Final report

project	**"Enhancing profitability of selected vegetable value chains in the southern Philippines and Australia" - Component 1 – Integrated soil and crop nutrient management**
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Contents

1 Acknowledgments

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2. World Agroforestry Centre (ICRAF)
3. Visayas State University (VSU)
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5. Misamis Oriental State College of Agriculture and Technology (MOSCAT)
6. University of the Philippines at Los Baños (UPLB)
7. Centre for Recycled Organics Agriculture (CROA)
8. Department of Industries of New South Wales (DPI NSW)
9. Ableblue Ltd. Pty

2 Executive summary

This terminal report presents the highlights of the Australian Centre for International Agricultural Research Project HORT/2007/066/1 “Integrated soil and crop nutrient management in vegetable crops in the southern Philippines”. This component forms a large section of a large multidisciplinary Program on (HORT/2007/066) “Enhanced profitability of selected vegetable value chains in the southern Philippines”. The aim of this component is to develop integrated soil and crop nutrient management in vegetable crops in the southern Philippines and Australia to facilitate more profitable and sustainable vegetable production.

Organic inputs are often promoted as the solution to problems of declining soil fertility and agricultural productivity. This is driven by high prices of inorganic fertilizers, opportunities to beneficially reuse recycled organics and a desire to be more “organic”. However, recycled organics alone are unlikely to provide the nutrients required to achieve the productivity required to meet the food demands in the Philippines. Nevertheless, they have great potential to be used in conjunction with inorganic fertilizers to increase fertilizer use efficiency, improve soil quality and crop growth. Though oorganics can play a role in increasing fertilizer use efficiency (FUE) and improve soil quality, will not completely substitute for inorganics. Sustainable soil fertility and nutrient management entails understanding soil fertility status, matching inputs to outputs and monitoring to ensure nutrients do not accumulate or diminish over time.

In this study, the establishment of the framework for integrated nutrient management (INM) for vegetable production in the southern Philippines is an important aspect of the project in coming up with a more sustainable production of vegetable or in any crop production in the agricultural systems. The evaluation of the current soil fertility status and management practices served as the basis for the Integrated Nutrient Management (INM) framework.

3 Background

Providing higher economic returns per unit area and developing new export markets for high value crops in the Philippines has been identified as a priority by the Philippine Government and the Australian Centre for International Agricultural Research (ACIAR) as a means of increasing economic growth and improving the standard of living of people living in rural areas. In the southern Philippines, vegetable is one of the primary crops where the regions 8 (Leyte), 10 (Northern Mindanao/Cagayan de Oro) and 11 (Southern Mindanao/ Davao) have significant potential for expanding vegetable production. Moreover, they are seen as strategically important to the Australian Government, whereby efforts to improve the livelihoods of the populations in these areas could contribute to improving geo-political stability in the region. However, a number of barriers exist to achieving these objectives including: a lack of grower expertise in soil management and crop agronomy; high incidence of pests and diseases; lack of developed markets and value chains for horticultural produce; and political/economic constraints, such as limited capital/resources and insecurity of land tenure. To address these issues, ACIAR has developed two large multi-disciplinary programs (HORT/2007/066 and 067).

A scoping study in the Philippines which was undertaken by Dr. Keerthisinghe (ACIAR), Dr. Menz (ANU) and Dr. Dorahy (Ableblue) in November 2007 had identified the following key issues with respect to soil and crop nutrient management in vegetable production systems in Northern and Eastern Mindanao and the Eastern Visayas (Leyte). These include declining soil fertility; high cost of inorganic fertilizers and a lack of grower capital; shift towards more “organic” production; availability of organic materials; lack of information and training; and the widespread prevalence of soil borne diseases. Common problems encountered by the vegetable farmers are inherent poor soil fertility and productivity, lack of appropriate technologies, improper water and soil conservation management and other production factors such as fertilizers and limited capital. The inadequate knowledge in soil and crop nutrient management of vegetable farmers leads to improper allocation of limited financial resources that could result to financial risk, poor soil fertility management and low productivity. This practice makes the soil less productive through time depending on the amount of fertilizer applied per cropping season.

Therefore, a need exists to assess the current soil fertility status in soils used for vegetable production, quantify the rates of nutrient removal from these systems (mass balances) and develop strategies for matching nutrient inputs to crop and soil requirement through the judicious and integrated application of inorganic and organic fertilizers. When organic fertilizers are used, there is a need to quantify the availability and types of materials, evaluate the treatment and stabilization technologies (e. g. composting) and determine how they can be applied in conjunction with inorganic fertilizers to optimize productivity and profitability. Dissemination and training activities are also required to promote the outcomes and maximize benefits to growers.

In the Philippines, the main issue is that conventional inorganic fertilisers are expensive and growers are looking towards alternative inputs such as composts, manures and crop residues to improve/ maintain soil fertility. Likewise there is a need to improve understanding of how inputs (both inorganic and organics) should be managed in these systems. This issue is of equal relevance to the vegetable industry in NSW where there is a need to improve nutrient management by vegetable growers to manage inputs more efficiently. This is highlighted by recent research from the NSW DPI research team, which demonstrated vegetable soils typically contain excessive concentrations of phosphorus and are structurally degraded (Chan et al., 2007a).

Research at the Centre for Recycled Organics in Agriculture (CROA) has demonstrated that compost addition can sustain vegetable yields and improve soil quality, whilst avoiding some of the phosphorus accumulation observed in conventional production systems (Chan et al., 2010). Therefore the work has real potential to change nutrient management practices and develop new markets for recovered organic resources in NSW. However, the benefits of organic inputs on soil physical, chemical and biological properties take a number of years to be fully expressed. This new ACIAR project (component 1) presents a unique opportunity to extend the current experiment at CROA by a further 3 years or more, to further define long term benefits of using compost in vegetable production systems. This will be of direct benefit to NSW vegetable growers as implementing the research outcomes should ensure NSW and Australian vegetable growers manage inputs more effectively to ensure production is profitable and sustainable in the longer term. The CROA experiment will also be used as a training resource to assist professional development for Philippine and Australian scientists associated with the project.

This Component forms a section of a large multidisciplinary Program (HORT/2007/066 ‘Enhanced profitability of selected vegetables value chains in the southern Philippines’). The aim of this component is to develop integrated soil and crop nutrient management in vegetable crops in the southern Philippines and Australia to facilitate more profitable and sustainable vegetable production.

4 Objectives

1. Define current soil fertility status and management practices.
2. Develop more productive nutrient management systems for vegetables.
3. Promote adoption of management practices best suited to local conditions.
4. Enhance capacity building of local staff to promote and develop more sustainable and profitable vegetable production.

5 Methodology

1. Soil fertility constraints were identified by interviewing farmers regarding current fertilizer and nutrient management practices; undertaking a baseline survey of soil fertility in key vegetable producing municipalities and on representative soil types of Leyte and Mindanao. The alternative nutrient inputs such as abundance, nutrient supply and cost, effect on soil physical, chemical and biological properties were evaluated.

2. The assessment activities involved gathering baseline information on (Appendix 1):
    a. The fertility status of vegetable soils in Mindanao and Leyte through conducting a paired soil survey;
    b. Soil and nutrient management practices including tillage, crop rotation and fertilizer application rates, and
    c. Availability and costs of inorganic (e.g. traditional NPK) and organic (e.g. poultry manure, carabao and cattle manures) fertilizer inputs.

3. The establishment of nutrient mass balances for different vegetable crop management; defined how fertilizer inputs were used (rates, timing, crops) and others.

4. Five field experiments were set-up at the farmers’ fields in (a) Cabintan, Leyte; (b) Maypayag and Lantapan, Bukidnon; (c) Kapatagan, Davao and (d) Claveria, Misamis Oriental. The same experimental layout was followed in five field trials with varying levels of treatment. It was laid out in the field in a Randomized Complete Block Design with four treatments and five replications (Table 1).

Table 1. Treatments used in five field trials in the project.

Treatment	**Cabintan**			**Claveria**			**Kapatagan**			**Kibangay**			**Mapayag**		
(kg/ha)	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1*	455	184	184	143	91	64	90	126	176	260	293	209	134	255	280
2	44	55	30	93	30	150	35	15	15	69	0	0	40	131	0
3	88	110	60	186	60	150	35	18	15	69	18	60	46	135	0
4	66	82.5	45	92	36	150	36	30	15	138	18	60	24	93	0

*Farmers practice

a. Cabintan is located approximately 18 km Northeast of Ormoc City with and elevation of around 900 m above sea level (asl). Common land uses of the area are annual vegetable cropping (e.g. sweet peppers, cabbage, eggplant, tomatoes etc.); corn production and others are left to wild shrubs and forest tree species. The soil in mountainous area of Cabintan is mainly developed from volcanic tuff, basaltic and andesitic materials which were ejected during the period of active volcanism (Aurelio, 1992 and Asio, 1996). Higher altitude of the area may however affected the agro-climatic pattern of the site, hence intermittent rainfall is always observed throughout the growing season leading to a higher leaching rate of nutrients especially nitrogen.

b. Bukidnon is considered to be the food basket of Mindanao. High value vegetable crops are most popular to local farmers for domestic consumption supplying as far as Luzon and Visayas islands. Lettuce, cabbage, tomato, cauliflower, broccoli, squash, potato and sweet potato are just few among preferred vegetable crops highly suitable in the province. Rainfall in Northern Mindanao is evenly distributed throughout the year. Its abundant vegetation, natural springs and high elevation contribute to the region’s cool and mild climate. Problems associated in vegetable production in these areas were identified such as soil infertility, soil erodibility due to poor structure, inaccessibility to soil test and inappropriate fertilization. Project site is located in Mapayag, Malaybalay City with an elevation of 1,301 meters asl while Kibangay, Lantapan has an elevation of 1,263 masl. These two sites are primarily an agricultural area most favoured to vegetable cropping due to its complementary geographic location.

c. Kapatagan, Davao City site is located at the southern slopes of Mt. Apo, the Philippines’ highest mountain. Its’ elevation of 1,200 meters above level is highly suitable for temperate vegetable production such as crucifers, potato and carrots. The region has a generally uniform distribution of rainfall throughout the year. Problems associated in these areas are declining the fertility status of the soil with increasing population growth and diminishing areas of arable land. Major vegetable products in Mindanao (cabbage, broccoli, eggplant, tomato etc.) are coming from this region, which supplies the nearby regions and even some other parts of the Philippines.

d. Claveria, Misamis Oriental is located at 980 meters asl. The soil is derived from pyroclastic materials (Mts Mat-i, Balatukan, Sumagaya), deep and well drained. Claveria soils represent most of acid uplands in Southeast Asia physically (Mercado, 2007) and socio-economically (Bertumeu, 2005). Tomato farmers in Claveria tend to apply 3-5 times more fertilizers than what are required affecting efficiency and income. Vegetable farmers tend to over-fertilize vegetables in order to secure optimum yield (Morris, 1996).

