Australian Government
Australian Centre for International Agricultural Research

Final report

project	**Optimising the productivity of the potato/brassica cropping system in Central and West Java and potato/brassica/allium system in South Sulawesi and West Nusa Tenggara**
project number	AGB/2005/167
date published	August 2011
prepared by	Peter Dawson
co-authors/ contributors/ collaborators	Putu Cakra Putra Adnyana, Dr Mieke Ameriana (dec.), Mr Akhmad Arifudin, Mr Muhammad Assad, Rofik Sinung Basuki, Budi, Ms Rachelle Crawford, Mr Rudolf de Boer, Ms Caroline Donald, Pepen Effendi, Dr Michael Furlong, Ms Fiona Goss, Dr Nikardi Gunadi, Gunawan, Ms Baiq Nurul Hidayah, Ir Dadan Hidyat, Mr Terry Hill, Mr Himawan, Ibu Siwi Indarti, Mr Eko Istiyanto, Jayadi Sp, Mr Kunto Kumoro, Mr Kus Kuswardiyanto, Ms Rachel Lancaster, Mr Stewart Learmonth, Mr Baso Aliem Lolugau, Dr John Marshall, Mr Paul Mattingley, Dr Ian McPharlin, Mr Mufrodin Sp, Lilik Mukhibah, Prof Mulyadi, Mulyanto Sp, Ms Rini Murtiningsih, Ibu Warda Mustafa, Dr Nasrullah, Ms Sri Wahyuning Ning, Nurjanami, Ms Mien Pakih, Rahadi Spd, Ir Juju Rukmana Mm, Bambang Rahayu, T.P, Dr Peter Ridland, Mr Hidayat Sayono, Mr Frans Silva, Dr Eri Sofiari, Mr Achmad Sudjudi, Ir Suhari, Sulistyo, Ms Helda Tahir, Mr Andrew Taylor, Mr Bruce Tomkins, Mr David Tooke, Mr B Triman, Mr Andrew Van Burgel, Dedi Wahid Sp, Ibu Warda, Ms Julie Warren, Wawan S, Purwono Yunianto and Mr Zamzaini
approved by	Mr David Shearer, Research Program Manager for Agribusiness, ACIAR

final report number	FR2011-24
ISBN	978 1 921962 08 0
published by	ACIAR GPO Box 1571 Canberra ACT 2601 Australia

Contents

1 Acknowledgments

1.1 Dedication

Vale Dr Mieke Ameriana, 1957 – 2009

Indonesian Project Coordinator ACIAR Project AGB/2005/167

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

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

We pray for her. May God bless her.

1.2 Acknowledgments

Enthusiastic help and generous hospitality was given by the following farmer groups: In West Java; Barokah Tani, Karya Mandiri, Medal Sawargi, Mekar Tani II, Mekar Tani Muda, Mitra Mukti, Mukti Tani, Perjuangan Tani Mukti, Sauyunan, Suka Haji, In Central Java; J: Bukit Mandu, Klakah Sarimulyo, Manunggal, Ngudi Luhur, Sekar Tani, Sri Rejeki, Tempel Sari, Trubus, Tunas Harapan Jaya, In South Sulawesi; Bonto Ganjeng, Kayu Putea/Gemah Baru, Lemo Lemo, Ta'ca'la, Taruna Tani Silanggaya, Veteran, In NTB; Orong Dayan Pangsor Serut, Orong Dayan Desa + Buatan, Orong Lendang Luar, Orong Tenjong, Orong Paok + Kekoro, Orong Ronggak + Telaga.

The assistance of the farmer group guides is acknowledged: In West Java; Ir Ade, Ayat H, Asep Budi DS, Pepen Efendi, Asep Koswara, Nandang, Endang Nuryaman, H. Otang, Rahmat, Asep Rohiman, Ade Rubini, Ending Sahidin, Oji Setiadi, Iwan Setiawan, H, Sopanji, Suryana, Encu Sofian, Dayat Suhendra Supiadi, Amang Taryana, Wahyudin, Central Java; Amin Didik Hartoji, Mahyat, Ahmad Nurholis, Muslim, Sadilan, Hari Sudrajat AMd, Widodo, In NTB; Darwinti, Halik Hasbi, Abdul Jalil, Risdun, Rupnih, Suhilwadi, Syuaib plus Mr Minardi, Head of Kelompok Horsela.

Georgina Wilson of DAFWA is thanked for her expert editing of the project's extension publications. Mr Cahyo Mursito of LPTP is thanked for his expert production of the three videos.

The Western Australian and Victorian potato and vegetable industries are thanked for the assistance with training visits for Indonesian project partners.

