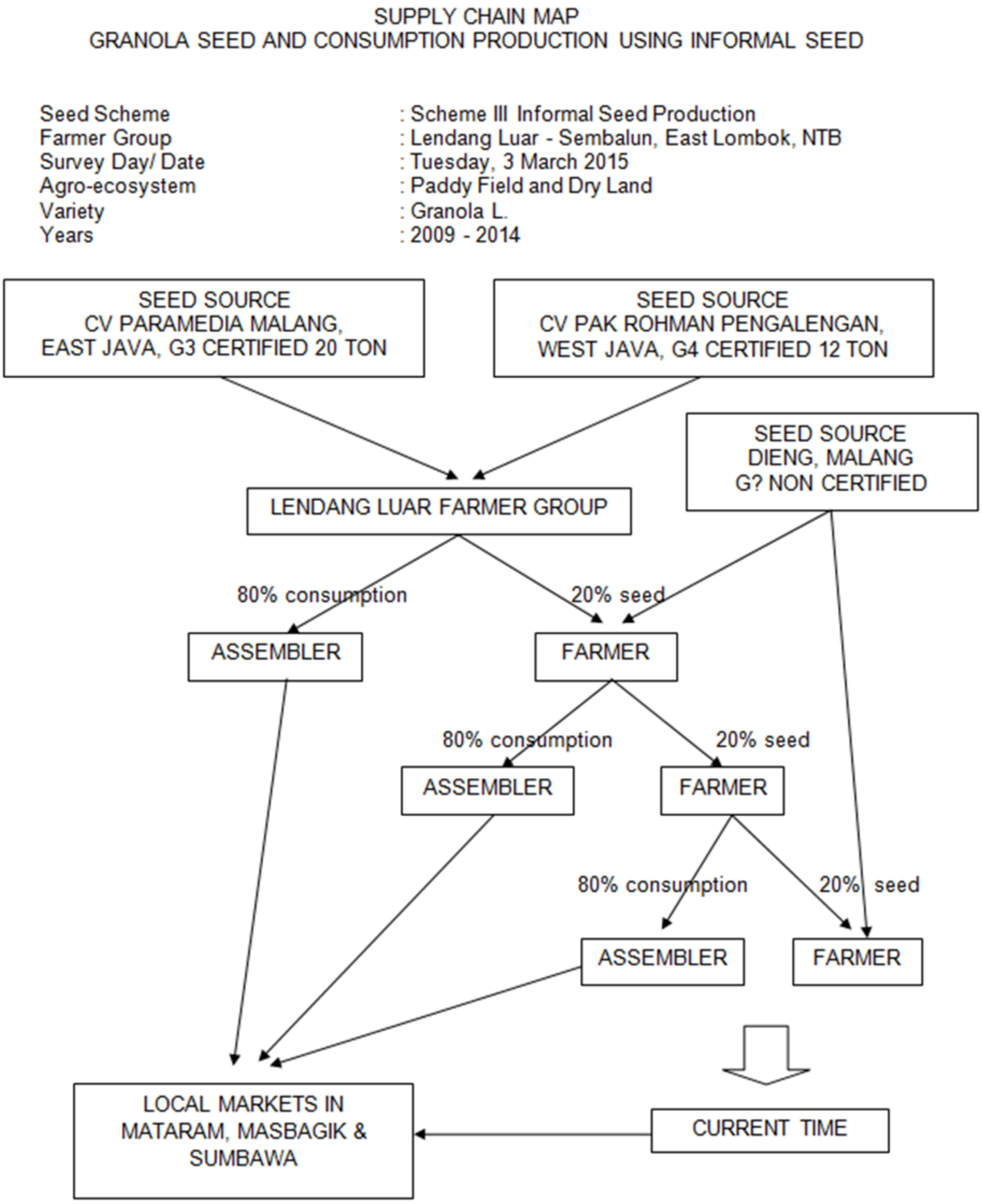

Figure 8.8. Granola seed and production supply chain map using informal seed from various sources by the Lendang Luar farmer group.

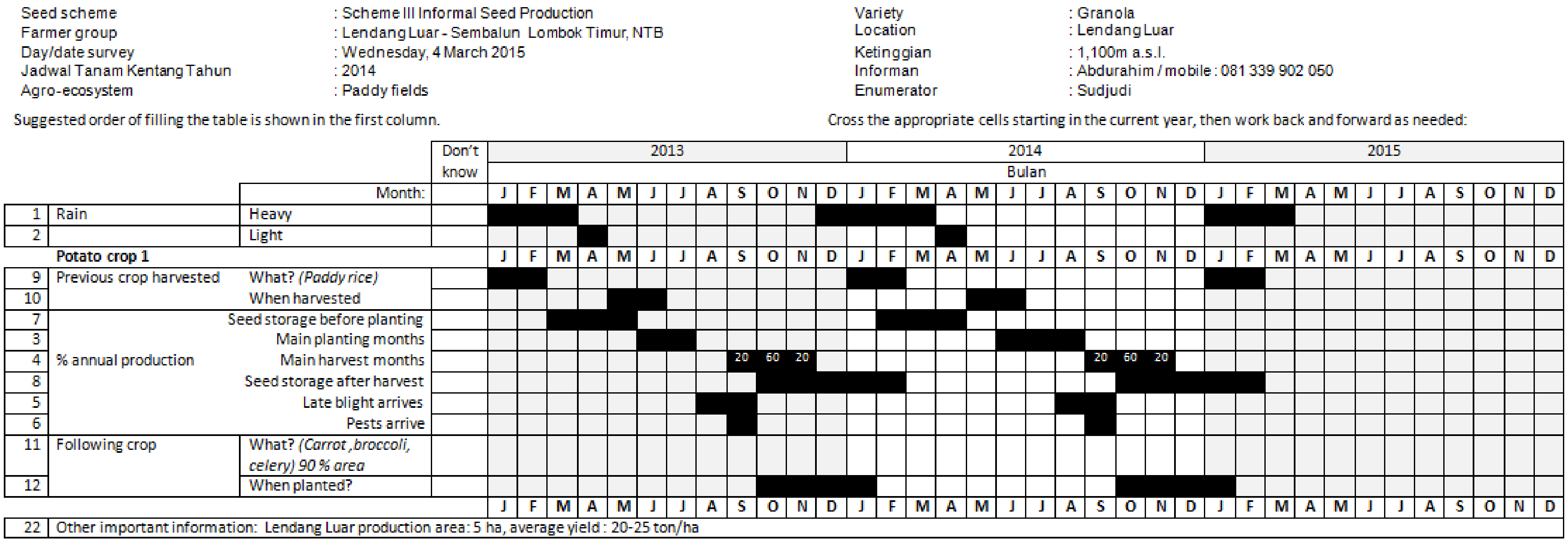

Figure 8.9. Paddy field cropping pattern for Granola fresh market crops grown at Sembalun by the Lendang Luar farmer group using informal seed.

Table 8.4. Granola seed and consumption production using informal seed, Lendang Luar farmer group, paddy field and dryland production

Item	Paddy field					Dryland				
	Grade by %	Amount (kg/ha)	Price (Rp/kg)	Total (Rp/ha)	% costs	Grade by %	Amount (kg/ha)	Price (Rp/kg)	Total (Rp/ha)	% costs
Income										
Table potatoes	88%	20,680	5,000	103,400,00		88%	17,600	5,000	88,000,000	
Waste	2%	470	0	0		2%	400	0	0	
Seed	10%	2,350	5,000	11,750,000		10%	2,000	5,000	10,000,000	
Total or average		23,500	4,900	115,150,00			20,000	4,900	98,000,000	
Variable costs (VC)										
Seed		2,100	8,000	16,800,000	36		2,100	8,000	16,800,000	37
Fertiliser				4,340,000	9				4,340,000	10
Support inputs				0					0	
Pesticides				5,863,000	13				4,598,000	10
Total labour				19,475,000	42				19,175,000	43
Total VC				46,478,000	100				44,913,000	100
Gross margin				68,672,000					53,087,000	
Income/VC				2.48					2.18	
BEP (Rp/kg)				1,978					2,246	
BEY (t/ha)				9,485					9,166	
Fixed costs										
Land rent				8,000,000					3,000,000	
Water costs				1,175,000					1,000,000	
Depreciation, land rent etc.				213,804					213,804	
Total costs				55,866,804					49,126,804	
Enterprise profit				59,283,196					48,873,196	

Certified seed for Granola fresh potato crops

Granola fresh market potatoes are also produced by the Lendang Luar farmer group using certified seed from PT Hortitek Farm at Pangalengan in West Java (Figure 8.10). They buy 2,000 minitubers at Rp 3,000 each. The minitubers produced around 20 G1 tubers which can be sold for Rp 1,500 each. This will plant 1.2 ha which produces 10 tonne of G2 seed which is priced at Rp 13,000/kg. This provides enough seed to plant 5 ha which produces 135 tonnes of G3 potatoes. 40% of this crop can be sold for seed with a price of Rp 11,000/kg while the remainder is sold as consumption potatoes at Rp 5,500/kg. The crops are grown alternately on paddy fields (dry season) and dryland (wet season), with 5 ha grown in each season.

Table 8.5 shows the budget for this crop grown on paddy fields has an income of Rp 162 million/ha which is Rp 47 million higher than the income from Granola grown on paddy fields by the group using informal seed (Table 8.4 LHS). 40% of the difference in income is due to a higher yield of 29 t/ha reported for certified seed and 60% due to the higher price for the seed fraction. Proceeds from seed sales from the crop grown with certified seed were Rp 31 million/ha comprising 2,600 kg with a price of Rp 12,000/kg (Table 5). The sale of Granola seed from the Lendang Luar crops grown from informal seed described in the previous section, was Rp 12 million/ha comprising a yield of 2,350/kg and price of Rp 5,000/kg (Table 8.4).

The cost of certified seed amounted to Rp 20 million/ha which was 29% of variable costs. Seed is Rp 13,000/kg and seed rate is 1,500kg/ha. Fertiliser costs were 7% of variable costs, pesticides 9% and labour 39%. The gross margin was Rp 95 million/ha. Fixed costs were Rp 13 million/ha to give an enterprise profit of Rp 82 million/ha.