5. Three experiments were set up at VSU for Nutrient Omission Trials on cabbage, maize and tomato using soil media to assess the nutrient supplying capacity of soils for vegetables from 5 different sites (Cabintan, Mapayag, Claveria, Kapatagan and Kibangay) in the southern Philippines.

6. Establishment of demo farms that had been used for the training of extension workers (EATWELL) and Farmers Techno fora at the five different sites in southern Philippines to demonstrate the varying effects of different levels of N, P and K on the growth and yield of vegetables.

7. Farmers field day were likewise conducted at VSU, Leyte during the VSU Anniversary held during August 8-11; NOMIARC Annual Field Days held during September 22-24; Claveria Field Days held in April 2010, September 2011 and April 2012.

Soil Analysis

Soil sample collection, preparation and analysis

Composite soil samples were taken at 0-20 cm depth and analyzed at the Soils and Environment Laboratory, Philippine Root Crops and Training Centre, VSU, Visca, Baybay City, Leyte. Air-dried soil samples were sieved through a 2-mm wire mesh for the determination of soil’s physico-chemical properties and 0.425 mm for organic matter determination. The following soil parameters were analyzed: Soil pH was determined potentiometrically using distilled water at a soil-solution ratio of 1:2.5 (ISRIC, 1995); OM and total N using modified Walkley-Black and modified Kjeldhal methods, respectively (USDA-NRCS, 1996); available phosphorus was extracted using the Bray No. 2 method of Jackson (1958) and Murphy and Riley (1962) for color development and quantified by measuring the percent absorbance at 880 nm using Spectronic 20; cation exchange capacity (CEC) using 1 N NH_4OAc at pH 7 (USDA-NRCS, 1996). Exchangeable K, Ca, Na, and Mg were extracted by using 1 N NH_4OAc neutralized to pH 7 (USDA-NRCS, 1996); and then quantified by atomic absorption spectrophotometry (AAS) (Westerman, 1990).

Microbial Analysis of Soil Samples

Soil sample were taken from five sites in the southern Philippines. Five core samples per site were mixed and 310 grams were set aside for soil microorganisms. The following microbial analyses include:

a. Soil Arthropods – 100 grams soil samples were transferred to Berlese funnel for 48 hours. Soil arthropods collected in vials with 70% alcohol were sorted and identified.
b. Soil Fungi – Distilled water was added to 100 grams of fresh soil per site and stirred. A loop from the dilution was streak into Na Agar media and followed to incubate for 24 hours. Samples were taken and isolated into PDA agar media for pure isolation. Spores were identified.
c. Nematodes – Using Baehrman technique, all soil nematodes were extracted from 100 grams of soil sample/ site for 36 hours. Nematodes were sorted, identified and counted from 5 mL extract.
d. Soil-borne bacteria – 90 mL sterile water added to 10 grams of soil sample/ site placed in bottle was shaken for 5 minutes. Serial dilution was done at 1 mL from sample suspension to 9 mL distilled water. Plating, isolation and re-isolation were done to obtain pure culture. Bacterial colony forming units/mL was counted.

Tissue sample collection, preparation and analysis

Leaf samples were collected 30 days after transplanting and at harvest period. Whole plants were also sampled for dry matter yield and plant nutrient uptake determination. Leaf samples were washed with deionised water, blotted dry with tissue paper and air dried. The leaves were then oven-dried at 70˚C for at least 2 days. The dried leaves were then ground using Willey mill and placed in labeled paper bags for analysis. Total concentration of P and K in the plant samples were analyzed by first dry ashing them at 500^{o}C for a minimum of 5 hours (but not exceeding 16 hours) followed by the addition of 6 M hydrochloric acid. Quantification of K was done using an atomic absorption spectrophotometer while P was analyzed using a spectrometer. Total N was analyzed by Kjeldahl method involving sample digestion with concentrated H_2SO_4, distillation and titration.

6 Achievements against activities and outputs/milestones

Objective 1: To define current soil fertility status and management practices

No.	Activity	Outputs/ milestones	Completion date	Comments
1.1	Identified soil fertility constraints through participatory appraisal of farmers regarding their current fertilizer and nutrient management practices; undertaking a baseline survey of soil fertility in key vegetable producing districts and on representative soil types of Leyte and Mindanao. (PC)	Documented fertilizer and nutrient management practices Characterised soil fertility status in Claveria, Cabintan, Kibangay, Mapayag and Kapatagan, which are in key vegetable producing areas in Mindanao and Leyte.	Participatory Assessment – completed February 2009 Soil Survey – completed February 2009	Results from these activities were used as the basis for a workshop, which was held at NOMIARC, Malaybalay, Bukidnon in March 2009 to plan and design 5 field experiments. The key outcomes from these investigations were: i) Growers identified lack of capital and high fertiliser prices as a key constraint to vegetable production. ii) However, evaluation of soil fertility and current fertiliser and nutrient management practices suggests growers are undersupplying some nutrients and oversupplying others, leading to nutrient imbalances in the soil. iii) Consequently, it is not an issue of lack of capital but an issue of more effective allocation of limited capital (fertiliser) resources. iv) The resulting research program has a strong focus on developing fertiliser strategies which are based on supplying the most cost-effective method of supplying the nutrient requirements of target vegetable crops. <u>Nutrient omission pot trials</u> The nutrient omission trials were conducted late 2010/ early 2011 using 3 key crops, namely tomato, cabbage and maize. This study has yielded valuable information on which nutrients are driving the productivity of the systems (N>P>K) and have enabled some soil test calibration work to be undertaken. These calibration studies will help in interpreting the fertility status of the soils collected in the baseline soil survey.

1.2	Evaluated alternative inputs (abundance, nutrient supply, cost, effect on soil physical, chemical and biological activities). (PC)	Quantified and characterised of alternative nutrient inputs and their potentials benefits. Identified organic inputs with the greatest potential for use in vegetable cropping systems.	Preliminary evaluations of alternative inputs were completed during the Participatory Assessments	Investigations into the effects of different input materials on the chemical characteristics of vermi-compost were completed by Dr Jun Mercado (ICRAF) (Jan-May 2011). Different substrates and substrate combinations were made and their impacts on nutrient concentrations were determined. Results were presented during the Mindanao wide vermin-forum as well as various farmer trainings locally and nationally. Determination of the characteristics and properties of different chicken dung used in the various field trials was completed in November 2009 Jun Mercado has also investigated the role of organic amendments with varying C/N ratios in improving Nitrogen Use Efficiency in tomatoes in Claveria like vermicast, chicken manure, corn stubbles that would immobilized N during the vegetable current crop that would reduce N losses and make it more available during the subsequent crops. Bensive Gabitano has investigated nitrogen cycling from chicken dung and urea under protected and open cropping as part of his BS student project. A more detailed analysis of the availability and characteristics of alternative inputs in Leyte were undertaken as part of a post-graduate research project (MSc) by Ms Clea Ann Vallejera (Visayas State University, Leyte). Initially this project was to be completed by March 2010, but her thesis was submitted in March 2011. The forms and types of alternative nutrient inputs vary from site to site and region to region. However a key achievement has been to provide researchers, advisors and farmers with a framework for working through the considerations surrounding the use of organic amendments as inputs to vegetable production systems. Four organic amendments such as chicken dung, swine manure, mudpress and vermicast were characterized using XRF and soil analysis to determine their nutrient content and suitability for vegetable production. This was undertaken by Ms. Clea Vallejera in her MS studies.

1.3	Evaluated treatments/value adding options (e.g. composting). (PC)	Listed of viable options for producing stable organic fertilizers and documented barriers to adoption	December 2010	A vermi-composting facility has been established in Claveria, Mindanao by Dr. Jun Mercado (ICRAF). Different substrates were evaluated as their effects on nutrient concentrations and were used treatments to determine their effects of vegetable crops nutrition. This is evaluating vermi-composting as a treatment/ value adding option. Other on-farm composting facilities have been identified (eg. Noel’s farm at Cabintan).

PC = partner country, A = Australia

Objective 2: To develop more productive nutrient management systems for vegetables

No.	Activity	Outputs/ milestones	Completion date	Comments
2.1	Calculated nutrient mass balances for different crop management systems (PC).	Improved understanding of the rates of inputs and removal of critical soil and plant nutrients for vegetable production systems in Leyte and Mindanao.		Mass balances for vegetable production systems have been determined as part of the field research program. (Mass balance = Soil nutrient status + nutrient inputs - nutrients removed in produce). This was based on current nutrient management practices described by farmers and predictions on typical nutrient uptake and removal patterns based on published data for the typical yields described. This suggests that nutrients such as N and K were being oversupplied while growers were not applying enough P. This information highlight the need to match inputs to outputs to ensure long-term soil fertility is maintained. Soil and plant tissue analysis were already completed and the data now collated for statistical analysis and interpretation.
2.2	Refined how fertilizer inputs are used (rates, timing, crops). (PC)	Established various field research trials in key vegetable producing areas in Leyte and Mindanao.	December 2010	Various 5 field trials research sites have been established in each of the key areas of investigation (Cabintan (Leyte) and Claveria, Kibangay, Lantapan and Kapatagan (Mindanao). Alternative rates and forms of nitrogen, phosphorus and potassium which are applied to vegetable production systems in the southern Philippines have been evaluated. Soil and plant tissue analysis were already completed and the data now collated for statistical analysis and interpretation.