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

2 Executive summary

Aim

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

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

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

Identification of constraints

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

Improved Farmer Field School Method to test constraints

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

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

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

Improved access to quality seed potatoes

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

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

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

Other project Impacts

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

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

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

3 Background

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

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

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

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

With potatoes, the major areas requiring improvement are:

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

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

- implementation of field pest and disease management strategies;

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

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

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

4 Objectives

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

The four major objectives are to:

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

5 Methodology

5.1 Project partners

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

5.2 Project planning

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

5.3 Baseline surveys

5.3.1 Planning

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

5.3.2 Design and scope

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

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

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

Potatoes

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

Cabbages

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

5.3.3 Survey assessment

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

5.3.4 Soil and plant tests

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

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

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

5.3.5 Pest and disease type, incidence and control

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

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

5.3.6 Diamondback moth studies

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

5.3.7 Yield

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

5.3.8 Agronomic data analysis

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

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

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

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

5.3.9 Economic data analysis

Gross margin

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

Regression analysis

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

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

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

Validity of data

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

5.4 PCN studies

5.4.1 PCN status of Lombok

Potato cyst nematode survey at Sembalun, NTB.

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

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

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

5.4.2 Development of Sembalun as seed production area

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

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

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

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

5.4.3 PCN species identification

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

PCR

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

Morphology

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

5.4.4 PCN pathotype identification

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

5.4.5 PCN population decline experiment

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

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

5.5 Training of trainers for potato-cabbage FFS facilitators

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

5.5.1 Training of trainers curriculum development workshops

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

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

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

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

5.7 FFS through consecutive potato and Brassica seasons

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

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

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

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

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

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

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

5.8 Mid-term review workshop

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

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

5.9 Farmer conference/project evaluation workshop

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

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

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

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

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

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

5.10 Impact evaluation of ICM activities

5.10.1 Survey of Brassica/potato farmer groups

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

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

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

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

5.10.2 Case studies to identify social change impacts

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

5.10.3 Economic evaluations of farmer initiated learning outcomes

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

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

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

Benefit of treating clubroot with variety and lime

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

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

Benefits of using PCN free seed for South Sulawesi

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

Benefit of improved potato late blight management

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

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

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

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

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

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

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

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

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

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

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

6 Achievements against activities and outputs/milestones

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

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

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

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

PC = partner country, A = Australia

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

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

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

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

PC = partner country, A = Australia

7 Key results and discussion

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

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

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

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

7.1.1 Potato ICM Farmer Field Schools, 1st cycle.

West Java 2007/08.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The farmers reported that they wanted to learn more about:

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

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

Central Java 2008

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

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

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

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

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

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

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

NTB 2008

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

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

7.1.2 Baseline surveys of potatoes (excluding seed)

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

Gross margins

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

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

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

Gross margin and yield correlations

The correlation of gross margin to yield was investigated to:

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

Indicative breakeven yields for the four provinces were:

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

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

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

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

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

Potato late blight

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

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

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

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

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

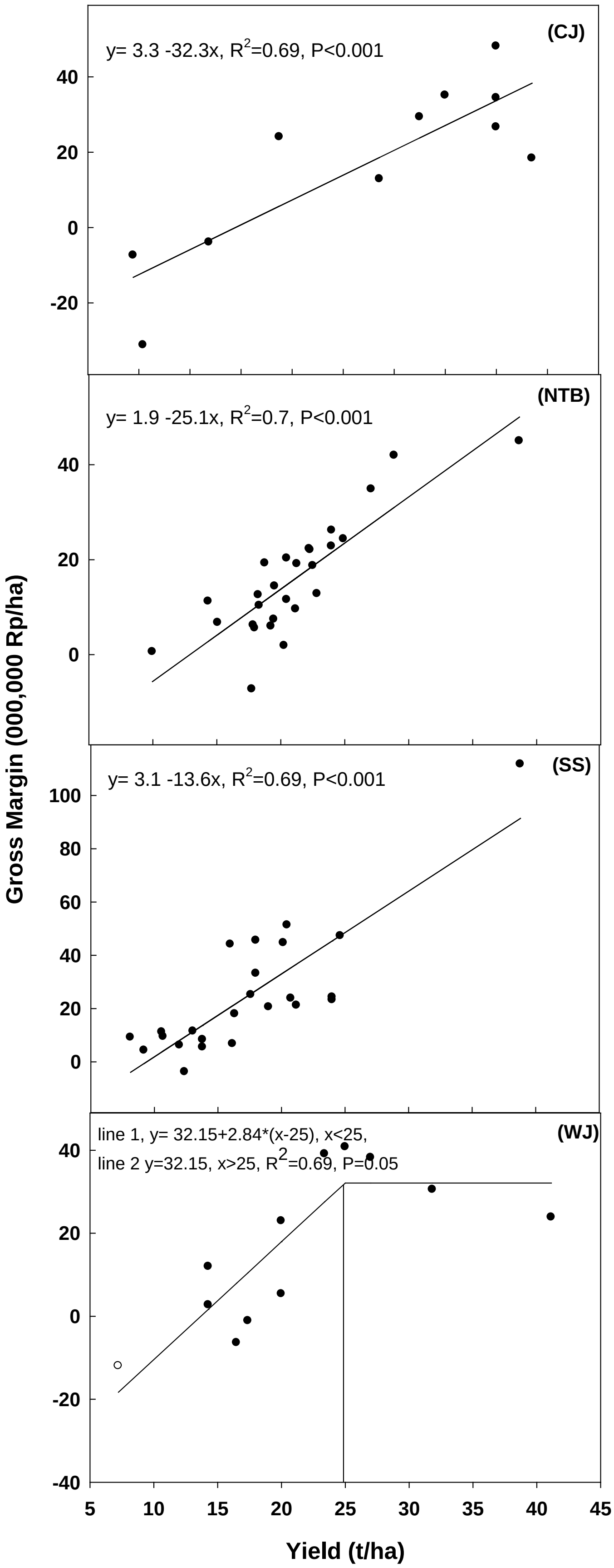

Figure 7.2. Linear regression of yield with gross margin in CJ, NTB, SS and WJ. (A2 F6.2).

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

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

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

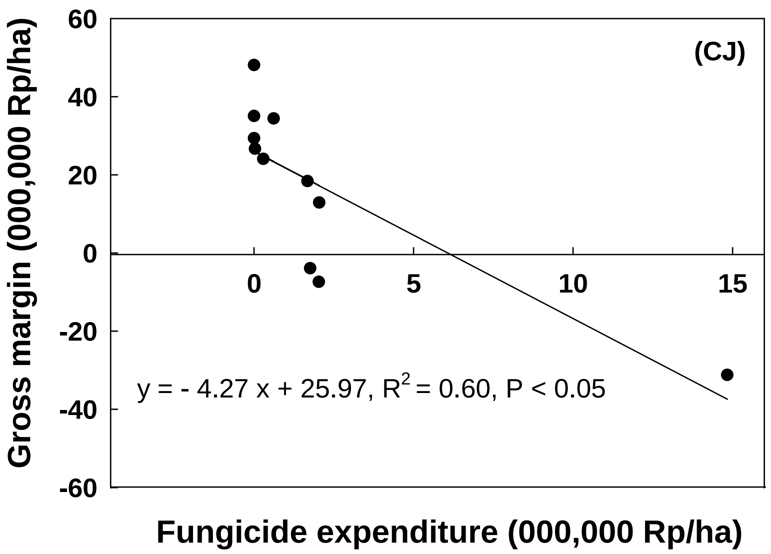

Figure 7.3. Linear regression of gross margin with fungicide expenditure (including labour costs to apply) in CJ. (A2 F6.11).

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

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

Soil pH

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

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

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

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

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

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

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

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

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

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

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

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

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

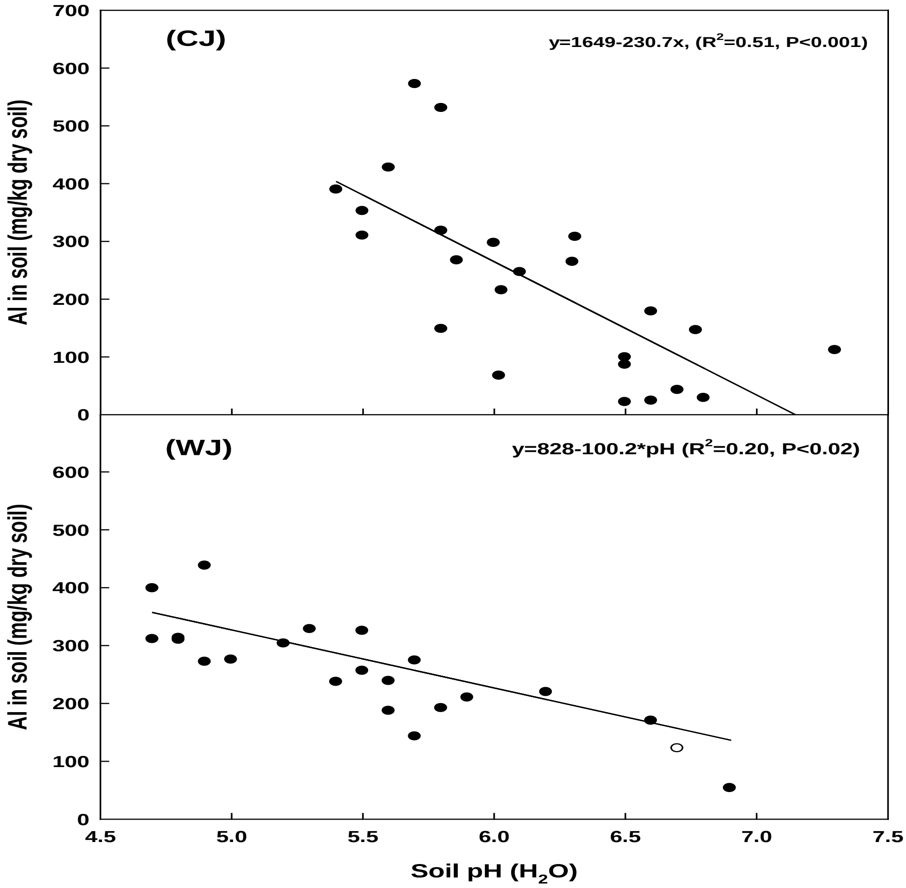

Figure 7.4. Linear regression between Al concentration versus pH in topsoil in CJ and WJ. (A1 F6.21).