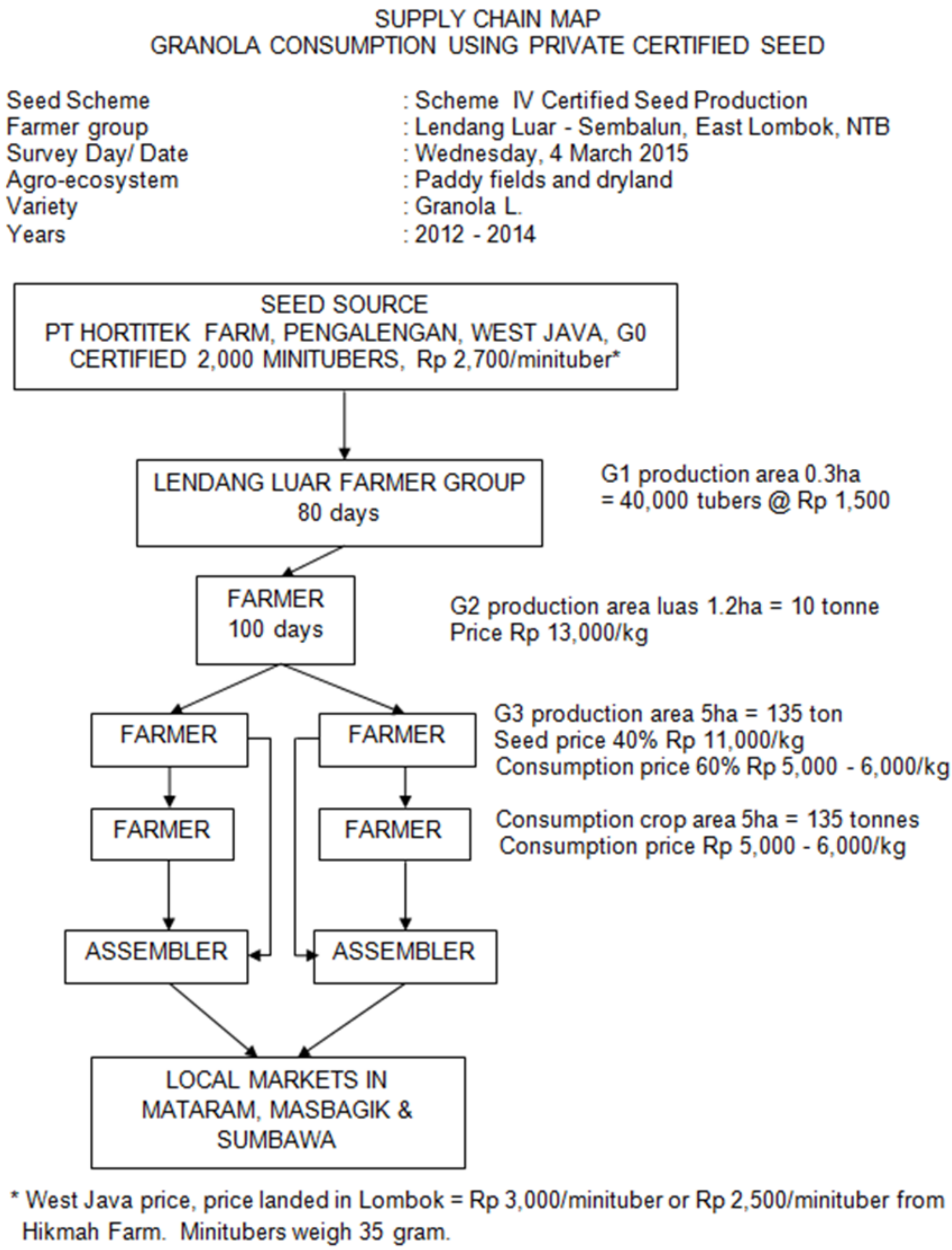

Figure 8.10. Granola seed and fresh market potatoes grown from certified seed by the Lendang Luar farmer group.

Seed scheme	: Private certified seed ->Konsumsi (sebagian disimpan untuk benih di lahan sawah)	Varietas	: Granola
Farmer group	: Lendang Luar	Location	: Bilapetung, Sembalun, Lombok Timur, NTB
Survey day/ Date		Elevation	: 1,100 m a.s.l.
Year of potato crop in question	: 2014	Informan	: Ruspaeani, mobile 0877 6303 1741
Agro-ecosystem		Enumerator	: Sudjudi

Suggested order of filling the table is shown in the first column.

Cross the appropriate cells starting in the current year, then work back and forward as needed:

			Don't know	2013												2014												2015											
				Bulan																																			
		Month:		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
1	Rain	Heavy		■	■	■										■	■	■										■	■	■									
2		Light					■	■											■																				
	Dryland			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
9	Previous crop harvest	What?																																					
10		When harvested?																																					
3	**Potato crop 1**	Main planting months		■	■											■	■																						
4	% annual production	Main harvest months				■	■											■	■																				
5		Late blight arrives		■	■											■	■																						
6	28-30 t/ha																																						
7		Pre-plant seed storage													green												green												
8		Post-harvest seed storage				pink	pink	pink										pink	pink	pink																			
11	Following crop	What?																																					
22	Other important information																																						
23	(pink) indicates yield stored for seed for planting in the paddy field crop and (green) is seed storage bought from private seed grower before planting. The total area of Sembalun Granola crops is around 30-40 ha for all farmer groups. These are planted partly on paddy land and partly on dryland. Granola yield from dryland is far lower than from paddy land while dryland costs are higher, this is because control of disease in the wet season (dryland cropping period) is very high, i.e. 2 hr every spray 25-30 times per season. Yield of dryland was 12 t/ha in 2013 and 15 t/ha in 2014. The price of Granola is higher, i.e. Rp 6,000/kg (2013) and Rp 7,500 - 8,000 (2014) than the price of Atlantic which was around Rp 3,800/kg. The price of Jala Ipam (Russet Burbank) was Rp 5,000/kg in Sembalun.																																						
	Paddy field crop			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
20	Previous crop harvest	What		■	■	■	■	■	■							■	■	■	■	■	■							■	■	■	■	■	■						
21		When harvested							■	■											■	■											■	■					
14	**Potato crop 2**	Main planting months							■	■											■	■											■	■					
15	% annual production	Main harvest months										■	■											■	■											■	■		
16		Late blight arrives							■	■											■	■											■	■					
17	20-30 t/ha (50% of production is from paddy fields in rotation with local rice-potato-fallow/cabbages) and 50% of this in available 10-20 ha of Granola that is produced independently by farmers themselves.																																						
18		Pre-plant seed storage							■	■											■	■																	
19		Post-harvest seed storage												blue	blue	blue																							
11	Following crop :	Cabbage planted											■																										
	Informasi lain yang penting			J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
23	Following crop cabbages harvested November																																						
24	(blue) indicates seed storage from harvest for the crop that will be planted on dryland. 30% of Sembalun's potato production is from paddy land with cropping pattern local rice-potato-fallow/cabbages with an average yield of 20-30 t/ha. 20% comes from paddy fields in a rotation with vegetables-potato-vegetables with yield of 16-20 t/ha & 20% comes from dryland with only one time of planting time, i.e. potato monoculture or potatoes together with corn, or other vegetables but in different plots (not companion cropping) with yield of 12-15 t/ha. The area of potato production for PT Indofood in 2014 was only 75 ha because the seed was not on time (too early arriving so that much of the seed was rotten and many farmers were brankrupt.																																						

Figure 8.11. Cropping pattern for Granola fresh market crops grown at Sembalun by the Lendang Luar farmer group using private certified seed

Table 8.5. Granola using private certified seed, Lendang Luar farmer group, paddy field production.

Item	Grade by %	Amount (kg/ha)	Price (Rp/kg)	Total (Rp/ha)	% costs
Income					
Variety and market	Granola				
Processing/table potatoes	90%	26,100	5,000	130,500,000	
Waste potatoes	1%	290		0	
Saved seed	9%	2,610	12,000	31,320,000	
Total or average		29,000	5,580	161,820,000	
Variable costs (VC)					
Seed		1,500	13,000	19,500,000	29
Fertiliser				4,420,000	7
Support inputs				0	0
Pesticides				6,240,000	9
Labour & contractors					
Tractor (cultivation)				6,500,000	
Crop management				11,385,000	
Harvest		29,000		7,250,000	
Post-harvest				870,000	
Total labour				26,005,000	39
Other				10,425,934	16
Total VC				66,590,934	100
Gross margin				95,229,066	
R/C (based on VC)				2.43	
BEP (Rp/kg, based on VC) (% of average price)				2,306	41
BEY (t/ha, based on VC)				11,986	
Fixed costs					
Depreciation				96,000	
Land rent				8,000,000	
Water costs				2,900,000	
other				195,000	
Land tax				100,000	
Development tax					
Store hire				2,000,000	
Total Costs				79,881,934	
Enterprise profit				81,938,066	

8.4 Discussion

8.4.1 Gross margin comparison

Important differences in some aspects of the supply chains are summarised in Figure 8.12.

Gross margins can be grouped into three categories: less than Rp 50 million/ha, between Rp 50 million/ha and Rp 70 million/ha, then greater than Rp 70 million/ha. In the first category are the Atlantic crisp processing crops grown for PT Indofood. The price paid to farmers is the lowest at Rp 4,000/kg. Another reason for the lower gross margin is the high costs of seed; 49% of variable costs. The potato processing industry throughout the world operates as a low margin but high volume crop which provides adequate income to efficient producers. The processors must be competitive in the market and want the chip stock at competitive prices. The price paid to farmers at Sembalun is similar to the base prices of AUD $380/tonne paid by crisp processors to Australian farmers.