2.4	Refined management strategies for protected cropping systems. (PC)	Developed recommendations on nutrient management strategies for protected cropping systems		A joint experiment between C1 and C2 has been completed VSU, Baybay. This evaluated the interaction between different rates and sources of N (organic and inorganic) inputs under a protected cropping and open field situation. Optimum rates of different types of vermicast were evaluated in Claveria. Experiment on the interaction between different rates of K fertilizers under protective structure and open field conditions was completed as part of student research by 2 High School students Completed cabbage demonstration trial experiment with different rates of organic and inorganic sources
2.5	Undertook Cost Benefit Analysis of different management options and identify constraints to adoption (PC).	The economic cost and benefit of different soil fertility management options determined. Cost effective management practices identified. Constraints to adoption identified.		The experiments have a strong Economic component whereby the treatments selected are based on the most cost-effective method of supplying the nutrient requirements of the target crop. Likewise options for reducing input costs but achieving the same yield have also been evaluated with varying results. Tools for evaluating the most cost-effective form of the required nutrient been developed. These have been used in the EATWELL and Farmer Techno Forums to help farmers and their advisors decide which products will deliver the most agronomically and economically effective form of nutrients. Key outcomes to date are that growers are applying the most cost-effective source of crop nutrients.
2.6	Monitored incidence and severity of pests and diseases in response to different treatment option (PC).	Assessments of the effects of soil fertility management options on the incidence and severity of pests and diseases.	February 2011	Diseases have been identified as a limiting factor on several of the field trial sites (e.g. Mapayag, Kapatagan and Cabintan) sites and have had a confounding/ masking effect on the experimental treatments. The potential of Wild sunflower (*Tithonia diversifolia*) and brassica residues as a means of controlling bacterial wilt was investigated at Claveria in 2010) as a joint initiative between C1 and C3.

2.7	Continued current field research experiment at CROA to evaluate the longer-term benefits of using compost in vegetable production systems (A).	Quantified longer-term benefits of applying compost in vegetable production systems (CROA field experiment).	A 2nd compost applications followed by the crops (crop 6-10) – 2008-2011)	Do economic analysis on crop 1-10 and 6-10 and statistical analysis on soil and crop data. Data indicate additional benefits from follow up applications for soil quality (carbon, biology, structure) & yield & economics. – Compost treatment effectively doubled the farmers practice yield for Capsicum, other crop responses were less pronounced, but did at least match farmer practice for yield. Additional outputs on carbon sequestration expected. 1 additional compost application& crop 1 to evaluate additional compost on responsive crop.
2.8	Established 2-3 demonstration trials in key vegetable growing regions of New South Wales (A)	Demonstration of the benefits of using compost and Component findings disseminated to growers.		Established a demonstration trial at NSW DPI vegetable Demonstration Farm (UWS-Richmond) May 2010 – Cabbage Crop Aug- Nov 2010, Visits by farmers leaning Irrigation skills – Nutrient smart Program. October – crop of Capsicum & watermelon (compost vs farmer practice) with large field day in January 2012 (several hundred farmers expected).

PC = partner country, A = Australia

Objective 3: To encourage adoption of best management practices for vegetables

No.	Activity	Outputs/ milestones	Completion date	Comments
3.1	Developed best management practice guideline and other education and extension material for optimal soil fertility and crop nutrient management in vegetables (PC & A).	Developed best management practice guideline and supporting Technotes/ Primefacts for optimising soil fertility and crop nutrient management in vegetables.		A draft framework for this guideline has been developed and is illustrated in supporting information for C1. Currently finalising economic and statistical analysis of field trial data from CROA, which may form basis of a NSW Primefact
3.2	Established various field trials on leading growers farms in main vegetable growing areas in the Philippines	Established and completed various participatory field research trials, fields day and farmer fora in the Philippines.	October 2012	Field experiments have been completed on September/October 2009 in Cabintan (Leyte) and Claveria, Kibangay, Lantapan and Kapatagan (Mindanao) on leading grower farms.

3.3	Involved farmers in various research activities	At least 3-4 farmer groups engaged in Component activities with expected flow on impact to individual members (50-60) and their communities	Participatory activity between farmer and scientists have been ongoing since 1/5/09 when the field trials were established	Farmers and farmer groups have been integrally involved in the field research, extension and training activities of the project. The field trials which were designed using the output from the Participatory and Soil Assessments are being conducted on the fields of some of these farmers, who will be responsible for managing the trials on a day-to-day basis. Farmers were involved in the conceptualization of all the trials and in managing the crops planted.
3.4	Conducted Farmer Field days, fora, training in collaboration with other components.	Conducted 17 farmer field days, fora and trainings on Integrated Soil and Crop Nutrient Management Training Workshops in each of the key vegetable producing areas of Leyte (5), Claveria (3), Bukidnon (6) Kapatagan (2) and in NSW (1)	April 2012	The EATWELL training workshop was held at NOMIARC last August 22-26 2011. Over 24 extension advisors attended. Four farmer Techno Forums were held in Sept/Oct 2011, with over 400 farmers attending. Eight Field Days were likewise conducted in VSU, NOMIARC, and Claveria from 2010-2012.

PC = partner country, A = Australia

Objective 4: To build scientific research capacity of collaborating staff in the Philippines to promote the development of more sustainable and profitable production in the Philippines

No.	Activity	Outputs/ milestones	Completion date	Comments
4.1	Trained component staff in new methods of agricultural and soil research (PC).	Philippine component team members gain experience in managing and implementing multinational Components. Several research and conference papers co-authored by Component team members.		PC team members have been responsible for designing and implementing the research program which has been undertaken. New techniques in identifying key research needs and prioritising research activities have been learnt.
4.2	Used the CROA field site as a training resource for collaborating scientists from the Philippines.	Four PC Collaborating scientists trained in field research techniques/ approaches in Australia	Aug. 2011	Trip undertaken in July/ August 2010 Trip report submitted Aug 2011
4.3	Selected Component team members to visit the CROA field research experiment to learn about Australian R&D and vegetable production systems in Australia.	Four Component team members from Philippines to visit Australia to learn about Australian R&D techniques and Australian vegetable production systems.	Trip undertaken in July/ August 2010	Had arranged for VSU lab technician, Mrs Cynthia Godoy to spend a few days training in the NSW DPI sample laboratory at Wollongbar last April 2012.
4.4	Selected Component team members to attend/ present at relevant national and international conferences.	3-4 Component team members to attend/ present at national/ international conferences in Australia and Philippines (linked to scheduled travel visits by collaborating Australian and Philippine team members to the Philippines/ SE Asian region and Australia, respectively.		5 papers were published in the proceedings of the World Congress of Soil Science which was held in Brisbane in August 2010. Component 1 team members have had a strong presence at the Philippine Society of Soil Science and Technology Conferences in 2009, 2010 and 2011 to promote and disseminate project outcomes (9 papers published in proceedings)

PC = partner country, A = Australia

7 Key results and discussion

Participatory and soil assessment surveys were conducted in five major vegetable producing areas; Kibangay, Bukidnon; Mapayag, Bukidnon; Kapatagan, Davao del Sur; Claveria, Misamis Oriental and Cabintan, Leyte in southern Philippines to define the current nutrient status and management practices involving vegetable production. Five sites were identified in each area representing four regions in Southern Philippines that were identified as vegetable producing farms and represent the major sources of vegetables sold in the Visayas and Mindanao islands. Soil samples were gathered in each site and were analyzed in the laboratory for its physico-chemical characteristics (Appendix 2) and the nutrient mass balances for vegetable systems were evaluated (Table 2).

Table 2. Nutrient mass balances for vegetable systems evaluated

Region	**Deficit/Surplus (kg/ha)**		
	N	P_2O_5	K_2O
Claveria	154	186	239
Cabintan	140	42	22
Bukidnon	112	120	78
Kapatagan	6	53	-68

In the participatory assessment surveys, more than 100 farmers were interviewed for the current management practices they employed in vegetable production and the major problems they encountered in producing vegetables. The key outcomes of these investigations are: 1) growers identified lack of capital and high fertilizer prices as a key constraint to vegetable production; 2) the results of soil fertility evaluation suggests that growers are undersupplying some nutrients and oversupplying others leading to nutrients imbalances in the soil and, 3) lack of capital is not an issue but an issue of more effective allocation of limited capital (fertilizer) resources.

Soil testing and understanding of crop nutrient requirements is therefore critical to improving nutrient management in vegetables. In this project, focus is more concentrated on the development of nutrient management programs that would lead to a more sustainable, productive and profitable vegetable production systems (Figure 1) through the adoption of more judicious and appropriate use of inorganic and organic fertilizer inputs (Figure 2). This was achieved by more effective use of limited fertilizer resources through matching fertilizer inputs to soil and crop nutrient requirements in vegetables, identifying key nutrient productivity drivers (Figure 3) and evaluating alternative fertilizer inputs (e.g. vermin-compost) (Table 3).

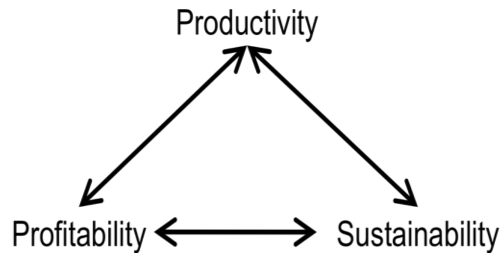

Figure 1. Contribution to economic growth and better livelihoods

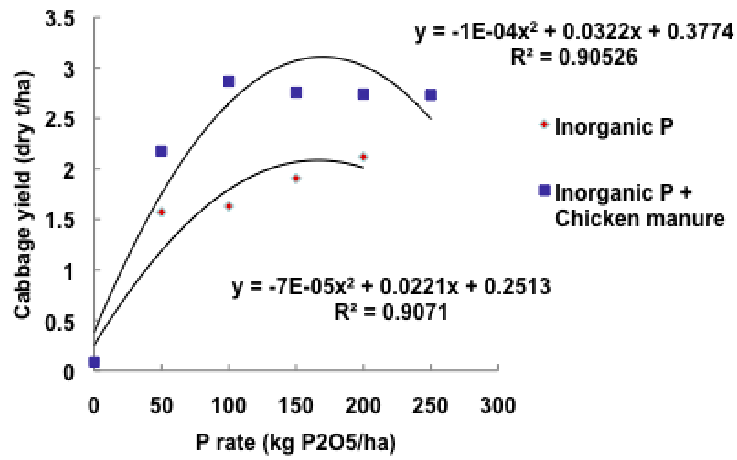

Figure 2. Optimising fertilizer inputs (rates and forms)

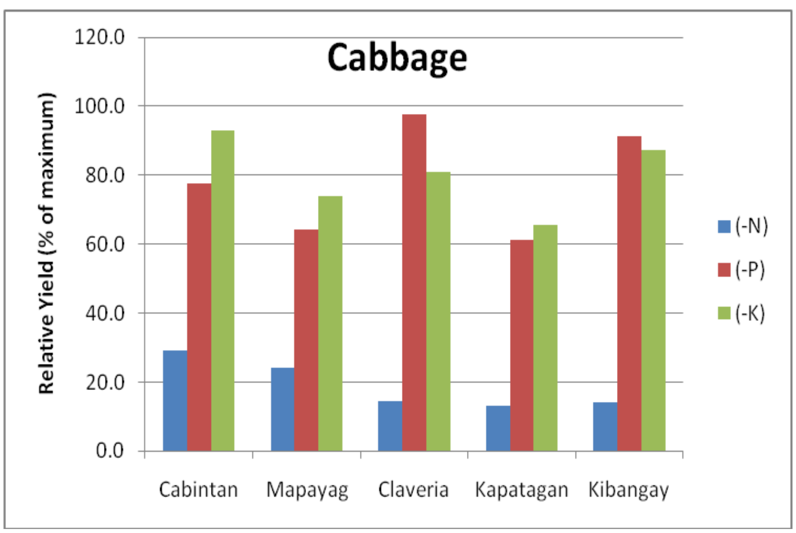

Figure 3. Relative yield of cabbage from five different sites as affected by the absence of one of the primary nutrients needed by the plants.