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

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

Leafminer fly

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

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

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

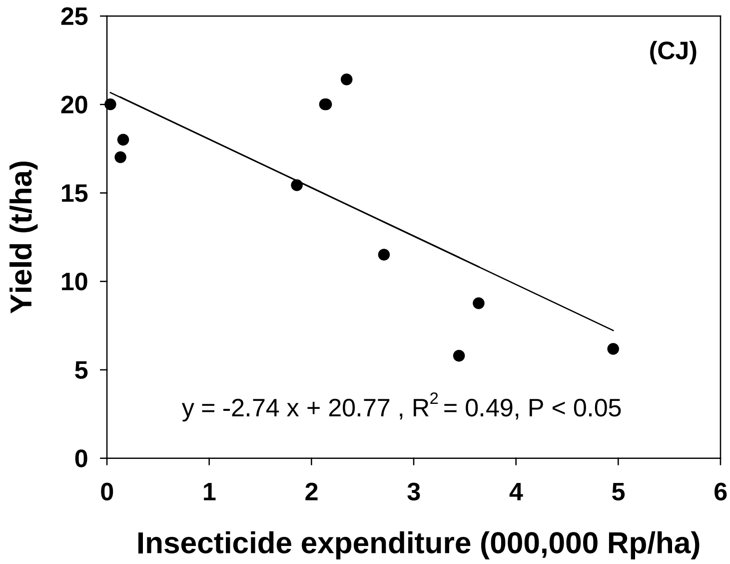

Figure 7.5. Linear regression of yield with insecticide expenditure (including labour to apply) in Central Java. (A2 F6.7).

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

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

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

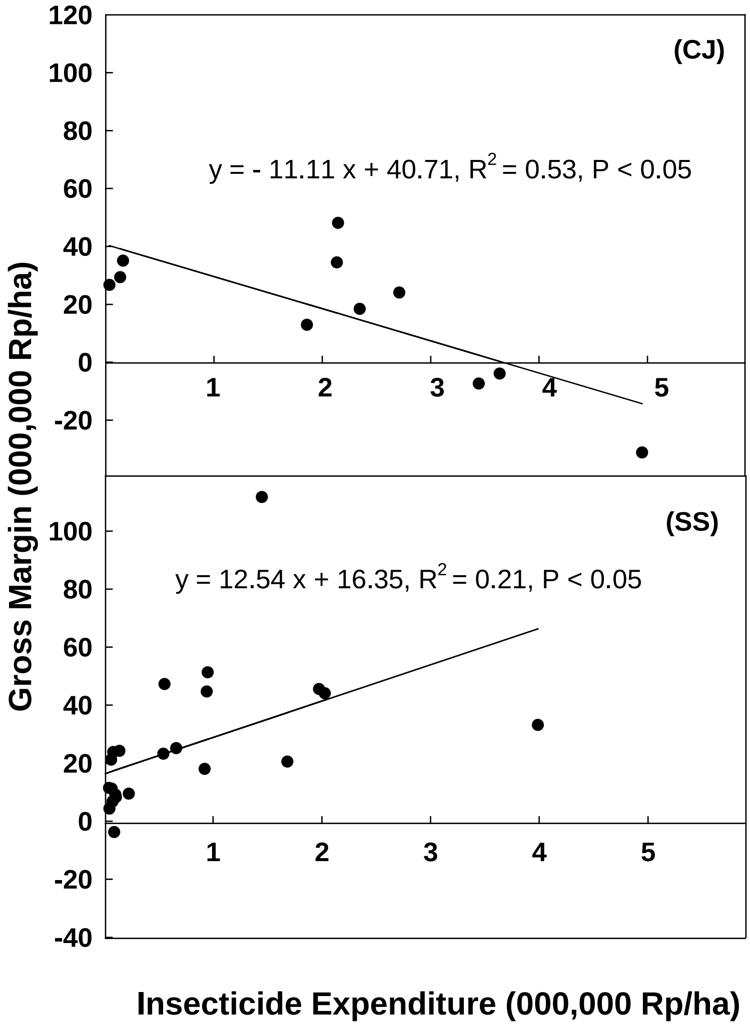

Figure 7.6. Linear regression of gross with insecticide expenditure (including labour to apply) in CJ. (A2 F6.8).