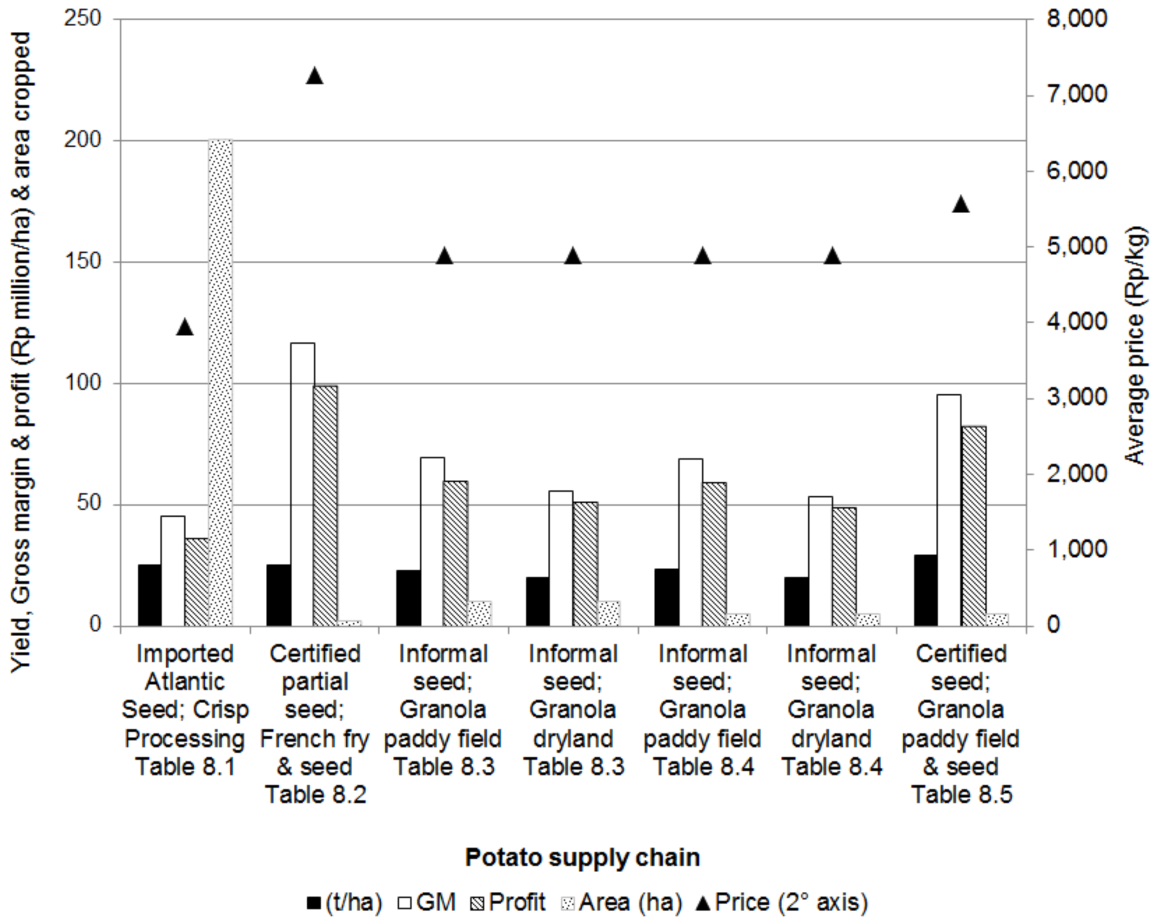

Figure 8.12. Summary of gross margins. Note that the yield, gross margin and enterprise profit are shown in the left hand axis while potato price is shown on the right hand axis.

In the second gross margin category are Granola crops grown for the local fresh market using informal seed. The price paid to the farmers is 24% higher compared with Atlantic and seed costs are lower, but still high, at 34% to 38% of variable costs.

The third gross margin category is for the French fry crops and the Granola fresh market crops grown from certified seed. The prices of both these crops which initially used certified seed (Fig. 8.12) were higher than for the other crops. This is mainly due to the seed grade being sold at higher prices than the seed from other supply chains. The French fry gross margin is high due to 29% of the yield being sold as informal seed at Rp

13,000/kg, the price the Atlantic farmers pay for imported seed. The Granola fresh market crops grown from certified seed also has a high gross margin due to the highest yield of 29 t/ha and 9% of seed sales at Rp 12,000/kg.

The other important feature of the supply chains clearly shown in Figure 8.12 is their respective scales. The Atlantic crisp processing supply chain is by far the largest with its 200 ha of production amounting to 84% of the total potato production area. All other potato supply chains amounted to 37 ha.

8.4.2 Seed cost by source

The cost of seed used by the farmers at Sembalun varies from Rp 13,500 for French fry Jala Ipam G2 and imported Atlantic seed to Rp 7,000/kg for informal Granola seed. Seed costs reported by farmers are shown in Table 8.6. Costs of early generation seed reported to the project team in December 2014 were: G2 seed from BBH Kledung Rp 16,500/kg, G2 West Java Rp 14,850/kg and Rp 17,000/kg (BPSPTPH).

Table 8.6. Cost of seed used at Sembalun in the 2014 cropping year.

Seed description	Price (Rp/kg)	Notes
Jala Ipam G2	13,500	Table 8.2.Screenhouse protection not used in G1 production stage so if this seed was certified it would be relegated to G3.
Imported Atlantic	13,500	Figure 8.2
	13,100	Table 8.1
	12,000	Figure 8.2
Granola certified	13,000	Table 8.5
	11,000	Figure 8.11
Granola informal	8,000	Table 8.3, Table 8.4
	7,000	Table 8.3

8.4.3 Increase profit by increasing seed production and sales

The key to increasing profitability of potato crops at Sembalun is to increase the seed component. The greatest impact to the community will occur if this can be achieved for the major supply chain, Atlantic crisp processing.

The Direktorat Kredit, BPR dan UMKM (2011) provides a financial analysis of returns from Atlantic crisp processing enterprises in West Java over a four year period where two crops are grown annually. Incorrect data input has meant the analysis is flawed due to the inclusion of income from two crops per year but only the variable costs of one crop a year[19]. Nevertheless their framework was sound and has been used to compare the financial of returns from the current Atlantic crisp processing crop at Sembalun with the likely financial returns if the enterprise is modified to produce a greater proportion of seed potatoes.

An analysis was run for a four year period where one crisp processing crop was grown annually based on budget information in Table 8.1 for Atlantic crisp processing crops at Sembalun. 85% of the yield is sold for processing at Rp 4,000/kg and 14% is sold as seed at Rp 8,000/kg. Additional costs included in this analysis are storage costs for seed at Rp 1,800/kg and interest and tax. The cool storage costs is based on costs reported for

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[19] *Their gross margin analysis for an individual crop was correct as quoted above in the section "***Atlantic crisp processing crops profitable in Sembalun"**

cool storage by CV Arjuna Flora in Batu, East Java (Ir Luki Budiarti personal communication, 27 February 2015) where capital cost of a 40 foot refrigerated container used as the cool store was Rp 65 million with monthly running costs maintaining 3°C of Rp 9 million. The potato storage costs used the assumptions of 16.4% annual interest rate, annual repayments over 10 years of Rp 13.6 million and storage period of 3.5 months. A credit scheme, as currently exists for the delayed payment of seed costs is assumed to operate which reduces interest costs. The result is shown in Table 8.7. This production system has a benefit cost ratio of 1.49, a net present value (NPV) of Rp 111 million/ha and an internal rate of return (IRR) of 693%.

When the analysis is re-run with the seed fraction increasing to 50% and the processing fraction reduced to 49% (Table 8.8) the benefit cost ratio increases from 1.49 to 1.55, the NPV increases from Rp 111 million/ha to Rp 159 million/ha and the IRR goes from 693% to 982%.

Assuming a cropped area of 150 ha the additional return to the Sembalun rural community would increase by a value of approximately Rp 5.5 billion (AUD $550,000). There is a strong demand for additional seed in Indonesia and additional benefits to supplying good quality affordable seed into these communities.

This shows that the Atlantic crisp processing growers at Sembalun have a large financial incentive to transform their operation into seed production. The technical aspects required to achieve this are discussed in the following chapter.

Table 8.7. Scenario 1. Atlantic crisp processing production financial analysis at Sembalun over four years annual cropping using imported seed with a credit seed to support seed costs.

Item	Rp/kg	Year			
		1	2	3	4
		(Rp millions/ha)			
Income 25 t/ha					
Process grade (85%)	4,000				
Seed grade (14%)	8,000				
Total income		113.8	113.8	113.8	113.8
Costs					
Seed		26.2	26.2	26.2	26.2
Fertiliser		5.2	5.2	5.2	5.2
Pesticides		5.4	5.4	5.4	5.4
Labour		16.8	16.8	16.8	16.8
Seed storage	1,800	6.3	6.3	6.3	6.3
Total direct costs		59.9	59.9	59.9	59.9
Gross margin		53.9	53.9	53.9	53.9
Fixed costs		9.0	9.0	9.0	8.0
EBIT		44.9	44.9	44.9	45.9
Interest (16.4% p.a.)		2.9	0.5	0.0	0.0
Tax		5.2	5.5	5.5	5.5
Net profit		36.8	38.9	39.4	40.4

NPV (Rp millions/ha)	111
IRR	693%
BCR	1.49
Credit scheme	yes
Partial seed	no
Sum of interest (Rp millions/ha)	3.4
Year 1 interest	86%
Year 2 interest	14%

Table 8.8. Scenario 2. Atlantic seed and crisp processing production financial analysis at Sembalun over four years annual cropping using imported seed with a credit seed to support seed costs.

Item	Rp/kg	Year			
		1	2	3	4
		(Rp millions/ha)			
Income 25 t/ha					
Process (49%)	4,000				
Seed (50%)	8,000				
Total income		149.8	149.8	149.8	149.8
Costs					
Seed		26.2	26.2	26.2	26.2
Fertiliser		5.2	5.2	5.2	5.2
Pesticides		5.4	5.4	5.4	5.4
Labour		16.8	16.8	16.8	16.8
Seed storage	1,800	22.5	22.5	22.5	22.5
Total direct costs		76.1	76.1	76.1	76.1
Gross margin		73.7	73.7	73.7	73.7
Fixed costs		9.0	9.0	9.0	8.0
EBIT		64.7	64.7	64.7	65.7
Interest (16.4% p.a.)		3.8	0.5	0.0	0.0
Tax		7.3	7.6	7.7	7.7
Net profit		53.6	56.6	57.0	58.0

NPV (Rp millions/ha)	159
IRR	982%
BCR	1.55
Credit scheme	yes
Partial seed	yes
Sum of interest (Rp millions/ha)	4.3
Year 1 interest	89%
Year 2 interest	11%

9 Seed Development Opportunity

9.1 Introduction

The current Indonesian seed potato system has some major problems which were discussed in Section 6.4.2. The management of early generation seed production enterprises observed by the project team indicates that the certified seed system in Indonesia will be difficult to implement according to the prescribed requirements of the scheme. Findings in this report reinforce the need for seed sources with better health (biosecurity) which are affordable for farmers to buy. Indonesian certified seed:

- does not provide protection against some important pests and diseases
- is expensive
- supplies insufficient quantities
    - seed growers have problems raising capital for cost of seed production
    - seed buyers have problems raising capital to buy seed
- benefits are not clear to many farmers who:
        - need information about long term benefits from seed through protection against exotic pests and diseases
        - need guidance on realistic outcomes improved seed will provide
        - need training in more efficient crop management techniques.