Table 3. Quantities of macro and micro-nutrients contained in 4 commonly used organic amendments in Leyte.

Elements	Organic Amendments			
	Swine Manure	Chicken Dung	Mudpress	Vermicast
Macronutrients (%)				
Phosphorus	1.4	2.3	1.6	0.5
Potassium	0.4	5.8	0.5	1.1
Sulfur	0.8	1.1	0.2	0.2
Micronutrients (mg/kg)				
Copper	340	70	15	10
Zinc	470	245	4	25

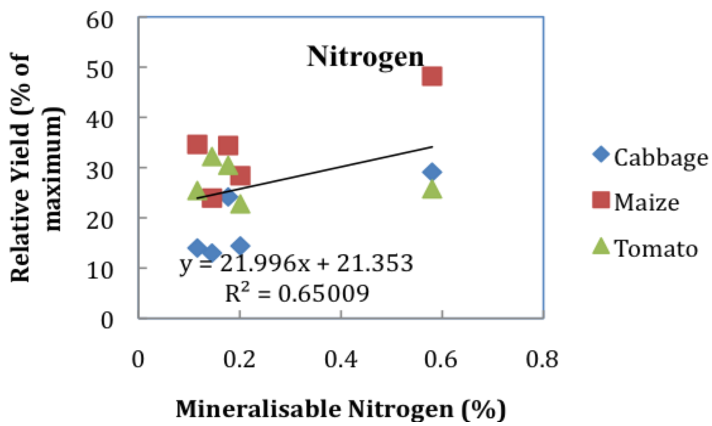

Figure 4. Yield response curved of vegetables vs. mineralisable N in the soil

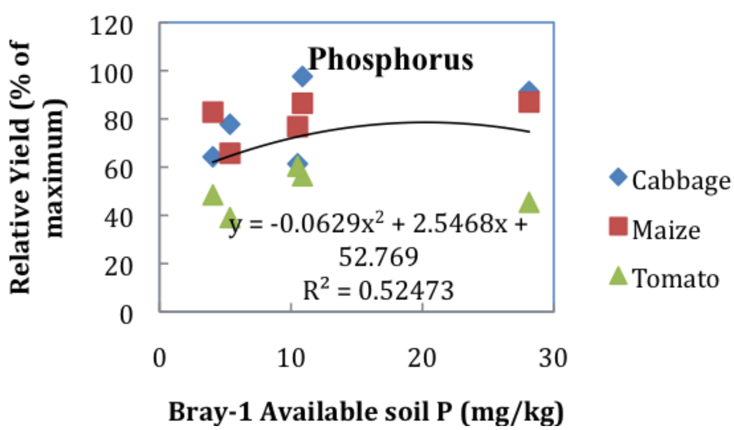

Figure 5. Yield response curved of vegetables vs. available P in the soil

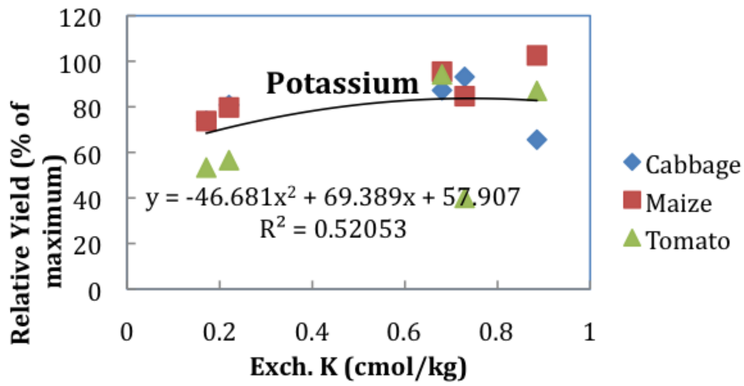

Figure 6. Yield response curved of vegetables vs. available K in the soil.

Dow and Roberts (1982) studies mentioned that there was a good relationship between the growth yield of the crop and the concentration of a nutrient in a crop. The results of the nutrient omission trial of cabbage using the soil samples from five various sites indicated that N is the most limiting nutrient followed by P and K (Figure 2). This findings can be seen on the yield response curved of different vegetables versus the mineralizable N, P and K (Figure 4, 5 & 6). For N, it is strongly related as shown by the highest regression value as compared to P and K. Again, this signifies that N was the most limiting nutrient if not the most needed nutrient for plant growth and development.

The sustainability of farmers practice was likewise determined to monitor the nutrient balance of soil in the production system. This is a very important tool in nutrient budgeting for proper nutrient management and to avoid over and under application of fertilizers. The result shows that there is an oversupply of some nutrients while other nutrients are deficit. There is a risk of nutrient accumulation in the soil, which had been reported to have a negative impact to ground water system especially in the case of nitrogen fertilizers and to the availability of essential nutrients needed by the plants. Thus the projects continuously monitor the nutrient balance and develop new recommendation based on soil test results for optimum crop production without over exploiting the soil.

The calculation of the partial nutrient budgets is very important in ascertaining the contribution of added fertilizers on the nutrient balance and sustainability in the soil system. This will help a lot in determining whether the added nutrients through organic and inorganic fertilization as indicated in the nutrient loading data was sufficient to supply the nutrient required by the crop throughout its growing stage as shown by the nutrient uptake and removal data (Figure 7 & Table 4).

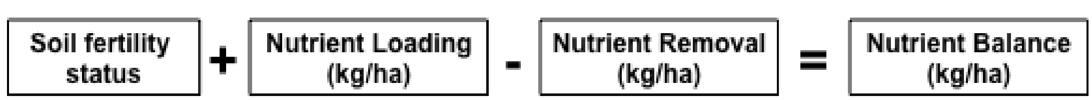

Figure 7. Nutrient balance calculation

Table 4. The vegetable yield, nutrient loading, crop removal and deficit-surplus of nutrient application in Cabintan

Cabintan	Yield (tons/ ha)	Nutrient Applied (kg)			Crop Removal (kg)			Deficit (-)/Surplus (+) (kg)		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
Tomato	4-8	24	19	28	11-22	3-6	15-30	+13,+2	+16, +13	+13, +2
Cabbage	3	145	32	32	13	5	16	+132	+27	+16
Tomato	10-20	24	19	28	27-55	8.0-15	37	16-31	2-4	24
Cabbage	10	145	32	32	25	9	32	+120	23	0

If the nutrient added is insufficient, the nutrient balance will indicate a negative value and the excess of applied nutrients will be indicated by high positive values. This partial nutrient budget will then be compared with the yield data to determine the most profitable and sustainable treatments. This will also help in deciding the optimum rates of fertilizers to be applied based on crop requirement and nutrient balance data. A very high amount of nutrients left in the soil would pose danger to the environment because of over accumulation of nutrients due to over fertilization.

A framework was established to guide agricultural researchers in the planning and implementation of high impact researches on integrated nutrient management (Figure 8). Proper allocation of limited resources such as fertilizers will result in the sustainable management of marginal soils. Likewise this approach will lead to better utilization of fertilizers by vegetables, which is valuable in the economic development of our country.

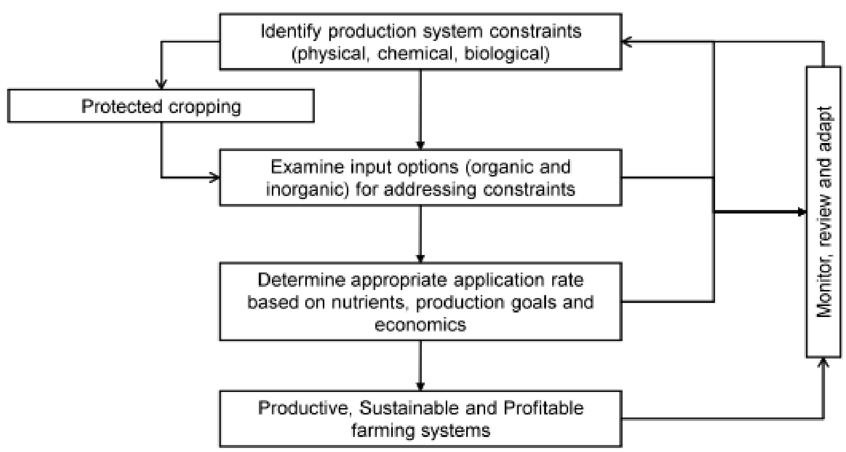

Figure 8. Framework for Integrated Nutrient Management

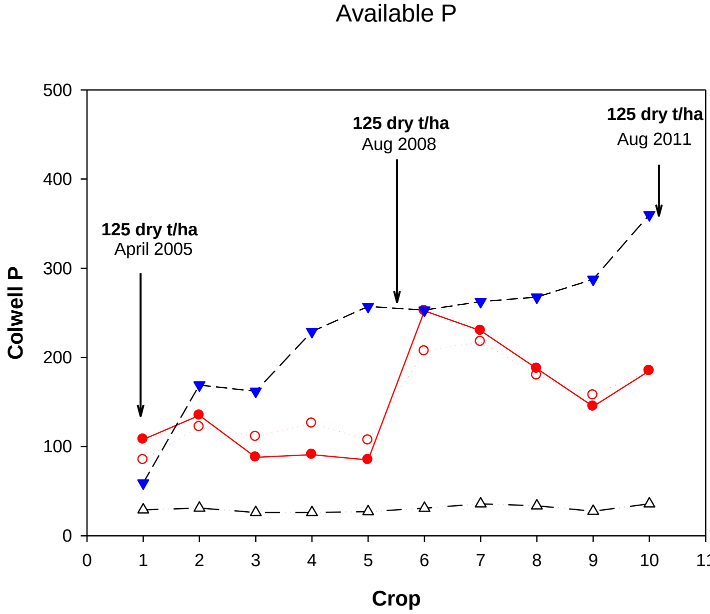

Figure 9. Result of experiments in CROA increasing P levels over time as monitored from 2005 to 2010.