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

Fertiliser management

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

Nitrogen

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

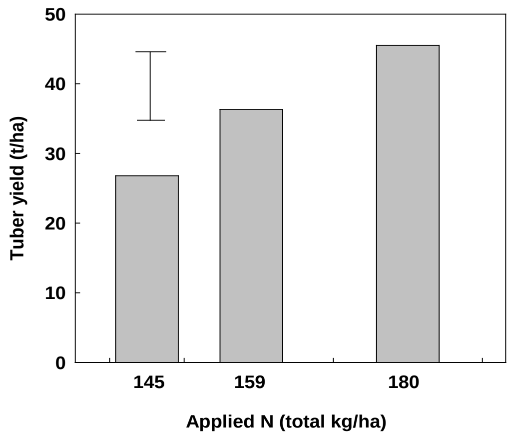

Figure 7.7. Tuber yield with rate of applied N in NTB. Bar is LSD for differences (P < 0.10) in yield between Kg N/ha from the ANOVA. (A1 F6.15).

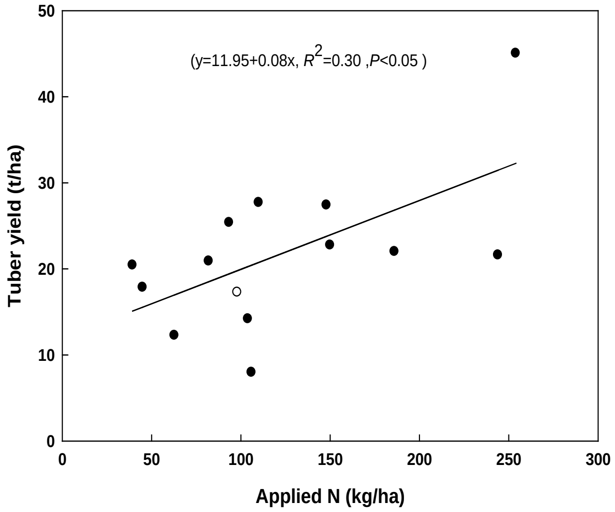

Figure 7.8. Linear regression between tuber yield and rate of applied N in SS. (A1 F6.18).

Phosphorus

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

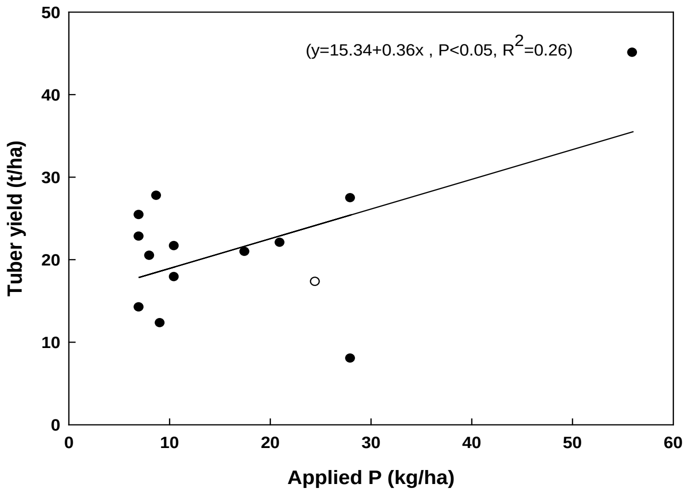

Figure 7.9. Linear regression between tuber yield and rate of applied P in SS. (A1 F6.19).

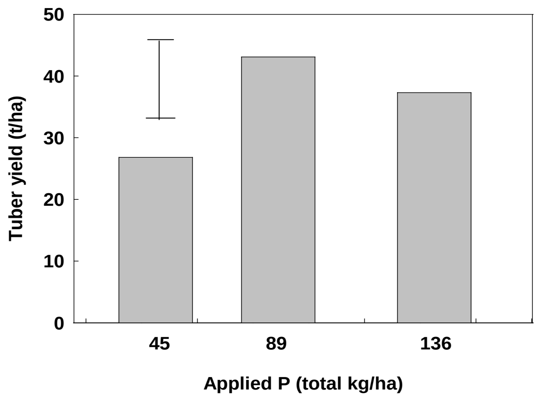

Figure 7.10. Tuber yield with rate of applied P in NTB. Bar is LSD for differences ($P < 0.05$) in yield between Kg P/ha from the ANOVA. (A1 F6.16).

Potassium

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

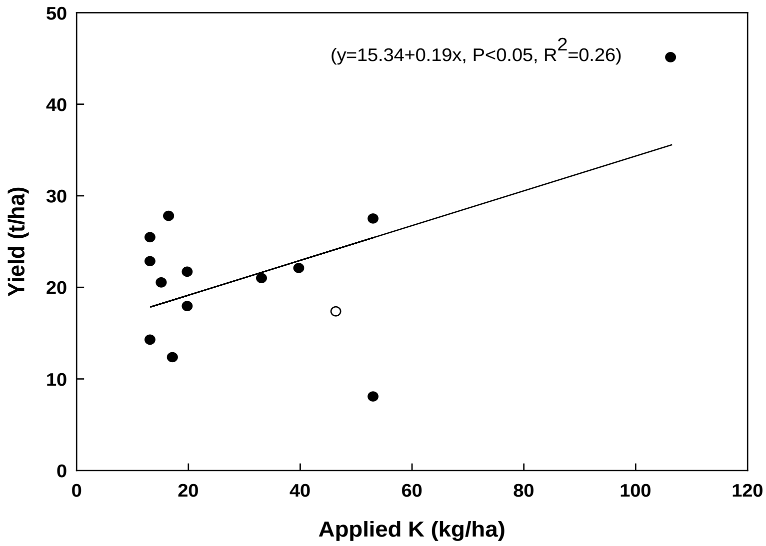

Figure 7.11. Linear regression between tuber yield and rate of applied K in SS. (A1 F6.20).