9.2 Proposed Solution

ACIAR project AGB/2005/167 (Dawson *et al.* 2011) identified a potential solution to the lack of Indonesian seed potatoes through augmenting the Indonesian government seed system with a partial seed scheme (PSS) based in the Sembalun Valley in Lombok, NTB.

PSSs 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 characteristics of potato production in the highland paddy fields at Sembalun provide improved protection against PCN (Dawson *et al.* 2011, pp. 80-81, Mulyadi *et al.* 2010). The annual flooding will also provide improved protection against bacterial wilt (Wang 2000, p 61) and bacterial ring rot (Cms) (van der Wolf *et al.* 2004, p. 161). The single multiplication of imported seed should reduce the cost of seed (Dawson *et al.* 2011, p 90) and provide similar quality compared with imported seed.

The scheme relies on imported PCN free seed but nevertheless this provides an opportunity for Indonesia to increase its supply of quality potato seed with improved protection from PCN, bacterial wilt and Cms. The benefits of importing two tonnes of seed, sufficient to plant one hectare, from Australia into a PSS are shown in Table 9.1. Under the current system this crop produces 85% chip stock and 14% seed which gives an income of Rp 113.8 million/ha. If this system was transformed to produce seed then the chip stock fraction would reduce to 49% and the seed fraction would increase to 50%. This would give an income of Rp 149.8 million/ha and provide 12.5 tonnes of PCN, bacterial wilt and Cms free seed potatoes. The seed sale price used was Rp 8,000/kg. The net profit for farmers of the current Atlantic supply chain system is Rp 36.8 million/ha while the net profit of the proposed PSS will be Rp 53.6 million/ha, an increase of 146%.

Table 9.1. Comparison of current crisp processing and proposed partial seed production. Data from Tables 8.6 and 8.7.

Item	Current			Proposed partial seed scheme		
		Rp/kg	(Rp million/ha)		Rp/kg	(Rp million/ha)
Income						
Total yield	25t/ha			25t/ha		
Process grade	85%	4,000		49%	4,000	
Seed grade	14%	8,000		50%	8,000	
Total income			113.8			149.8
Costs						
Seed	2t/ha		26.2	2t/ha		26.2
Fertiliser			5.2			5.2
Pesticides			5.4			5.4
Labour			16.8			16.8
Seed storage		1,800	6.3		1,800	22.5
Total direct costs			59.9			76.1
Gross margin			53.9			73.7
Fixed costs			9.0			8.0
EBIT			44.9			65.7
Interest (16.4%)			2.9			3.8
Tax			5.2			7.3
Net profit			36.8			53.6

The potential for seed production under this system at Sembalun is estimated to be 6,000 tonnes annually based on 15 t/ha of seed grade from 400 ha of highland paddy fields at Sembalun. This is equivalent to 90% of the high quality seed used in 2013 in Indonesia. This high quality seed was 6,686 tonnes, comprising 3,152 tonnes of Indonesia certified seed (Table 6.2) and 3,534 tonnes of imported seed (Table 6.10).

9.2.1 Why Partial Seed Scheme?

Partial seed schemes were devised to overcome problems of seed production in areas of high degeneration where three or four field generations are not possible without seed degradation (Struik & Wiersema 1999, p. 305). PSS 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 PSS are (Struik & Wiersema 1999, pp. 305-307):

- 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.

9.2.2 Does the Sembalun Valley and Australia have the resources to meet the requirements of a partial seed scheme?

It is appropriate to revisit the requirements of a PSS and the current situation in Sembalun to determine whether the suggestion of a PSS four years ago is still appropriate. The requirements for a PSS in the dot points above are discussed in turn.

Good farmers' organisations to multiply the seed

Farmers' groups at Sembalun have experience at coordinating various potato supply chains. The most important is Horsela which has the most experience in the production of chip stock for PT Indofood and the Lendang Luar Farmer group which produces Granola for the local market using various seed sources.

The Horsela group was considered to be run honestly with transparent management by Mr Asep Abdi, the former Head of the Agriculture Service of West Java, after he met with members of this group at Sembalun during his review of ACIAR Project AGB/2005/167 (Additional review Report 'A case for "HORSELA" Farmer Group in Sembalun Lawang, NTB. Asep Abdi 9 June 2010).

Appropriate imported seed class

To meet Indonesian seed scheme regulations, seed that is to be multiplied in the field must meet the G1 specifications shown in Table 6.6. These specifications are determined during a visual inspection of the growing crop as well as an inspection of the harvested tubers. These tolerances are repeated in Table 9.2 below together with tolerances for crops meeting Rating 1 standards in the Western Australian (WA) Certified Seed Scheme. The WA seed meets or exceeds the field inspection requirements. However, the WA seed allows higher levels of some tuber disorders, such as the scab and scurf disease.

Table 9.2. Minimum Technical Requirements Seed Potatoes Indonesia G1

Parameter	Indonesian G1	WA Rating 1‡
	% of plants affected	
Crop inspection		
Other mixed varieties	0.0	0.0
Disease (Maximum % of plants attacked by number)		
Virus (PLRV, PVX)	0.0	0.01
Virus (PVY)	0.0	0.0
Bacterial wilt (*Ralstonia solanacearum*)	0.1	knto†
PCN (Globodera sp.)	0*	knto†
Bacterial ring rot (*Cornybacterium* michiganensis subsp. *sepedonicus)*		knto†
Tuber health (Maximum % of tubers affected by number)		
Brown rot	0.0	knto†
Soft rot	0.0	0.25
Common scab, black scurf, powdery scab	0.5	2.0
Late blight (mild infection)	0.5	knto†
Dry rot	0.1	2.0
Damage by tuber borers (*Phthorimaea operculella*)	0.5	1.5
Root knot nematode (mild infection)	0.5	
Varietal mixture	0.0	0
Mechanical damage	0.5	2.0

†knto = known not to occur

‡ Department of Agriculture and Food, Western Australia (2015, pp. 10-11). Rating is independent of generation as it is an assessment of crop health. Generations in the WA certified seed scheme are G1 to G5.

Indonesian currently only permits the import of Australian seed potatoes from South Australia and WA (Department of Agriculture and Water Resources 2014). The requirements that must be met are:

- Seed potato produced by seed potato growers who are registered in Western Australia under a Seed Potato Certification scheme are permitted to be exported to Indonesia.
- All seed potatoes must meet a rating of 1, 2 or 3 according to the Western Australian Seed Potato Scheme Production Rules.
    - Endorsement #1265 applies which pertains to
        - WA freedom from potato rot nematode (*Ditylenchus destructor*), golden cyst nematode (*Globodera pallida*), potato cyst nematode (*G. rostochiensis),* bacterial ring rot of potato (*Clavibacter michiganesis* subsp *sepedonicum*), and New Zealand black wart (*Synchytrium endobioticum*) and skin spot (*Polyscytalum pustulens*),
    - and WA ability to produce seed from areas where powdery scab (*Spongospora subterranea*), blackleg (*Erwinia carotovora* spp *atroseptica*) and tomato spotted wilt virus are known not to occur.

The Indonesian acceptance of seed potatoes from WA is recognition of the disease and pest freedom of WA. These ideal seed potato production conditions have also been recognised by the International Potato Centre (CIP) who stated that “There is no other potato growing area in the world, known to CIP, where such [ideal seed potato production] conditions are found.” (Department of Agriculture and Food, Western Australia 2014, p. 3).

Potential for Australian partners to export appropriate seed

From 2011 to 2013 WA exported 78% to 96% of Australian seed potatoes and Indonesian was one of the main markets (Department of Agriculture and Food, Western Australia, 2014, p. 12). Meetings were held with two major seed potato producers and exporters in WA (Appendix 2, May 2015) who indicated support for the development of a PSS to Indonesia. In WA the larger potato industry also support development of seed potatoes to Indonesia. The Potato Growers Association is actively seeking ways to accelerate development of seed potato exports to Indonesia through WA government funding sources (Ross Taylor, Executive Officer PGA, personal communication, 24 November 2015). In 2014 the Potato Marketing Corporation of Western Australia commissioned an assessment of the opportunity to export WA seed and ware potatoes to Indonesia. This assessment endorsed the strategy to develop Atlantic and Granola seed exports, recognising that a relaxation of Indonesian import regulations would be required (Australian Venture Consultants, 2014, pp. 6-7). Also DAFWA is seeking to support intensive studies into optimising the physiological age of seed potato export varieties through potential Royalties for Regions WA Government funding.

Export of Trial Quantity of Granola Seed to Indonesia

Initially it was planned to export 1 tonne of Granola seed from WA to Indonesia to enable work on the planned follow-up project to begin sooner. Seed for experimentation can be imported with an experimental import permit. However, during this project, as Indonesian seed regulations changed, it was realised that additional permits, or exemptions to regulations, would have to be obtained before the seed was exported to avoid the risk of the seed being rejected by authorities along the supply chain.

The additional permits required are:

- A permit for G4 WA certified seed to be accepted as equivalent to Indonesian G1 Stock Seed (Benih Pokok) to allow it to be multiplied within the Indonesian seed scheme to become the equivalent of Indonesian G2 Extension Seed (Benih Sebar).

- A permit for this equivalent of G2 Extension Seed produced in the PSS to enter East Java for testing. This permit is required from the Plant Quarantine authorities of East Java province.

Owing to these changes it was thought prudent to delay the seed shipment until the new project had been finalised and all permits obtained. PT Indofood indicate that the recent reduction of generations in the new seed scheme whereby Extension Seed is now G2 has not affected their importation of G4 seed for Atlantic crisp processing crops (Budi Dharmadi, personal communication, 15 June 2015). This shows that the Indonesian authorities are willing to be flexible to industry needs and shows that obtaining the permits may be achievable with sufficient time and goodwill.

Physiological age of the imported to suit planting time

Seed and Atlantic chip stock crops have quite different requirements for seed physiological age.