The group also determined the key activities such as reduction of N rates; timing of N application; reallocation of investments from P and K to N; lime application; application of N rich compost) that have high levels of impact as well as high levels of success (Figure 9). Training in nutrient management especially on the application of Best management Practices are also very important.

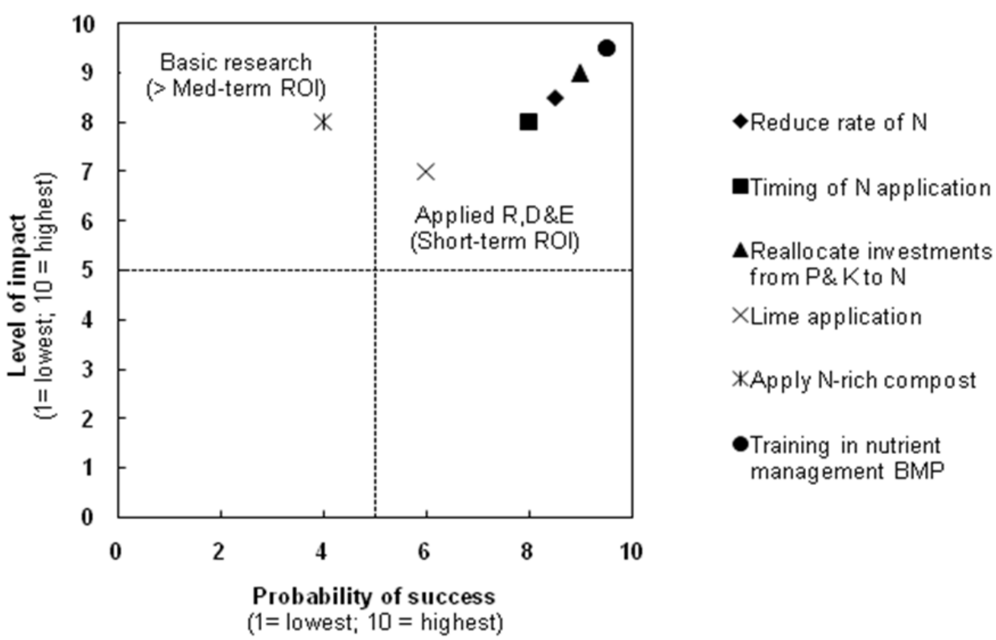

Figure 10. Optimising probability of success and likelihood of impact

8 Impacts

8.1 Scientific impacts – now and in 5 years

The key impact of the project is that it will provide a framework for managing nutrient inputs and outputs for sustainable nutrient management for vegetable production in the southern Philippines.

The key message for achieving this impact is likely to be as follows:

“Organic inputs are often promoted as the solution to problems of declining soil fertility and agricultural productivity. This is driven by high prices of inorganic fertilisers, opportunities to beneficially reuse recycled organics and a desire to be more “organic”. However, recycled organics alone are unlikely to provide the nutrients required to achieve the productivity required to meet the food demands of the Philippines. Nevertheless, they have great potential to be used in conjunction with inorganic fertilisers to increase fertiliser use efficiency, improve soil quality and crop growth.

Sustainable soil fertility and nutrient management entails understanding soil fertility status, matching inputs to outputs and monitoring soil conditions to ensure nutrients do not accumulate or diminish over time”.

8.2 Capacity impacts – now and in 5 years

The most important impact has been in developing the capacity of the various project collaborators relating to new techniques for evaluating key issues affecting vegetable farmers and designing effective research programs for addressing these issues. These include new skills in designing and conducting facilitated workshops; critically evaluating current nutrient management practices using soil testing and knowledge of crop nutrient requirements; and performing economic analysis on the most cost effective forms of available fertilizers for supplying crop nutrient requirements.

The project has delivered professional development opportunities for both early stage and mid-career scientists as illustrated below:

In addition to being involved in the project, Dr. Anabelle Tulin, Dr. Agustin Mercado, Mr. Carmelito Lapoot and Ms. Juanita Salvani visited Australia in 2010, with highlights of the trip including:

- attending a project meeting in Victoria;
- visiting the NSW DPI’s Centre for Recycled Organics in Agriculture (CROA);
- touring agricultural enterprises in Victoria, South Australia, New South Wales and Queensland;
- meeting vegetable farmers engaged in large scale commercial vegetable production;
- observing the production, harvesting, post- harvest handling and storage and marketing of vegetables;
- visiting various research laboratories engaged in vegetable research
- having the opportunity to interact with Australian scientists.
- Visiting large scale commercial composting facilities in Sydney
- Attending the World Congress of Soil Science in Brisbane

The manager of the soil and plant laboratory, Mrs Cynthia Godoy, is scheduled to visit the NSW DPI laboratory at Wollongbar in April 2012 for training in new analytical techniques, sample processing and data management. Additional funds have also been secured from ACIAR to purchase new laboratory equipment to improve the capacity of the VSU lab to perform particular analytical techniques.

Another project team member, Dr. Nelda Gonzaga was awarded the John Dillon Fellowship in Australia last February 13, March 21, 2012

Moreover, the project has had a strong focus on building the capacity of the next generation of Philippine Agricultural Scientists through the completion:

- 1 Master of Science (Soil Science),
- 3 Bachelor of Science final year student projects in 2011
- 1 fourth year secondary school project.
- 1 elementary research paper submitted and presented during the science fair
- Capacity building of 6 recent graduates through their employment as Research Assistants on the project (Regie Bicamon, Mechelle Ranises, Roland Rallos, Cecille Quinones, Don Immanuel Edralin, Ruby Monera, Bensive Gabitano, Adrian Pahayac and Marciana Galambao).

Likewise the external capacity building of the project has been through the involvement of more than 5 farmer collaborators, the training of 24 Extension workers at the EATWELL workshop and over 400 farmers who attended the Farmer Techno Forums. In addition more than 10,000 farmers attended the various Field Days held in Visayas State University, NOMIARC, MOSCAT and Kapatagan.

8.3 Community impacts – now and in 5 years

The project has created awareness among farmers in each of the project sites on the importance of developing a site specific nutrient management program based on the efficient utilization of available soil resources. The current research program has a strong focus on developing nutrient management strategies which will lead to more sustainable, productive and profitable vegetable production system through the adoption of more judicious and appropriate use of inorganic and organic fertilizer inputs. Trainings have been held with farmer groups and their advisors to assist them in working through the considerations for achieving these goals. The trainings on Integrated Nutrient Management for Sustainable Vegetable Production improved the understanding of farmers and extension workers on the importance of properly managing the soils in their respective areas for a more profitable and highly sustainable vegetable production.

8.3.1 Economic impacts

The experiments undertaken have a strong economic component whereby the treatments selected are based on the most cost-effective method of supplying the nutrient requirements of the target crop. Hence, the key areas where the project is expected to deliver economic benefits are through adopting new nutrient management systems and using limited resources more efficiently. For example, tools have been developed to identify and compare the most cost effective form of nutrient inputs, whilst partial gross-margins budgets have been developed for the alternative nutrient management strategies which have been investigated.

8.3.2 Social impacts

At this stage, it is difficult to measure social impacts arising from the project. However, the participation of farmers, scientists, researchers and extension workers in the project will encourage good social interactions and collaboration which will result in positive empowerment of all the partners involved in this project. One very important accomplishment of the project so far has been the assistance given to two high school students, three undergraduate BSc students and one MSc student at the Visayas State University in meeting the operating costs of their respective research projects. This not only helped the students financially, but most importantly it gave them exposure to being involved in a multinational collaborative research project. Longer term it is hoped that this will create opportunities for both professional and social advancement, which may not have otherwise been possible. Moreover, campaigns on increasing consumption of vegetable and the importance of soil nutrients on vegetable production were done through the support given to elementary and high school students in the conduct of their student of their science research projects. These researches were presented during science fairs last year and fortunately these projects garnered awards as best research projects and best poster papers.

8.3.3 Environmental impacts

The key environmental impacts will be through the more efficient use of limited resources to ensure soil and water quality is protected. This will be achieved by advocating management practices which will ensure that soil fertility and crop productivity is maintained without leading to depletion or accumulation of nutrients in the soil and potential off-site impacts. The project also strongly advocates the use of organic amendments such as animal manures and vermi-composts in combination with inorganic fertilisers to ensure soil and waste resources are managed in a sustainable manner.

8.4 Communication and dissemination activities

Reports

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Dorahy, C. G. 2009. Integrated soil and crop nutrient management in vegetable crops in the southern Philippines. ACIAR Project SCNM/2007/066/1. Trip report July, 2009.

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Lapoot, C.R., JB Salvani, LV Duna, CA Dumayaca, RA Bicamon, **AB Tulin** and CG Dorahy. **2011**. Enhancing farmers knowledge on soil and crop nutrient management for vegetable production in Bukidnon. Proceedings of the 14th PSSST Annual Meeting and Scientific Conference held at Visayas State University, Baybay City, Leyte on May 25-27, 2011. pp. 62-63. ISSN 2094-5361.

Lapoot, CR, JB Salvani, LV Duna, CA Dumayaca, RA Bicamon, **AB Tulin** and CG Dorahy. **2011**. Nutrient elimination addition test (NEAT) on hybrid tomato in Adtuyon clay soils. Proceedings of the 14th PSSST Annual Meeting and Scientific Conference held at Visayas State University, Baybay City, Leyte on May 25-27, 2011. pp. 127-128. ISSN 2094-5361.

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Mercado A Jr, Tulin, AB and Dorahy C. 2010**.** Soil management and crop nutrition for tomato in acid soil of Claveria, Philippines. In Gilkes, RG, Prakongkep N, editors. Proceedings of the 19th World Congress of Soil Science; Soil Solutions for a Changing World; ISBN 978-0-646-53783-2; Published on DVD; http://www.iuss.org; Symposium 3.3.1; Integrated nutrient management; 2010 Aug 1-6. Brisbane, Australia: IUSS; 2010, pp. 271-273.