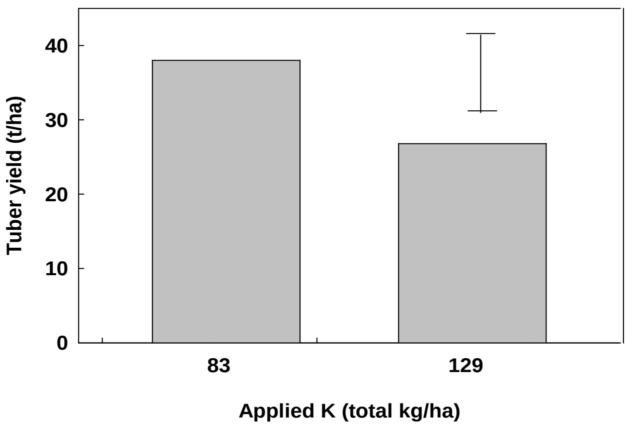

Figure 7.12. Tuber yield with rate of applied K in NTB. LSD bar shown is for differences (P < 0.05) in yield between Kg K/ha although the ANOVA showed differences were significant at P = 0.001. (A1 F6.17).

Potato cyst nematode

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

7.1.3 Potato ICM Farmer initiated learning, 2nd cycle

Modification of FFS methodology to FIL

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

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

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

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

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

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

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

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

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

FIL lime West Java 2008/2009

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

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

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

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

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

Potato late blight West Java 2008/09

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

Superphosphate and compost NTB 2009

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

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

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

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

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

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

Potassium NTB 2009

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

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

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

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

7.1.4 Potato ICM Farmer initiated learning, 3rd cycle

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

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

Updating training manuals, and develop extension materials

Technical Toolkits

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

Instructional DVDs

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

Factsheets and posters

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

Website

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

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

FIL NTB 2010

Potato late blight

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

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

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

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

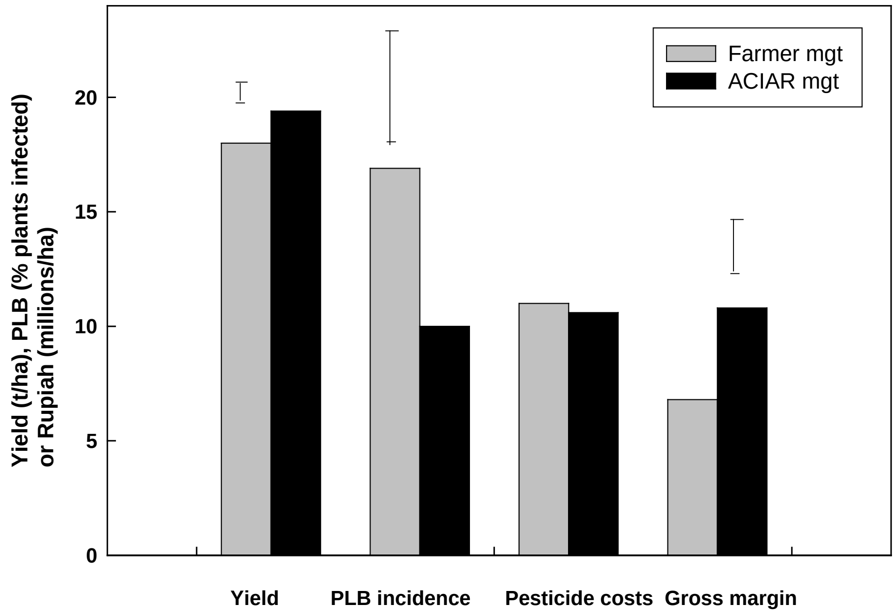

Figure 7.13. Effects of improved PLB management at Sembalun, Lombok. Yield was significantly higher for the ACIAR management (LSD P < 0.05 = 0.4 t/ha), % plants infected by PLB was significantly lower for the ACIAR management (LSD P < 0.1 = 4.9%) and gross margin was significantly higher for the ACIAR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