Young physiological age is usually appropriate for commercial crops where large tubers are required. Young seed produces fewer sprouts due to the apical dominance of the main shoot; less shoots per plant results in fewer but larger tubers and the crop tends to mature later (Table 9.3).

Physiologically old seed increases the seed fraction of a crop as it produces greater numbers of small tubers. Old seed has branches on its shoots so it produces the most stems, sets the most tubers and matures earliest. If physiologically older seed is used for seed production at Sembalun it may overcome the problems observed by PT Indofood (Section 8.3.1). The physiologically older seed will mature more rapidly and if it is used for the first plantings then the seed should be able to be harvested dry. This should reduce losses due to rots. Physiologically old seed will also overcome the low seed fraction of 14% mentioned by farmers.

For seed of the right physiological age to be sourced for seed production at Sembalun there must be improved communication along the supply chain. Negotiations about the physiological age requirements of seed for Sembalun should also include information about the specifications of seed size and delivery time to overcome previous shortcomings. The importance of seed physiological age in manipulating the proportion of seed grade has long been known but only recently has measurement methodology been determined to allow seed buyers to specify their seed age requirements according to day-degree exposure before planting (Blauer *et al.,* 2013).

Some experimentation in WA and Sembalun will be required to determine the correct seed treatments to optimise seed fraction yield at Sembalun.

Suggested physiological age experiments for Australian seed potato crops

Tubers of the cultivars Granola and Atlantic should be obtained from certified seed growers in WA within days of harvest in March. Tubers of >115g size will be used to enable the standard commercial practice of using cut seed.

Tubers of both cultivars will be subjected to 12 heat treatments over the storage period to manipulate the physiological age, similar to treatment used by Knowles and Knowles (2006). All seed tubers will receive the initial 80 degree-days at 12°C for 10 days as part of the wound healing curing process. This treatment will also act as the control for the experiment. Tubers will then be placed at 12, 22 and 32°C for the appropriate number of days until the desired degree days of 450, 900, 1250 and 1500 is reached. The tubers will then be returned to 4°C cool room until the 200 days of storage is completed.

The experiments should be planted in December and grown according to standard seed production practices and adhering to WA potato certified seed potato scheme rules. The experiment will be sprayed off with a desiccant herbicide (diquat) after tubers in the control plots reach export seed size. Harvest will be 10-20 days later in approximately March.

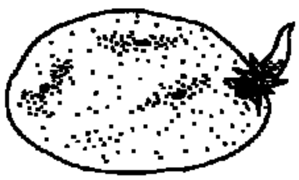
Treatment plots will be assessed for emergence and stem number, prior to row closure, during the crop. Post-harvest, tubers will be sorted by size range to determine which treatment provided the optimal number of tubers at the 50mm or 25-35 gram tuber range which is the preferred seed size of Indonesian farmers.

Suggested physiological age experiments for Indonesian seed potato crops

Tubers from the WA trial in the 50mm range will be cured at 12°C for 10 days and subjected to heat treatments of 80, 500 and 1 000 day degrees. Treated tubers should then be shipped to Indonesia in May, using refrigerated containers. Temperature and humidity probes will be place in the seed lots to determine whether temperature and humidity fluctuate during shipment and changes to degree day calculations are needed. Using FIL training, farmer groups in Lombok will be given the opportunity to plant the aged seed on community fields. A training manual will be developed and given to each farmer groups to provide for observations and training whilst the crop is growing. Harvest results will be recorded to determine the optimum physiological aged seed required for optimal seed yield in Indonesia.

This trial will be conducted over two consecutive years so will provide for data from two field trials in WA and two crops grown in Indonesia.

Table 9.3. Stages of physiological age of seed potatoes. Young seed is better for chip stock production while old seed is better for seed production. (After Johnson 1997).

Physiological age	Seed performance
Young 	• Young seed is characterised by sprouts from apical end of tuber (apical dominance) • Fewer stems per plant • Fewer tubers but larger in size • Crop matures later
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 • Crop maturity is average
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 • Crop matures earlier

Field multiplications need a quality control system,

BPSP NTB has trained inspectors who have certified some seed produced at Sembalun. In addition farmers at Sembalun have attended national training workshops in seed potato production held by the Directorate of Horticulture Seed.

The official certification of the crop is important to ensure that the seed meets all requirements of the Indonesian seed scheme. The scheme is being proposed due to the benefit of PCN and bacterial wilt freedom of the seed. It is important the seed can meet all other requirements of the seed scheme. To achieve G2 Extension Seed (Benih Sebar) Status BPSB would have to accept the imported seed standard was equivalent to G1 Stock Seed (Benih Pokok).

One field generation only until seed farmers have gained experience

A one generation only partial scheme is proposed. More generations would only be considered once degeneration rate experiments had been done, the results of seed inspections of seed produced considered and suitable storage infrastructure developed.

Monitoring of customers' (ware farmers') response to seed produced,

The performance of crops grown with seed produced at Sembalun must be compared against other seed sources to determine whether the seed performance provides value to customers. The potato grower alliance Gapoktan Mitra Arjuna produces high yielding crops at Batu in East Java grown from various seed sources at various times of year. This group would be appropriate to assess the performance of the seed produced at Sembalun. Assessment of the seed sources should include aspects of crop performance such as percentage of plant emergence, speed of emergence, seed-borne disease levels, marketable yield, cost of production, returns to growers and biosecurity risk.

Modification to the system after suggestions from seed farmers and seed buyers.

A system of improved supply chain communication is required for good communication between seed supplier and seed buyers to be achieved. This is especially important because the Extension Seed produced by the proposed PSS involves two seed suppliers, WA and NTB as well as two seed buyers; NTB and Gapoktan Mitra Arjuna. Any seed development project must include provision to provide an appropriate level of communication which should include site visits by members of the supply chain.

Other requirements identified in this report are:

The following requirements are those identified by this SRA in addition to the requirements suggested by Struik and Wiersema (1999).

Capital for seed growers to buy seed

The affordability of seed was discussed as a reason why farmer seed demand may fall below the seed demand determined by crop area and planting rate (Chapter 7). The lack of finance for seed growers was a reason that the cluster seed scheme based on aeroponic minituber production in South Sulawesi had not succeeded (Rukmana et al., 2013) (see Section 6.3.3).

Currently seed costs of the Horsela farmer group are supported through the credit scheme provided by the partnership with PT Indofood. It is reasonable to expect that PT Indofood would support Atlantic seed production at Sembalun because it is in PT Indofood's interest to obtain a less expensive supply of seed for their growers. Cheaper Atlantic seed will remove the high cost of seed disincentive for potential crisp processing farmers. PT Indofood has already tested partial seed from Sembalun and will be willing to support further work to provide cheaper seed which does not have the rot problem experienced in their earlier test.

PCN biosecurity

The many potato production systems now used at Sembalun described in Chapter 8 means there are increased challenges for the production of quality seed there. Uncertified, or informal seed from Java is being used at Sembalun to produce Granola crops for the local fresh market (Figures 8.6, 8.8). The regulations to prevent the entry of seed which poses a threat to the PCN free status of Sembalun are not being effectively enforced (Section 8.3.3). Some of the crops grown from informal seed are on dryland sites which won't be protected from PCN through annual inundation. Potato crops are also grown on areas of the paddy land in the dry season without a rice rotation (Figure 8.11, row 24). This means that PCN could be introduced to the paddy areas which are not flooded as they grow other vegetables during the wet season.

Seed from Java, whether certified or informal, has the potential to introduce PCN to Sembalun. This is because even certified seed doesn't provide protection against PCN due to inadequate rotation provisions combined with a PCN test that fails to detect the pest until five seed crops have been grown on an infested site.

The best way to prevent farmers using seed from outside Sembalun is for Sembalun to become self-sufficient in seed. Farmers estimate 500 tonne of seed is needed annually. Therefore Granola seed production should be included in the PSS to ensure local Granola PCN free seed is available. The Granola seed should not be sourced from certified seed as undertaken by the Lendang Luar farmer group because their seed multiplication alternates between paddy field (safe from PCN) and dryland (not safe from PCN) and so poses a threat of PCN build should the pest be introduced to Sembalun.

Regulations and policy

The proposed PSS relies on acceptance of the seed produced by the Indonesian authorities. If the imported seed is accepted as being suitable for field multiplication to produce Extension Seed (Benih Sebar), then subsequent movement to other provinces will meet Indonesian inter-provincial seed movement requirements. However, if the seed is not accepted within the scheme, then approval for inter-provincial movement of seed must be negotiated. This may require testing of the seed produced from the PSS to show it meets specifications.

Import permits will be required for the Atlantic and Granola to be produced within the scheme. Initially, research permits should be suitable for initial seed tests. Due to the two generation testing cycle proposed for the PSS a commercial permit may be required before tests of the performance of the first crop of Extension seed from the partial scheme has been completed. This will require changes to the current practice where import permits for Granola seed potatoes are not issued. We feel the change to policy is warranted as there is a need to protect Sembalun from exotic disease. The most effective way to do this is for Sembalun to produce its own Granola seed requirements through a PSS. The project team of Terry Hill and Julie Warren discussed these issues with the Indonesian government stakeholders from 18 – 19 August 2014. Dr. Ir. Muhammad Prama Yufdy, M.Sc, ICHORD Director, Dr Yusdar Hilman, ICHORD Principal Researcher, Dr Liferdi, Head IVEGRI were supportive of the project. Head of Horticulture Seed, Mrs Sri Wijayanti Yusuf also gave verbal agreement for the testing of PSS at Sembalun to go ahead. Mr Budi Dharmadi of PT Indofood, also gave support for the project.

In the longer term the policy that all commercial seed of a registered variety must be produced in Indonesia after two years (see Section 5.1.3) will need to be modified to allow the importation of the PCN, bacterial wilt and Cms free source seed.

Improved crop management through farmer training

There is a need to improve productivity of Indonesian potatoes through elucidation of best practises for each area. An appropriate method is through FIL (Section 4.1.6). Unless yield can be increased, demand for seed may not increase as farmers will not see immediate benefits from its use.

Increasing farmer seed demand through yield & profit

The initial supplies of seed from the PSS will be small and would be used for crisps processing crops in other provinces as well as providing local seed. However there is a need to increase farmer demand for seed in the long term. Farmer demand for seed can be increased through:

- greater farmer awareness of the importance of using seed with high plant health for its biosecurity benefits
- providing seed buyers with agronomic support to assist them increase yields and profits.