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Gabitano, B. 2010. Nutrient dynamics of soils planted to sweet pepper under protective structure and in an open field. A thesis submitted in partial fulfilment of the requirements of Bachelor of Science (Soil Science) at the Visayas State University, VISCA, Baybay, Philippines.

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Vallejera, C. A. E. 2011. Characterization and nutrient content analysis of various organic amendments used for vegetable production. A thesis submitted in partial fulfilment of the requirements of Master of Science (Soil Science) at the Visayas State University, VISCA, Baybay, Philippines.

Training Workshops

Extension Advisor Training Workshop with Excellent Learning Lessons (EATWELL). Northern Mindanao Integrated Agricultural Research Centre (NOMIARC), Department of Agricultural Regional Field Unit 10 (DARFU X), Malaybalay, Mindanao, Philippines. ACIAR Project SCNM/2007/066/1, 22-26 August, 2011. (http://projects.aciar.gov.au/philippines/node/2296)

Farmer Techno Forums

- 9th September 2011, NOMIARC, Malaybalay, Bukidnon
- 16th September 2011, MOSCAT, Claveria Misamis Oriental,
- 27th September, 2011Kapatagan, Davao del Sur,
- 4th October, Cabintan Vegetable Farmers Cooperative, Cabintan, Leyte,

Internal Workshops

Component 1 Team. 2010/11. ACIAR Project SMCN/2007/066/1 Research review and planning workshops:

- Glenelg Inn, Casterton, Victoria, Australia, July, 2010
- Xavier Estates, Cagayan de Oro, Mindanao, Philippines. 27-29 September, 2010
- Northern Mindanao Integrated Agricultural Research Centre (NOMIARC), Department of Agriculture Regional Field Unit 10 (DA RFU X), Malaybalay, Mindanao, Philippines. 11-15 April, 2011.

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Field Days

Science and Technology Based Farm on Chemical-free cabbage and bell pepper production. Northern Mindanao Community Agricultural Rural Research and Development (NOMCARRD), DARFU X, PCARRD, LGU, Imbayao, Malaybalay City, Bukidnon, Philippines. 19 May, 2009.

Drip irrigation, rainwater harvesting, soil and water conservation (ACIAR Small Research Activity SRA).

Field Day showcasing previous results and current research activities. Claveria, Misamis Oriental Philippines. 26 April, 2009.

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Farmers Field Days held in 2009, 2010 and 2011 at Visayas State University wherein the ACIAR Projects were presented to more than 5,000 farmers who attended the yearly events in the university. It is also worth noting that some of the outstanding farmer awardees during the anniversary were all collaborators of the ACIAR Vegetable Project At VSU.

Farmers Field Days held at NOMIARC in 2009, 2010 and 2011 were attended by more than 3,000 farmers, which were oriented with the latest developments in vegetable production.

Awards Obtained

1. 2012 AFMA Research and Development Award for Applied Research this coming October 17, 2012 durirng the 24th NRS Symposium sponsored by DA-BAR.
2. 2012 PSSST Best Paper Award given last May 18, 2012 during the 15th PSSST Annual Meeting and Scientific Conference held at Silliman University, Dumaguete City.
3. 2012 John Dillon Fellowship Award for Dr. Nelda R. Gonzaga last February 13 to March 21, 2012.
4. 2011 AFMA Research and Development Award for Applied Research during the 23rd NRS Symposium sponsored by DA – BAR.
5. 2011 Best Research Poster Award - 3rd Place during the 23rd Joint RRDEN and VICARP Regional Research and Development/Extension Symposium on August 2-3, 2011.
6. 2011 Regional POSTE Award for Best Research Paper
7. 2011 Best Research Award for Group Life Science Category during the VSULHS Science Fair – First Place (High School Division)
8. 2011 Best Research Poster Award during the VFES Science Fair – First Place (Elementary Division)
9. 2011 Best Research Paper Award during the VFES Science Fair - Second Place(Elementary Division)
10. 2011 Rookie Award for Outstanding Student’s Thesis during the ACIAR-PCARRD Annual Meeting last July 2011 for Ms. Clea Anne Vallejera.
11. 2010 PSSST Best Research Award (Junior Researcher Category – Jessie Sabijon and Anabella B. Tulin) given during the 13th PSSST Annual Conference and Scientific Meeting held at Puerto Princesa City, Palawan last May 27-28, 2010.
12. 2010 William Dar Research and Development Award for Dr. Anabella B. Tulin given during the PSAI Biennial Conference at BSWM last Nov 2010.
13. 2010 VSU Outstanding Researcher Award for Dr. Anabella B. Tulin given during the 86th VSU Anniversary Celebration last August 11, 2010.

1. Five posters were presented during the 19th World Congress of Soil Science held in Brisbane Australia last August 1-6, 2010.
2. A poster presenting the results of farm trial in Cabintan was presented as finalist during the Regional Symposium for RDE at VSU last August 25-27, 2010.
3. Kibangay trial paper entitled "Enhancing Farmers Knowledge on Soil and Crop Nutrient Management for Vegetable Production in Bukidnon, Mindanao, Philippines" was presented during the NOMIARC In – House Review (June 9, 2010) and during the Regional Agency In – House Review (June 29, 2010), won third place for Best Paper Award (Research Category). It was also presented during the 17th NOMCARRD RHSRD Symposium (August 5-6, 2010).

9 Conclusions and recommendations

9.1 Conclusions

The key findings of the project can be summarized in the following statement;

"Organic inputs are often promoted as the solution to problems of declining soil fertility and agricultural productivity. This is driven by high prices of inorganic fertilisers, opportunities to beneficially reuse recycled organics and a desire to be more "organic". However, recycled organics alone are unlikely to provide the nutrients required to achieve the productivity required to meet the food demands of the Philippines. Nevertheless, they have great potential to be used in conjunction with inorganic fertilisers to increase fertiliser use efficiency, improve soil quality and crop growth.

Sustainable soil fertility and nutrient management entails understanding soil fertility status, matching inputs to outputs and monitoring soil conditions to ensure nutrients do not accumulate or diminish over time". The framework for achieving these objectives was established. Each of the sections were supported by the key results from experimental work undertaken in the project both in the Philippines and Australia.

1. Vegetable growers identified lack of capital and high fertilizer prices as key constraints to vegetable production. However they are undersupplying some nutrients and oversupplying others leading to nutrients imbalances in the soil. Lack of capital is not an issue but an issue of more effective allocation of limited capital resources.

2. Sustainable soil fertility and nutrient management entails understanding of soil fertility status, matching inputs to outputs and monitoring soil conditions to ensure nutrients do not accumulate or diminish over time

3. A framework was developed to guide agricultural researchers in the planning and implementation of high impact researches on integrated nutrient management. Proper allocation of limited resources such as fertilizers will result in the sustainable management of marginal soils. Likewise this approach will lead to better utilization of fertilizers by vegetables.

4. Better vegetable soil and crop nutrition management enabled farmers to produce more with lesser inputs attaining better profitability and lesser environmental negative impacts

In answering the four major objectives of the project, the following activities were accomplished.

- Critically evaluated the current nutrient management practices and proposed alternative forms and rates of fertilizer inputs based on the soil test results and the current farmer's practice that would increase the productivity and profitability of vegetable production systems in the southern Philippines.
- Implemented alternative management practices that are based on the philosophy of matching fertilizer application to the nutrient requirements of the crop and the fertility status of the soil based on soil test results and mass balance approaches.
- Develop a framework for integrated nutrient management through the application of fertilizer based on crop need through soil analysis gave a better understanding of the farmer's effective and efficient allocation for farm inputs.

- Better understanding on the fertility status of the soil which served as the basis for proper fertilizer management in the area, understanding on nutrient application, uptake, removal and mass balances in vegetable production.
- Develop the capacity of the project team, farmer leaders, students, by exposing them to the latest researches on vegetable production in Australia, providing support for student thesis and research projects, and linkaging with the other components of the vegetable program.

9.2 Recommendations

Some of the following recommendations are suggested as possible researchable areas in the project.

1. Field based nutrient diagnosis (nutrient omission trials based on demo design)
2. Refinement of fertilizer forms and rates
3. Integration of organic and inorganic inputs
4. Lab capacity building (Equipment, Personnel, Processes)
5. Peri-urban Ag in Philippines and Australia - Key drivers of climate change and Environmental Sustainability
6. Continuing Education and Extension

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10.2 List of publications produced by project

List of oral and poster papers to be presented on the coming 15th PSSST Conference in Dumaguete, Negros Oriental on May 16-18, 2012:

a. Enhancement of the growth, yield and antioxidant activity of tomato grown under protective structure and open field conditions through potassium biofortification
b. Nutrient balance studies for sustainable cabbage production in P deficient soil
c. Material Substrates for Vermiculture
d. Revisiting nutrient balance for white potato production in Bukidnon, Minadanao Philippines

A. Conference Proceedings

Tulin, A.B., M.B. Ranises, M.B. Galambao and C. Dorahy. 2012. Nutrient balance studies for sustainable cabbage production in P deficient soil. Proceedings of the 15th PSSST Annual Meeting and Scientific Conference held at Silliman University, Dumaguete City, Negros Oriental on May 16-18, 2012. pp. 39-41. ISSN 2094-5361.

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Lapoot, C.R., J.B. Salvani, L.V.Duna, R.Bicamon, A.B. Tulin and C.G.Dorahy. Revisiting nutrient balance for white potato production in Bukidnon, Mindanao, Philippines. Proceedings of the 15th PSSST Annual Meeting and Scientific Conference held at Silliman University, Dumaguete City, Negros Oriental on May 16-18, 2012. pp. 95-96. ISSN 2094-5361.

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B. Journal Paper

Tulin, A.B., R.V. Rallos, M.B. Ranises and C. Dorahy. 2012. Integrated nutrient management for increased cabbage production in vegetable producing area of Cabintan, Ormoc City, Leyte, Philippines. Annals of Tropical Research. (Accepted for publication in ATR).

11 Appendixes

11.1 Appendix 1: Questionnaire used in the participatory assessment and soil survey

INTEGRATED SOIL AND CROP NUTRIENT MANAGEMENT IN VEGETABLE CROPS IN THE SOUTHERN PHILIPPINES- PARTICIPATORY APPRAISAL QUESTIONS IN LEYTE AND MINDANAO

SEPTEMBER-OCTOBER, 2008

Objectives:

The objective of this participatory assessment (PA) is to identify constraints / issues for soils used for vegetable production in the southern Philippines. The PA is structured around the following potential constraints, although others may become evident during the PA.