7.1.5 Baseline surveys of cabbage

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

Gross margins

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

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

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

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

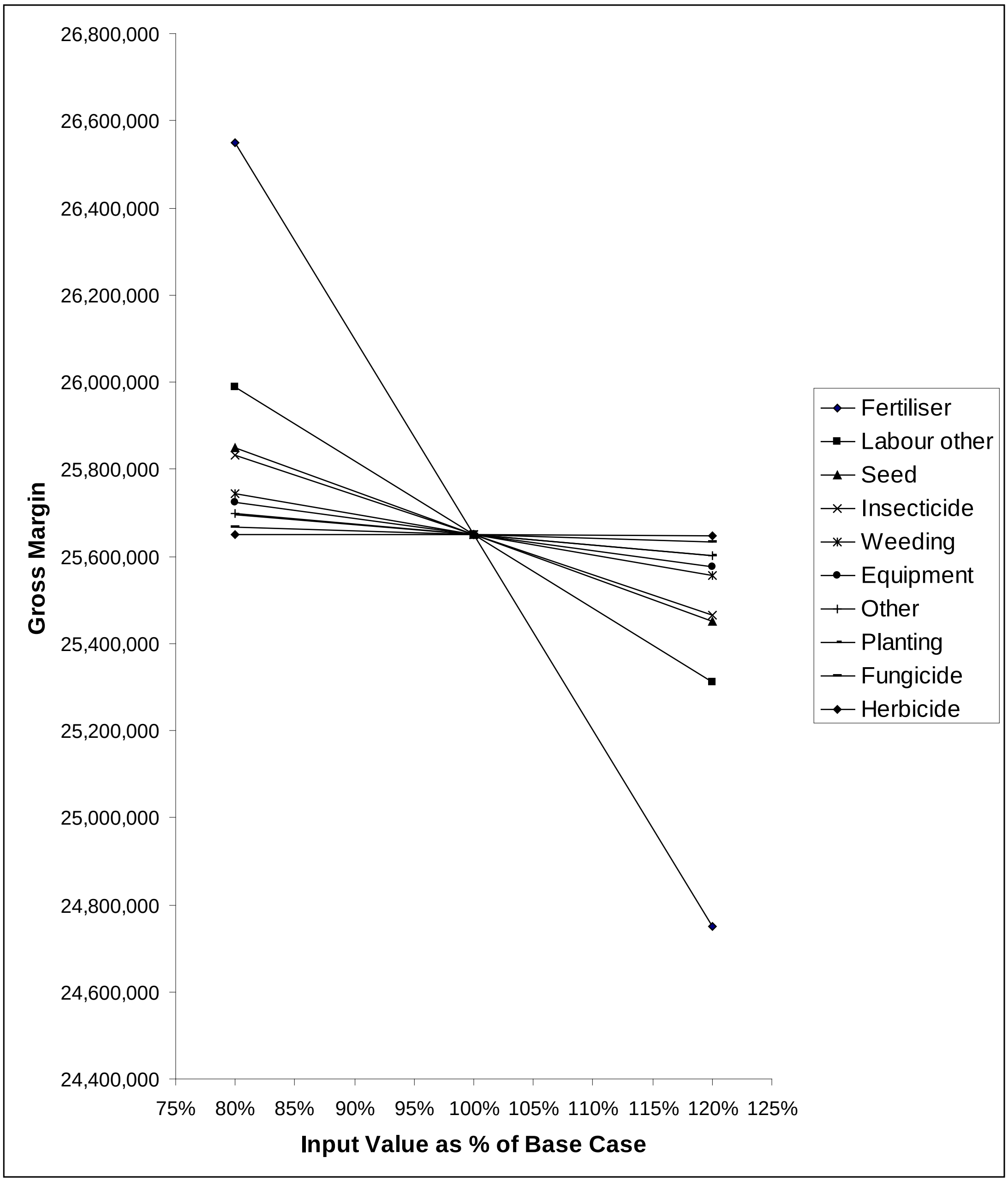

Figure 7.14. Gross margin sensitivity analysis (spider chart) for cabbage in Central Java. (A4 F6.1).