Project AGB/2005/167 recommended a program of participatory FIL must be developed along with the PSS to provide this agronomic support. FIL is a development of Farmer Field Schools which is focused on simple but effective farmer experiments to effectively test changes in crop management so farmers can become experts in potato production in their area.

Seed Storage

If Sembalun is to become self-sufficient in seed the seed production program needs to be planned to provide the seed without cool storage. The main planting times are June, July, November and February. Seed stored under ambient conditions from July planting which is harvested in October should be suitable for February planting. The February plantings could, in turn, supply seed for the November plantings. However the February planted crops are on dryland sites which are not protected from PCN by flooding. A rotation of sufficient length will be needed to provide protection against the possibility of PCN build up, for example four years.

A better solution would be the establishment of cool stores at Sembalun to enable improved and more flexible seed potato storage. The costs and benefits of this technology were presented in Section 8.4.3 and have been included in the comparison of the current seed scheme with the proposed PSS in Table 9.1.

9.2.3 Benefits to poor farmers in development of a partial seed system at Sembalun

The potato crop has a role in alleviating poverty through the opportunity of hired labour, a useful source of income to the poorer households who cannot produce vegetables themselves. 195 days labour (including 17 days of women’s labour) was reported for Sembalun by Dawson *et al.* (2013, Appendix 2, Annex 2, p. 47). If the potato crop employs 200 days/ha/crop of hired (non-family) rural labour then for 10,000 ha grown in East Java a million labour days is provided by the potato industry. Also Fuglie (2007) states that ‘While the high input cost associated with growing potato is often expressed as a constraint facing poor farm households, in fact potato is widely grown by very poor households throughout the developing world, if only on a very small scale.” Improvement in productivity of the potato industry should have a direct impact on poor farmers’ and labourers’ incomes.

10 Conclusions and recommendations

10.1 Conclusions

10.1.1 Status of Indonesian potato industry

The Indonesian potato industry appears to have stalled. The industry has lost exports, is facing increasing imports and the crop is becoming less financially rewarding to growers compared with other alternatives. The hired labour opportunity for the rural poor will not grow unless interventions improve the competitiveness of the industry and turn around its performance.

10.1.2 Indonesian seed potato scheme

Meeting seed requirement

The Indonesian certified seed potato scheme does not produce sufficient quantities of seed potatoes to fulfil Indonesia's seed requirement. In 2013 certified seed used in Indonesia amounted to 6,686 tonnes, comprising 3,152 tonnes of Indonesian seed and 3,534 tonnes of imported seed. Indonesian 2012 potato seed demand calculated from the area of potato production multiplied by the seed rate was 97,827 tonnes based on potato production area of 65,218ha with a 1.5 t/ha seed rate.

Soil-borne disease protection

The seed that is produced does not provide protection against some serious soil-borne pests and diseases. Indonesian certified seed will spread PCN, bacterial wilt and bacterial ring rot (Cms) to uninfested areas.

Seed cost

The seed produced is expensive. At Sembalun the cost of certified seed was similar to the cost of imported seed, around Rp 13,000/kg while informal seed was Rp 7,000/kg to Rp 8,000/kg.

Aeroponic seed production

Recent changes have reduced the number of seed scheme generations from five to three. To maintain and increase the supply of seed with reduced generations, aeroponic production is being relied upon to increase the supply of minituber G0 Basic Seed. Farmer production of Basic Seed is also being encouraged to further increase supply. Observations of aeroponic seed production show the following problems:

- damaged screenhouses do not provide effective protection against insects
- aeroponic minituber production systems had:
    - widespread problems with bacterial wilt contamination
    - problems of power supply failure and unsuitable water temperature
- hygiene measures were not adequate:
    - soil sterilisation was not adequate
    - isolation requirements were not met
    - footbaths were not being used.

The longest established aeroponic seed production system, the cluster system in Sulawesi, has not been able to supply seed demand for this minor production area.

10.1.3 Value of quality seed

The use of certified seed is often assumed to provide increases in yield and profit. We failed to find convincing evidence that improved seed quality leads to increased crop profitability in Indonesia. This is probably due to other constraints preventing the potential of the seed being realised.

This situation is not limited to Indonesia and occurs in Australia and the USA where surveys of seed users also did not provide convincing evidence of increased yield and profits associated with certified seed use.

An indisputable and vital quality of seed is the improved protection it provides against new pest and disease incursions. If farmers do not experience increased profits when using certified seed they will choose cheaper alternatives which are perceived to provide better short term return, and thus weaken their farm biosecurity.

10.1.4 Increased profit for Sembalun farmers

The key to increasing profitability of potato crops at Sembalun is to increase the seed component. The greatest impact to the community will occur if this can be achieved for the major supply chain, i.e. Atlantic crisp processing for PT Indofood.

10.1.5 Farmer Initiated Learning to improve yield and profit

Farmer Field School (FFS) methodology, which compares an integrated crop management plot with a conventional plot, concurrently tests many, disparate management techniques which makes interpretation of the results difficult. The modified FFS method, Farmer Initiated Learning (FIL), allows easier and more rigorous interpretation of the results. FIL provides both a method of training farmers in new techniques as well as enabling farmer groups to find the best solutions for constraints for their specific location.

10.1.6 Increased income for poor farmers

The potato crop has a role in alleviating poverty through the opportunity of hired labour, a useful source of income to the poorer households who cannot produce vegetables themselves. 195 days labour (including 17 days of women's labour) was reported for Sembalun. If the potato crop employs 200 days/ha/crop of hired (non-family) rural labour then for 10,000 ha grown in East Java, 2 million labour days is provided by the potato industry. Also Fuglie (2007) states that 'While the high input cost associated with growing potato is often expressed as a constraint facing poor farm households, in fact potato is widely grown by very poor households throughout the developing world, if only on a very small scale." Improvement in productivity of the potato industry should have a direct impact on poor farmers' and labourers' incomes.

10.2 Recommendations

10.2.1 Partial seed scheme

There is an opportunity for a PSS based at Sembalun highland paddy soils to provide certified potato seed free from PCN, bacterial wilt and bacterial ring rot (Cms) at reduced prices compared with imported seed. The freedom from these pests and diseases will provide seed of better quality than Indonesian certified seed.

Two tonnes of PCN, bacterial wilt and Cms free seed from WA will plant one hectare of potatoes at Sembalun. Under the current system this crop produces 85% chip stock and 14% seed which gives an income of Rp 113.8 million/ha. If this system was transformed to produce seed then the chip stock fraction would reduce to 49% and the seed fraction would increase to 50%. This would give an income of Rp 149.8 million/ha and provide 12.5 tonnes of PCN free seed potatoes. Granola seed must also be produced under this scheme to enable Sembalun to become self-sufficient in seed to stop the current threat of exotic disease through use of seed potato from Java.

Potential seed from a PSS at Sembalun is estimated to be 6,000 tonnes p.a. based on 15 t/ha of seed grade from 400 ha of highland paddy fields. This is equivalent to 90% of the high quality seed used in 2013 in Indonesia. This high quality seed was 6,686 tonnes, comprising 3,152 tonnes of Indonesia certified seed and 3,534 tonnes of imported seed.

A draft Phase 1 proposal for the commercial development of a PSS has been submitted to ACIAR. A summary of activities required for the development of the PSS are given below:

- Seed policy and regulations changes:
    - Import permit for Atlantic and Granola seed potatoes
    - Approval for WA G4 Rating 1 seed (shown to be of similar specifications to Indonesian G1 in Table 9.2) to be multiplied once under the auspices of the Indonesian seed scheme in NTB for use as Extension Seed in East Java.
    - Permit obtained for this Extension Seed to enter East Java.
    - Approval for source seed to be classified as non-commercial seed so that it can be imported in the longer term and not subject to the requirement for all commercial seed to be produced in Indonesia (see Section 5.1.3).
- PCN, bacterial wilt and Cms free seed source:
    - WA Atlantic seed is appropriate as WA is free from these pests and diseases and seed growers and the wider industry is supportive.
    - Permit to import experimental seed of WA Atlantic and Granola obtained from Indonesian authorities.
    - Appropriate physiological age of seed exported from WA that will produce short maturing crops at Sembalun that have a high yield of seed grade tubers must be determined.
- Best management practices for multiplying seed at Sembalun developed, including:
    - Determining appropriate physiological age of seed produced at Sembalun that have a high yield of seed grade tubers and good performance when replanted.
    - Investigating the degeneration rate of seed produced at Sembalun in order to plan the most efficient seed multiplication program.
    - FIL program developed to prove effective integrated crop management practices
    - Determination of the cost/benefit of cool storage for seed produced at Sembalun.
    - Seed production training for NTB crisp processing growers to become expert seed potato growers. BPSBTPH West Java and NTB must be recruited to assist this training.
- Improving seed storage facilities.
- A FIL program to elucidate effective management of seed buyers' crops is needed to ensure the seed performs to its potential.
- Seed produced by the PSS must be compared against other seed sources in high yielding potato production districts. Batu in East Java is suggested. The comparison must include:
    - financial analysis of all seed sources
    - pest and disease risk analysis of all seed sources
    - workshopping of results with stakeholders.
    - evaluation of seed comparison and recommendation of value of PSS.
- Second year of testing PSS on larger scale.
- Finance sources for second round of imported seed for testing PSS must be found. This will include Granola seed as well as Atlantic.

- Business plan developed for continuation of PSS after project ends
- A successful demonstration of improved seed quality and reduced seed cost should enable the PSS to be adopted as an official Indonesia seed supply chain. This will enable the production of both Granola and Atlantic seed by this seed supply chain.

10.2.2 Improved biosecurity protection in existing Indonesia certified seed scheme

The Indonesian seed potato scheme will spread PCN, bacterial wilt and bacterial ring rot (Cms) to uninfested areas. Seed scheme stakeholders need to review these threats and introduce improved protection within the IGCS. A longer rotation period is required to improve protection against these threats.

10.2.3 Farmers' awareness of biosecurity benefit of seed

Farmers need to be made aware that the benefits of seed include protecting their land from the introduction of pests and diseases; benefits that only show tangible benefits in the longer term. The comparative biosecurity benefits of the various seed sources available to Indonesia farmers must become common knowledge.