- Nutritional disorders (e.g. N,P,K, S and micronutrients)
- Soil structural degradation (e.g. Poor infiltration)
- Salinity/sodicity
- Pest and diseases

It is also an important mechanism for gathering information about the various vegetable production systems in the southern Philippines.

Introduction:

- Provide farmer with some context of the project and why we are conducting the PA (ie. Why are we here?)
- Ask the farmer what their needs are in terms of information they need to help them overcome production constraints (ie. What is in it for him?)

1.0 Farmer Information:

1.1. Name of Village: __________________ Barangay: _______________, Region

1.2. Farmers’ names, genders: _____________________

1.3. Size of farm: Marginal (<1ha.)/ Small (1-2.5 ha.) / Large (>2.5 ha.)

1.4. Land tenure (owner, tenant, share farmer, other):

1.5. Major occupation (s):

1.6. How long have you been farming?

1.7. How long have the fields in your village used for farming (years)?

1.8. What is the rainfall distribution and pattern in your area? (mm /month; mm/year, number of rainy days per month throughout the year?)

1.9. What are the sources of labour on your farm? (Family, contracted. How much does it cost to hire labour (PHP/hour or PHP/day)?

2.0 Management Practices:

2.1. What are the key crops grown in your village?
2.2. Which varieties are grown?
2.3. Where do you get your seed from?

2.4.	**Crop: Tomatoes**	**Crop: Potatoes**	**Crop: Brassicas**
Land preparation			
Nursery activities			

Planting			
Fertilizer			
Irrigation			
Weeding			
Spraying			
Other pest control measures			
Harvesting			
Marketing			
Others			

2.5. Are your crops irrigated or rainfed? If irrigated, can you please describe the irrigation system? Where do you get your water from and how is it applied?
2.6. What are yield differences between irrigated and non-irrigated crops?
2.7. Can you please describe your typical calendar of operations for each crop you grow? (appendix 1)
2.8. What yields do you usually get for your crops? (Important to make sure units of measurements are consistent (eg. t/ha.)

2.9. Do you grow vegetable crops in rotation with any crops (eg. Rice, legumes, others)? Which crops in which season?

3.0 Soil Management

Soil type

3.1. Can you please describe your soil?

3.2. How deep is the top soil?

3.3. Is it sand, silt or clay?

3.4. Does the water drain away quickly of does it sit on the soil surface after rain or irrigation?

3.5. Have you ever had soil test done? If so, do you any historical soil test results?

3.6. Do you know whether the soil is acid, neutral, of alkaline?

3.7. Have you noticed any changes in your soil over time (better or worse)?

3.8. Do you have any issues with respect to erosion or other forms of land degradation?

4.0 Nutrient Management:

4.1. Can you please describe the fertilizer history of each of your fields (eg. Fertilizer type, rate of application, dates of application)? (Important to ascertain N:P:K:S concentrations and application rates (kg/ha)

4.2. Where do you get your fertilizers from and how much do they cost? (Important to be able to convert prices to PHP/kg or PHP/t)

4.3. Do you use composts or animal manures? If so where do you get these from or do you make them? How much do they cost to make or buy? At what rate do you apply composts/manures (Kg/ha; t/ha)?

4.4. What are the key challenges around using organic fertilizers?

4.5. Do you use gypsum or lime in your soils? At what rate do you apply them? (Kg/ha; t/ha)

4.6. Is it difficult to obtain inorganic fertilizers, composts, lime or gypsum in your districts?

4.7. Have you observed any nutritional deficiencies in your vegetable crops? If so, what symptoms have you observed?

4.8. Have you had any nutrient /crop disorders diagnosed by soil testing or Department of Agriculture officer?

4.9. Do you have any soil salinity problems?

5.0 Bed preparation and management:

5.1. Can you please describe how the soil is cultivated on your farm?

5.2. If you used beds for your vegetable crops, how are they prepared? Do you use plastic mulching?

5.3. Do you use permanent beds?

5.4. What are the typical dimensions of your beds (height, width, length in meters)?

5.5. How do you drain your fields?

5.6. Have you noticed any soil structural problems (eg. Dospersion, sodicity, water logging, poor infiltration, and root growth)?

5.7. How do you manage crops residues (burning, incorporation, removal, composting)?

6.0 Pests and Diseases:

6.1. What are the main pests and diseases in your vegetable crops?

6.2. What measures do you usually use to control pests and diseases?

6.3. Has disease / pets incidence increased or decreased in recent years? If so, which ones?

In the field:

Vegatable	Most damaging pests and diseases	Amount of yield reduction	Control measures used	Control measures successful?	Additional information
Crop					
Crop					
Crop					

6.4. Sources of pests control recommendation:

6.5. Indigenous methods of pest control used:

6.6. Number of pesticide applications per crop and frequency ( ):

6.7. Names of pesticides used on each crop:

6.8. Rates of pesticides used (ml or L/ha)?

6.9. Cost of pesticides per crop per season (PHP):

6.10. Cost of pesticide application per spray (labour + pesticide cost):

6.11. Have you undergone any training in pest control? If yes what training? Who organized it?

6.12. Are you aware of seed treatments to control insects and diseases?

6.13. If yes, what measures do you use?

6.14. Are there beneficial insects/spiders (natural enemies) that help control pests on vegetables?

6.15. Do you do anything that affects the beneficial insects/spiders?

6.16. Do you monitor for pests/ diseases before spraying? If yes, do you use threshold levels?

7.0 Weeds:

7.1. What are the main weeds on your farm and how are they managed?

7.2. Do you use any herbicides? If so, which ones are used in each crop and at what rates (l/ha)?

7.3. How much herbicides costs (PHP/L)

8.0 Crop marketing:

8.1. What influence your decision to grow a particular crop?

8.2. Do you sell this vegetable immediately after harvest, or store them until prices are good?

8.3. Where do you market your vegetables?

8.4. Is the price based on grading?

8.5. Do you use crop insurance?

8.6. Are you a member of farmers’ group or organization?

9.0 Concluding questions:

9.1. What are your key soil fertility and plant nutrition needs?

9.2. What information do you need with respect to soil fertility and plant nutrition?

9.3. What factors will motivate you to adopt new soil management techniques?

9.4. What factors will constrain you from adopting new soil management techniques?

9.5. What resources do you need? (labour, fertilizers, chemicals, other inputs, equipment)?

9.6. What other information do you need?

Seasonal Calendar for ____________________ village, Barangay of ____________________

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Major crops												
Crop:												
Crop:												
Crop:												
Seasons												

11.2 Appendix 2. Physico-chemical characteristics of various soil samples from Cabintan, Claveria, Kapatagan, Kibangay and Mapayag.

A. Cabintan site

Site	Farmer	Soil depth (cm)	Bulk density (g/cc)	Moisture Content (%)	Particle size distribution			soil texture
					% clay	% silt	%sand	
	A	0-20	0.42	13.636	17.900	13.699	68.402	sandy loam
		20-40		23.457				
	B	0-20	0.33	16.279	10.605	10.977	78.419	sandy loam

Cabintan		20-40		23.205				
	C	0-20	0.82	13.636	24.110	19.909	55.982	sandy clay loam
		20-40		29.87				
	D	0-20	0.56	11.11	51.504	47.434	1.062	silty clay
		20-40		13.636				
	E	0-20	0.54	11.11	39.279	30.270	30.450	clay loam
		20-40		20.482				

Site	Farmer	Soil depth (cm)	Soil pH			OC %	Total N (%)	Avail P (mg/kg)
			H_2O	$CaCl_2$	KCl			
Cabintan	A	0-20	5.5	4.74	4.76	6.315	0.454	0.101
		20-40	5.58	5.18	5.39	3.239	0.259	0.126
	B	0-20	5.65	5.08	5.09	5.561	0.372	0.175
		20-40	5.57	5.22	5.14	4.392	0.321	0.178
	C	0-20	5.66	4.67	4.68	6.667	0.523	0.153
		20-40	5.93	5.36	5.14	3.809	0.260	0.133
	D	0-20	5.39	4.48	4.48	4.398	0.377	0.179
		20-40	5.24	4.66	4.68	2.62	0.250	0.167
	E	0-20	5.13	4.79	4.79	5.146	0.400	0.152
		20-40	5.54	4.81	5.13	3.289	0.289	0.192

Site	Farmer	Soil depth (cm)	Exchangeable Elements (me/100g soil)						
			Cations					Acidity	CEC
			K	Na	Ca	Mg	Al		
Cabintan	A	0-20	0.272	0.038	0.965	0.194	0.215	0.456	1.6840
		20-40	0.132	0.149	0.843	0.137	0.078	0.212	1.3390
	B	0-20	0.188	0.04	0.726	0.087	0.220	0.467	1.2610
		20-40	0.334	0.121	1.052	0.102	0.162	0.368	1.7710
	C	0-20	0.309	0.111	0.704	0.177	0.358	0.586	1.6590
		20-40	0.329	0.112	0.509	0.122	0.078	0.355	1.1500
	D	0-20	0.411	0.1	0.909	0.184	0.910	1.083	2.5140
		20-40	0.401	0.144	0.46	0.103	0.215	0.717	1.3230
	E	0-20	0.645	0.178	0.62	0.122	0.210	0.446	1.7750
		20-40	0.425	0.108	0.902	0.188	0.076	0.484	1.6990

B. Claveria site

Site	Farmer	soil depth (cm)	Moisture Content (%)	Particle size distribution			soil texture
				% clay	% silt	%sand	
	F	0-20	20.041	48.230	20.905	30.864	clay
		20-40	3.093				

Claveria	G	0-20	2.041	70.569	23.252	6.179	clay
		20-40	4.17				
	H	0-20	2.041	62.951	19.344	17.705	clay
		20-40	1.01				
	I	0-20	4.17	67.049	23.443	9.508	clay
		20-40	3.093				
	J	0-20	1.01	62.439	23.252	14.309	clay
		20-40	1.01				