10.2.4 Improved competitiveness through farmer training

Indonesia

There is a need to improve productivity of Indonesian potatoes through elucidation of best practises for specific locations. This will provide the best chance for farmers to experience short term yield increase from the use of superior seed through overcoming the effect of other production constraints. This should be done using the FIL investigation method to allow the impact of single management changes to be investigated in a standardised way. FIL provides both a method of training farmers in new techniques as well as enabling farmer groups to find the best solutions for constraints for their specific location.

Australia

Australian farmers need to be presented with results of their seed performance in Indonesia so that they can adequately prepare their export crops to arrive in Indonesia with the right physiological age for the appropriate planting times.

Physiological age experiments need to be undertaken in Australia to provide the information needed to so that farmers can achieve this.

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12 Appendixes

12.1 Appendix 1: Questionnaires

Potato Seed Users Questionnaire

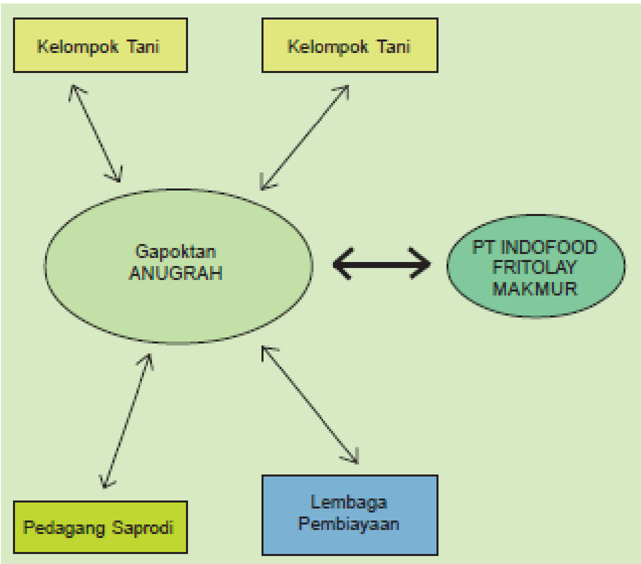
Interviewee details:	
Full name:	Phone no:
Short name:	Mobile:
Title:	Email:
Position:	Facebook name:
Company:	Business address:
Business card:	

To plan a seed scheme one needs to know:

What is the amount of potato seed needed for this location?

Month	Amount (A) (units)	Actual amount (B) (use same units)	If B is less than A why?
Your farm:			
All farms in the area:			
Is this amount increasing or decreasing?			
What are your expectations about the performance of seed? Yield? Cost? Protection from pests and disease? Inspection and quality assurance?			

If you can't get the seed you want what will you use instead?
What are the risks of using this second choice of seed?
Which are the best months for planting?
What varieties do you want to plant? Why
How much of your seed came from? (percentage or total kg) 1 Grower 2 Agent/Market 3 Carrier 4 Storage (your own seed)
If your seed came from 1. Grower, do you know where this seed came from?
Communication between players?
Please draw a map of supply chain – see example



Budget template, sheet 1 summary

	A	B	C	D	E	F	G	H	I	J	K
1	Isikan sel-sel berwarna kuning.										
2	**Skema Sistem Perbenihan**										
3	**Kelomok Tani**										
4	**Hari/ Tanggal Survey**										
5	**Agroekosistem**										
6	**Varietas**										
7	**Data Analisa Ekonomi Tanaman Tahun**										
8	**Enumerator**										
9	**Budget description:** ACIAR SRA										
10	**Table 1. Anggaran singkat - rincian-rincian bisa dimasuki di Tabel 2 di worksheet bernama "Budget details"**										
11	**Planting date:**		**Harvest date:**				**IDR/AUD exchange rate and date:**			10,672	2014
12		**Bahasa Indonesia**						**English**			
13	**Kentang industri per hectare**						**Crisp processing potatoes per hectare**				
14		Bahasa Indonesia						English			
15	Uraian	Jumlah	Satuan	Harga	Usahatani	%	Item	Amount	Units	Unit	Crisp
16				satuan	kentang industri					cost	potato farming
17				(Rp)	Nilai (Rp/ha)					($AUD)	value ($AUD/ha)
18		**MARJIN BRUTO**						**GROSS MARGIN**			
19	**Penghasilan**		kg/ha				**Revenue**	0.0	t/ha	0	
20	Kelas kentang yang dijual	-			0		Class of potatoes sold	0.0	0%	0	0
21	Kelas kentang yang dijual	-			0		Class of potatoes sold	0.0	0%	0	0
22	Kelas kentang yang dijual	-	100.0%		0		Class of potatoes sold	0.0	100%	0	0
23	Nilai rata-rata	#DIV/0!	Rp/kg				Average price	#DIV/0!	$/t		
24	**Penerimaan**				**0**		**Total Income**				**0**
25	**Biaya variabel (BV)** (Rincian di Tabel 2)						**Variable costs** (Details in Table 2)				
26	**Benih** (G2 bersertifikat)		kg		**0**	0%	**Seed** (G2 certified)	0.0	tonne	0	**0**
27	**Pupuk**				**0**	0%	**Fertiliser**				**0**
28	**Bahan penunjang**				**0**	0%	**Supporting materials**				**0**
29	**Pestisida**						**Pesticides**				
30	Nematisida				1	100%	Insecticide				0
31	Fungisida				0	0%	Fungicide				0
32	Insektisida				0	0%	Nematicide				0
33	Herbisida				0	0%	Herbicide				0
34	Perata & perekat				0	0%	Surfactant				0
35	Other				0	0%	Other				0
36	**Jumlah Pestisida**				**1**	100%	**Total Pesticides**				**0**
37	**Tenaga kerja**						**Labour**				
38	Pengolahan tanah dengan mesin				0	0%	Land tillage				0
39	Tenaga kerja untuk beragam perkerjaan				0	0%	Labour for various tasks				0
40	Tenaga kerja panen				0	0%	Labour for harvest				0
41	Tenaga kerja pasca panen				0	0%	Post-harvest labour				0
42	**Jumlah Tenaga kerja**				**0**	0%	**Total labour**				**0**

43	**Biaya variabel lain-lain**						**Other costs**				
44	Grading				0	0%		-		0.00	0
45	Pengeringan dan sortasi				0	0%		-		0.00	0
46	Label Kemasan (isi 25 kg)				0	0%		-		0.00	0
47	BV lain 4				0	0%					0
48	BV lain 5				0	0%					0
49	**Jumlah lain-lain**				**0**	0%	**Total other**				**0**
50	**Jumlah BV**				**1**	100%	**Total variable costs**				**0**
51	**Hasil marjin bruto**				**-1**		**Gross margin result**				**0**
52	**BIAYA USAHATANI LENGKAP**						**TOTAL ENTERPRISE COSTS**				
53	**Penyusutan**						**Depreciation**				
54	Penyusutan alat				0		Machinery & tool depreciation				0
55	Penyusutan lain				0		Other depreciation				0
56	**Jumlah Penyusutan**				**0**		**Total depreciation Penyusutan**				**0**
57	**Biaya tetap (BT)/Overheads**						**Fixed costs/Overheads**				
58	Name 1	0	0	0	0		Name 1	0	0	0.00	0
59	Name 2	0	0	0	0		Name 2	0	0	0.00	0
60	Name 3	0	0	0	0		Name 3	0	0	0.00	0
61	Name 4	1	0	0	0		Name 4	1	0	0.00	0
62	Name 5	0	0	0	0		Name 5	0	0	0.00	0
63	Name 6	0	0	0	0		Name 6	0	0	0.00	0
64	Name 7	0	0	0	0		Name 7	0	0	0.00	0
65	**Jumlah BT**				**0**		**Total fixed cost**				**0**
66	**Jumlah Penyusutan + BT**				**0**		**Total depreciation & fixed costs**				**0**
67	**SURPLUS OPERASI (= LSBP, laba sebelum bunga dan pajak)**				**-1**		**OPERATING SURPLUS (= EBIT, earnings before interest and tax) (c**				**0**
68	**Bunga**				**0**		**Interest**				**0**
69	**Pajak**				**0**		**Tax**				**0**
70	**Mengeluarkan Pribadi**				**0**		**Personal Drawings**				**0**
71	**Jumlah Bunga, Pajak & Mengeluarkan**				**0**		**Total interset, tax & drawings**				**0**
72	**BIAYA TOTAL**				**1**		**TOTAL COSTS**				**0**
73	**KEUNTUNGAN USAHATANI**				**-1**		**ENTERPRISE PROFITABILITY**				**0**
74	R/C (income/variable costs)	0.00					Returns to cost	0.00			
75	B/C (gross margin/variable costs)	-1.00					Benefit to cost	-1.00			
76	BEP (based on variable costs)	**0**	Rp/kg				Break even price	**0**	$/t		
77	BEY (based on variable costs)	**0**	kg/ha				Break even yield	**0.0**	t/ha		
78	**BEP (break even price) calculations**						**BEY (break even yield) calculations**				
79	Solve the equation "average price x yield - variable costs = 0" by changing av price						Solve the equation "av price x yield - variable costs = 0" by changing average yield				
80	"Paste Special Values" of average price fron	#DIV/0!	<-- here	to here -->	0	Rp/kg	and to here:			Rp/kg	
81	"Paste Special Values" of yield from	0	<-- here	to here -->		kg/ha	and to here:			kg/ha	
82	"Paste Special Values" of variable costs fror	1	<-- here	to here -->	1	Rp/ha	and to here:		1	Rp/ha	
83	Then use "Data/What-if Analysis/Goal Seek" to set white cell to below left to zero by changing average price in white cell above right						Then use "Data/What-if Analysis/Goal Seek" to set white cell below left to zero by changing average yield in white cell above right				
84	-1						-1				