Site	Farmer	Soil depth (cm)	Soil pH			OC (%)	Total N (%)	Avail P (mg/kg)
			H_2O	$CaCl_2$	KCl			
Claveria	F	0-20	5.54	5.03	5.05	3.831	0.11	31.594
		20-40	5.6	4.86	4.94	2.312	0.06	2.046
	G	0-20	6.69	6.28	5.03	7.163	0.22	3.461
		20-40	5.45	5.1	5.01	4.368	0.13	0.43
	H	0-20	5.32	4.74	4.8	4.478	0.13	30.226
		20-40	5.01	4.7	4.78	2.56	0.07	2.832
	I	0-20	5.25	4.48	4.49	5.942	0.17	41.107
		20-40	5.24	4.61	4.64	3.769	0.11	4.105
	J	0-20	5.73	4.82	5.04	7.19	0.14	12.555
		20-40	5.26	5.14	5.24	2.364	0.07	0.144

Site	Farmer	Soil depth (cm)	Exchangeable Elements (me/100g soil)						
			Cations					Acidity	CEC
			K	Na	Ca	Mg	Al		
Claveria	F	0-20	0.605	0.034	2.365	0.39	0.193	0.175	3.569
		20-40	0.726	0.06	0.818	0.134	0.130	0.236	1.974
	G	0-20	0.822	0.123	10.094	0.86	0.064	0.175	12.074
		20-40	0.718	0.175	3.776	0.441	0.460	0.538	5.648
	H	0-20	0.772	0.063	1.785	0.392	0.064	0.175	3.187
		20-40	0.672	0.061	0.879	0.19	0.127	0.174	1.976
	I	0-20	0.601	0.036	2.224	0.252	0.328	0.538	3.651
		20-40	0.477	trace	1.505	0.118	0.065	0.532	2.632
	J	0-20	0.441	0.094	2.544	0.179	0.127	0.290	3.548
		20-40	0.388	0.099	1.412	0.183	0.197	0.580	2.662

C. Kapatagan site

Site	Farm	Soil	Moisture	Particle size distribution	Soil texture

	er	depth (cm)	Content (%)	% clay	% silt	% sand	
Kapatagan	W	0-20	12.359	45.249	18.100	36.652	clay
		20-40	12.359				
	X	0-20	8.696	58.596	21.930	19.474	clay
		20-40	13.636				
	Y	0-20	20.482	41.786	15.000	43.214	clay
		20-40	11.11				

Site	Farmer	Soil depth (cm)	Soil pH			OC (%)	Total N (%)	Avail P (mg/kg)
			H_2O	$CaCl_2$	KCl			
Kapatagan	W	0-20	5.52	4.79	4.49	1.578	0.224	0.852
		20-40	5.91	5.15	4.78	2.283	0.169	0.341
	X	0-20	5.65	4.9	4.69	2.396	0.239	0.753
		20-40	5.5	4.75	4.68	1.95	0.204	0.951
	Y	0-20	5.8	5.02	4.67	2.02	0.229	0.996
		20-40	5.22	4.7	4.37	1.82	0.200	0.441

Site	Farmer	Soil depth (cm)	Exchangeable Elements (me/100g soil)						
			Cations					Acidity	CEC
			K	Na	Ca	Mg	Al		
Kapatagan	W	0-20	1.684	0.292	4.073	0.817	0.308	0.516	7.174
		20-40	2.828	0.091	5.186	0.888	0.142	0.258	9.135
	X	0-20	1.124	0.256	4.996	0.793	0.206	0.436	7.375
		20-40	1.786	0.258	4.073	0.591	0.358	0.717	7.066
	Y	0-20	2.159	0.121	4.848	1.035	0.128	0.207	8.291
		20-40	1.266	0.215	4.294	0.769	0.630	1.083	7.174

D. Kibangay site

Site	Farmer	Soil depth (cm)	Moisture Content (%)	Particle size distribution			Soil texture
				% clay	% silt	%sand	
Kibangay	P	0-20	14.943	67.778	27.778	4.444	clay
		20-40	19.048				
	Q	0-20	11.11	34.260	19.937	47.803	Sandy clay loam
		20-40	14.943				
	R	0-20	14.343	60.893	26.786	12.321	clay
		20-40	20.482				
	S	0-20	8.696	55.197	21.834	22.969	clay
		20-40	9.89				
	T	0-20	6.383	46.261	15.826	37.913	clay
		20-40	12.359				
	Z	0-20	14.943	49.550	22.523	27.928	clay
		20-40	5.263				
	a1	0-20	9.89	50.044	22.026	27.930	clay
		20-40	12.359				

Site	Farmer	Soil depth (cm)	Soil pH			OC (%)	Total N (%)	Avail P (mg/kg)
			H_2O	**$CaCl_2$**	**KCl**			
Kibangay	P	0-20	5.53	4.61	4.36	2.846	0.322	16.683
		20-40	5.7	4.92	4.54	2.135	0.25	6.333
	Q	0-20	5.75	4.88	4.65	4.787	0.667	18.567
		20-40	6.02	5.15	4.9	4.033	0.506	4.309
	R	0-20	5.34	4.52	4.49	2.644	0.241	4.767
		20-40	5.49	4.77	4.5	1.645	0.157	0.617
	S	0-20	5.67	4.76	4.74	2.968	0.304	8.895
		20-40	5.94	5.12	5.12	1.522	0.176	3.344
	T	0-20	6.1	5.23	5.09	3.029	0.255	21.697
		20-40	6.06	5.26	5.19	1.578	0.157	0.552
	Z	0-20	5.55	4.73	4.48	3.183	0.31	0.834
		20-40	6.15	5.48	5.47	1.765	0.137	0.260
	a1	0-20	5.52	4.8	4.54	2.722	0.264	0.726
		20-40	5.08	4.38	4.22	1.862	0.18	0.307

Site	Farmer	Soil depth (cm)	Exchangeable Elements (me/100g soil)						
			Cations					Acidity	CEC
			K	Na	Ca	Mg	Al		

Kibangay	P	0-20	2.76	0.084	0.752	8.865	0.255	0.527	12.716
		20-40	3.383	0.142	0.794	8.705	0.150	0.273	13.174
	Q	0-20	1.869	0.168	0.596	11.636	0.350	0.573	14.619
		20-40	2.276	0.179	0.529	9.517	0.072	0.461	12.573
	R	0-20	0.881	0.182	0.389	4.267	0.362	0.725	6.081
		20-40	0.753	0.128	0.37	3.795	0.228	0.622	5.274
	S	0-20	0.353	0.101	0.13	2.769	0.206	0.312	3.559
		20-40	0.388	0.111	0.091	0.923	0.069	0.315	1.582
	T	0-20	0.639	0.096	0.254	6.991	0.425	0.244	8.405
		20-40	0.523	0.121	0.151	3.796	0.142	0.257	4.733
	Z	0-20	1.31	0.125	3.302	0.659	0.507	0.593	5.903
		20-40	0.124	0.138	2.648	0.295	trace	0.302	3.205
	a1	0-20	1.576	0.062	3.719	0.874	0.346	0.441	6.577
		20-40	0.537	0.186	2.572	0.438	0.921	1.740	4.654

E. Mapayag site

Site	Farmer	Soil depth (cm)	Moisture Content (%)	Particle size distribution			Soil texture
				% clay	% silt	%sand	
Mapayag	K	0-20	12.359	56.178	22.222	21.600	clay
		20-40	12.359				
	L	0-20	17.647	21.887	4.717	73.396	sandy clay loam
		20-40	21.951				
	M	0-20	9.89	51.053	17.544	31.404	clay
		20-40	11.11				
	N	0-20	8.696	55.929	17.699	26.372	clay
		20-40	13.636				
	O	0-20	7.527	67.706	12.987	19.307	clay
		20-40	9.89				

Site	Farmer	Soil depth (cm)	Soil pH			OC (%)	Total N (%)	Avail P (mg/kg)
			H_2O	$CaCl_2$	KCl			
Mapayag	K	0-20	5.94	5.06	4.99	1.183	0.124	0.514
		20-40	5.76	5.14	5.14	0.898	0.079	0.108
	L	0-20	5.7	4.66	4.7	5.962	0.447	0.508
		20-40	5.73	4.93	5.01	2.877	0.256	0.201
	M	0-20	5.56	4.75	4.77	2.336	0.264	0.226
		20-40	5.85	5.03	5.05	1.602	0.155	0.037
	N	0-20	5.78	4.92	4.96	1.378	0.152	0.068
		20-40	5.83	5.26	5.22	0.842	0.114	0.243

	O	0-20	5.44	4.52	4.66	2.16	0.172	0.238
		20-40	5.46	4.87	5.02	1.479	0.121	0.788

Site	Farmer	Soil depth (cm)	Exchangeable Elements (me/100g soil)						
			Cations					Acidity	CEC
			K	Na	Ca	Mg	Al		
Mapayag	K	0-20	0.285	0.142	0.095	2.199	0.071	0.193	2.792
		20-40	0.230	0.132	0.067	1.379	0.142	0.258	1.950
	L	0-20	0.269	0.127	0.192	2.334	0.304	0.405	3.226
		20-40	0.310	0.134	0.132	1.34	0.154	0.280	2.070
	M	0-20	0.407	0.125	0.191	3.465	0.208	0.315	4.396
		20-40	0.329	0.117	0.120	2.124	0.210	0.318	2.900
	N	0-20	0.348	0.121	0.076	1.034	0.206	0.312	1.785
		20-40	0.189	0.124	0.077	1.291	0.086	0.390	1.767
	O	0-20	0.277	0.123	0.103	0.577	0.504	0.573	1.584
		20-40	0.257	0.113	0.092	0.581	0.126	0.229	1.169

Site	Farmer	Soil depth (cm)	Exchangeable Elements (me/100g soil)						
			Cations					Acidity	CEC
			K	Na	Ca	Mg	Al		
Kapatagan	W	0-20	1.684	0.292	4.073	0.817	0.308	0.516	7.174
		20-40	2.828	0.091	5.186	0.888	0.142	0.258	9.135
	X	0-20	1.124	0.256	4.996	0.793	0.206	0.436	7.375
		20-40	1.786	0.258	4.073	0.591	0.358	0.717	7.066
	Y	0-20	2.159	0.121	4.848	1.035	0.128	0.207	8.291
		20-40	1.266	0.215	4.294	0.769	0.630	1.083	7.174

11.3 Dissemination and Communication Papers/Proceedings

1. Proceedings of the EATWELL training held in NOMIARC, Dalwangan, Malaybalay, Bukidnon last August 2011.

2. Proceedings of Farmers Techno fora held in Cabintan, Leyte; NOMIARC, Malaybalay, Bukidnon and MOSCAT, Claveria, Misamis Oriental last September and October 2011.

3. Proceedings of Farmer's Field Day held in Claveria, Misamis Oriental last April 2012.