Budget template, sheet 2 details

	A	B	C	D	E	F	G	H	I	J	K
1	Yellow cells to be filled in.										
2	Budget description: ACIAR SRA										
3	Tabel 2. Rincian-rincian										
4	**Table 2 Details of costs:**							Amount	Units	Unit cost	Total cost
5										(Rp)	(Rp/ha)
6	**Variable costs**										
7	Seed description	Source, not certification type,									
8	Harvest date of seed,										
9	Storage time										
10	Planting date										
11	Transport costs										0
12	Storage costs										0
13	Fertiliser										
14	Fertiliser 1	Name 1									0
24	**Total fertiliser**										**0**
25	**Bahan penunjang**										
26	Bahan penunjang 1, e.g. BBM mesin semprot (L)										0
27	Bahan penunjang 2, e.g. BBM pompa air (L)										0
34	**Jumlah Bahan penunjang**										**0**
35	**Pesticide (add surfactants to group they are added to)**										
36	Fumigant/nematicide						Target				
37	Nematicide 1	Name 1						1	L	1	1
38	Nematicide 2	Name 2									0
42	Total fumigant/nematicide										1
43	Fungicide						Target				
44	Fungicide 1	Name 1									0
45	Fungicide 2	Name 2									0
54	Total fungicide										0
55	Insecticide						Target				
56	Insecticide 1	Name 1									0
57	Insecticide 2	Name 2									0
66	Total insecticide										0
67	Herbicide						Target				
68	Herbicide 1	Name 1									0
69	Herbicide 2	Name 2									0
73	Total herbicide										0
74	Perata dan perekat/surfactant_spreader_sticker						Target				
75	Surfactant 1	Name 1									0
76	Surfactant 2	Name 2									0
80	Total surfactant										0

81	Other		Target				
82	Other 1	Name 1					0
83	Other 2	Name 2					0
87	Total other						0
88	**Tenaga kerja**						
89	**Mesin**						
90	Pengolahan tanah dengan mesin		tractor				0
91							0
92	**Tenaga kerja untuk beragam perkerjaan**						
93	Pembuatan garitan		L				0
94			P				0
109	Other 1		male				0
110			female				0
121	**TOTAL ENTERPRISE COSTS**						
122	**Depreciation/penyusutan**						
123	Penyusutan alat (depreciation of tools)	Alat		Harga	Umur	Nilai residu	Nilai
124	Biaya Penyusutan Metode Garis Lurus			Beli	Ekonomis	(assumsi	Penyusutan
125				(Rp)		20%)	(Rp)
126	Alat 1			0	1	0	0
127	Alat 2				1	0	0
132						Total	0
133	Penyusutan lain (other depreciation)	Lain					
134	Lain 1				1		0
135	Lain 2				1		0
140						Total	0
141	**Biaya tetap (BT) / Fixed costs/Overheads**			Amount	Units	Unit cost	Total cost
142						(Rp)	(Rp/ha)
143	Biaya tetap 1	Name 1					0
144	Biaya tetap 2	Name 2					0
150	**Total biaya tetap**						**0**
151	**Bunga/Interest**						
152	Bunga			0	%/th		
153	Waktu bunga			0	Bulan		
154	Modal sendiri			0	%		0
155	Kredit/investasi			100	%		0
156	**Total bunga**						**0**
157	**Pajak/Tax**						
158	Pajak lahan						0
160	**Total pajak**						**0**
161	**Mengeluarkan Pribadi**						
162	Mengeluarkan pribadi 1						0
164	**Total mengeluarkan pribadi**						**0**

Cropping Calendar

Completed examples shown in Figure 8.5.

12.2 Appendix 2: Field work schedule

2014, Terry Hill and Julie Warren

Dates	Location	Purpose
18 August	IVEGRI Lembang	Negotiating SRA participation Dr Eri Sofiari (Potato Breeder, Seed Specialist), Asma Sembiring (Social Economist), Ineu Sulastrini (Plant Pathologist)
18 August	Bandung	Negotiating ICHORD SRA participation Dr Yusdar Hilman (ICHORD Principal Researcher), Dr Liferdi (Head IVEGRI) Pak Prama, Dr Eri Sofiari, Mirah (ACIAR Jakarta)
19 August	Department of Agriculture South Jakarta	Negotiating Horticulture Seed support Mrs Sri Wijayanti Yusuf (Ibu Yanti) (Head of Horticulture Seed) Mr Tommy Chitra, PT Clarexindo Mega Sukses (Seed Importer) Ibu Mufti Dr Yusdar Hilman (ICHORD Principal Researcher)
	Indofood Tower, Jakarta	Negotiating SRA participation Mr Budi Dharmadi (Purchasing Manager), Mr Ivan Halim (Supply Chain), Mr Suriyanto Lim (Manager Agro Division)
21 August	BPTP Malang	Identification of farmer groups in East Java Mr Fuad Arema Mr Koesnan (Head Setia Kawan Cooperative)
	Batu	Identification of farmer groups in East Java Mrs Luki (Head Gapoktan Mitra Arjuna)
22 August	Surabaya	Negotiating SRA participation Pak Eko (Head Agriculture Service) Sita Ratih Purwandari (Head Horticulture East Java) Pak Benny Pak Chandra Ibu Tini Ibu Luki
24 August	Sembalun NTB	Negotiating SRA participation Horsela farmer group
25 August	Narmada NTB	Negotiating SRA participation Pak Dwi (Head BPTP NTB) Quarantine, Seed Certification, Seed production centre, Dinas, farmers BPTP

2014, Andrew Taylor (Plant Pathologist DAFWA) and Dr Nigel Crump (General Manager ViCSPA)

Dates	Location	Purpose
24 November	IVEGRI Lembang	Tissue culture laboratory, aeroponic minituber production, Dr Eri Sofiari (Potato Breeder) Rofik Basuki (Potato Agronomist)
	Pangalengan	Seed potato scheme management Mr Dedi Ruswandi (Technical Manager for Seed Potato Inspection, BPSPTPH)
25 November	Pangalengan	Seed potato production at BPBK Sri Mukti Rahayu
	Pangalengan	Seed potato production by farmer
27 November	Wonosobo Central Java	BBH Kledung seed production Dwiningsih Akhmad Arifudin Mufrodin
28 November	Dieng Plateau Central Java	Farmer aeroponic minituber production Fanini Brothers
1 December	Hasanuddin University, Makassar, South Sulawesi	Aeroponic minituber production Professor Baharuddin Zulkifli Razak
2 December	Malino South Sulawesi	Aeroponic minituber production PT Labiota Indah
		Farmer seed production Ibrahim Certified farmer

February 2015, Peter Dawson

Dates	Location	Purpose
24 February	Indofood Tower, Jakarta	Use of PSS by PT Indofood Mr Budi Dharmadi (Purchasing Manager), Mr Ivan Halim (Supply Chain), Mr Suriyanto Lim (Manager Agro Division) Tato Sugianto (Agronomist, Pangalengan)
25 February	Lembang	Evidence for increased profits from the use of certified seed Dr Eri Sofiari (Potato Breeder) Asma Sembiring (Social economist)
26 February	Surabaya East Java	Contract negotiations, Agriculture Service Dyah Fauzi (East Java Government Liaison) Irita Rahayu (Head Vegetables)
27 February	Batu East Java	Identification of high yielding sites for testing seed potato performance Gapoktan Mitra Arjuna
28 February	Surabaya	Private certified seed production Mr Sudarisman Suyoko CV Mulyo Asri Agro
2 March	Narmada NTB	Preparing farmer meeting questionnaires BPTP NTB Muji Rahayu (Project Leader) Sudjudi Achmad (Agronomist) Silvi (economist)
3 March	Sembalun NTB	Horsela farmer Group Crisp processing seed supply chain mapping
		Koang Londe farmer group PSS supply chain information mapping
		Lendang Luar farmer group Granola informal seed supply chain mapping
4 March	Sembalun NTB	Lendang Luar farmer group Granola certified seed supply chain mapping
5 March	Narmada NTB	BTPB NTB information collation

June 2015, Peter Dawson

Dates	Location	Purpose
1 June	Sembalun NTB	Phase 1 Project Proposal planning Koang Londe farmer group
2 June	Sembalun NTB	Phase 1 Project Proposal planning Lendang Luar farmer group
	Phase 1 Project Proposal planning Lendang Luar farmer group	Phase 1 Project Proposal planning Horsela farmer group
3 June	Narmada	Phase 1 Project Proposal planning BPTP NTB Quarantine University of Mataram BPSB NTB
4 June	Surabaya	Phase 1 Project Proposal planning Agriculture Service East Java Potential for testing seed on high yielding sites in East Java
5 June	Surabaya	BBK Tosari
7 June		Private certified seed production Mr Sudarisman Suyoko CV Mulyo Asri Agro
8 June	Batu	Gapoktan Mitra Arjuna Supply chain mapping
11 June	South Bandung	BPSPTPH West Java Training requirements for seed growers at Sembalun Performance of revised Indonesian certified seed system
12 June	Garut	Screenhouse minituber production Muhammad Khudori
15 June	Indofood Tower, Jakarta	Use of Indonesia certified seed by PT Indofood Mr Budi Dharmadi (Purchasing Manager), Mr Ivan Halim (Supply Chain), Suriyanto Lim (Manager Agro Division) Ibu

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6 May	Manjimup Western Australia	PT Indofood seed requirements Aaron Chapman Managing Director, WA Elite Seed
15 May	Manjimup Horticultural Research Institute Western Australia	Indonesia seed import regulations Mr Tommy Chitra, PT Clarexindo Mega Sukses (Seed Importer)
25 May	Yarloop Western Australia	Phase 1 Project Planning PC Fox

12.3 Appendix 3: Budgeting Methods

Budgets in the literature are often a mix between gross margin budgets and net farm income budgets so the budgets presented below have been standardised to the gross margin format to improve comparisons. This means there will be some discrepancies between costs and gross margins[20] discussed below and those reported in the literature.

In an attempt to improve budget comparisons a standardised format was used. Gross margins are commonly used to compare the effect of different management practices on crop economic performance such as different seed sources. The gross margin is defined as:

Gross margin = enterprise income - enterprise variable costs.

Variable costs are those costs directly attributable to an enterprise and which vary in proportion to the level of output. For example, if the area of potatoes planted doubles, then the variable costs associated with growing it, such as seed, will double (Davies & Scott 2007).

A gross margin does not include fixed costs. Fixed, or overhead costs, remain constant and independent of the enterprise output level. Fixed costs include rates, insurance, permanent paid labour, administration and depreciation. When these are deducted from the gross margin budget a net farm income budget results;

Net farm income = gross margin – fixed costs.

The gross margin format above is from the Department of Environment and Primary Industries, Victoria (2010). It is appropriate to use this format for this study as it has been employed by Adiyoga *et al.* (2010) to investigate the economic impact of changes in vegetable cultivation practices in Indonesia.

Net profit = gross margin – fixed costs – interest – tax

[20] *Gross margin is called keuntungan (profit) by Ridwan et al. (2010) and Sayaka and Hestina (2011).*