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

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

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

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

Gross margin regression analysis

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

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

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

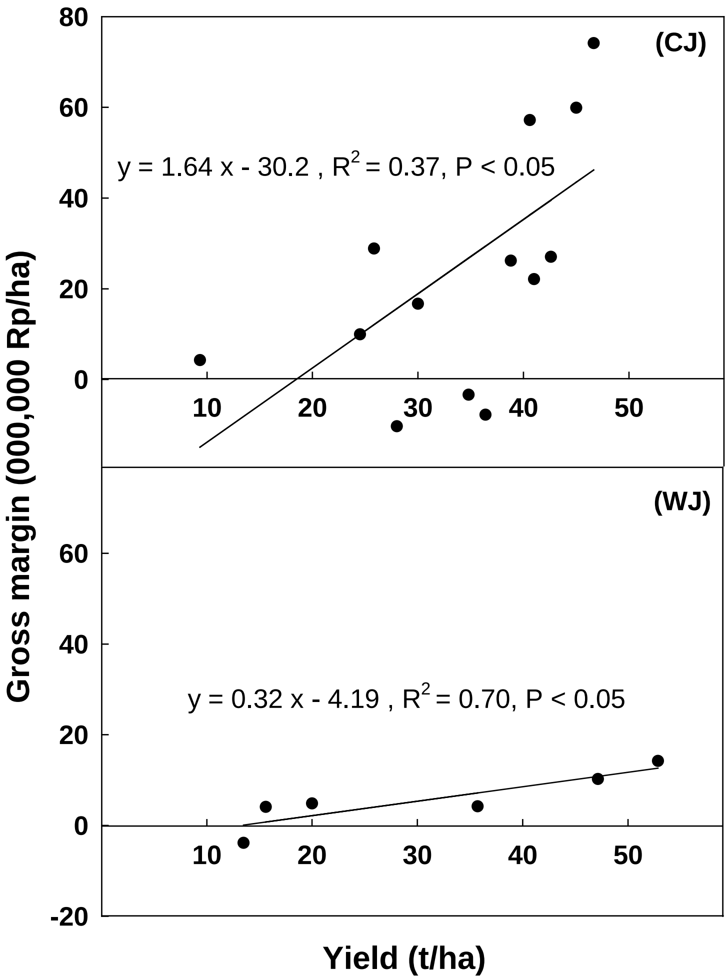

Figure 7.15. Linear regression of cabbage yield with gross margin in WJ and CJ, ($P < 0.05$). (A4 F6.2).

Fertiliser expenditure and average price regression

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

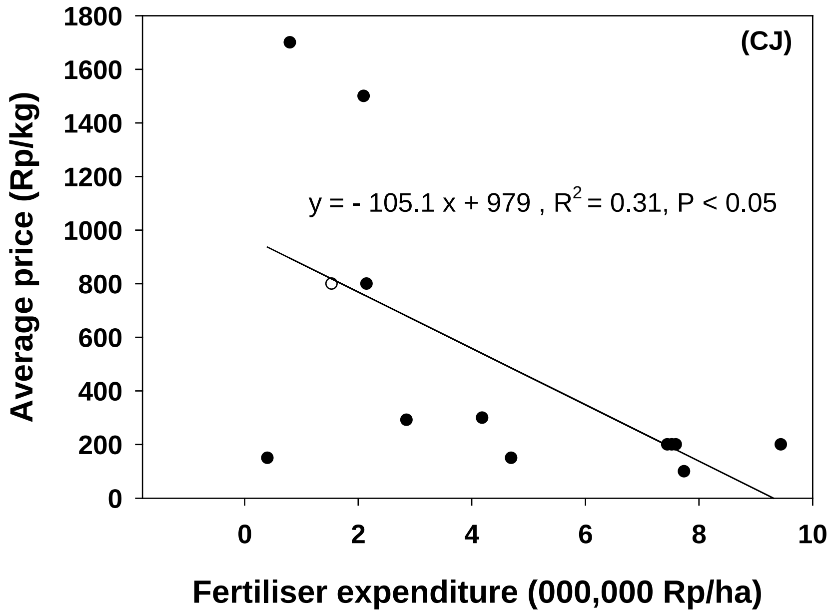

Figure 7.16. Linear regression of fertiliser expenditure (including labour to apply fertilisers) with average cabbage price per kg in Central Java. (A4 F6.4).

Insecticide and average price regression

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

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

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

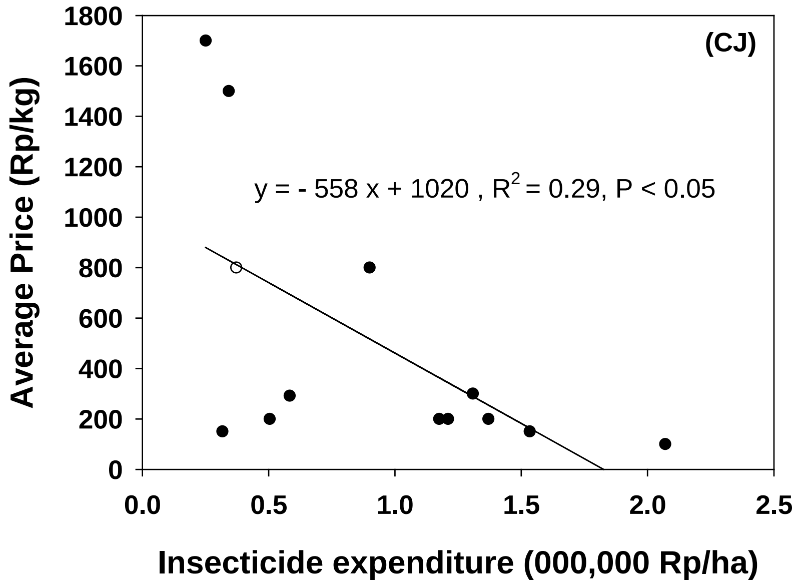

Figure 7.17. Linear regression of insecticide expenditure (including labour to apply insecticides) with average cabbage price received in Central Java. (A4 F6.7).

Clubroot incidence

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

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

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

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

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

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

Pests

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

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

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

Soil factors and fertiliser management

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

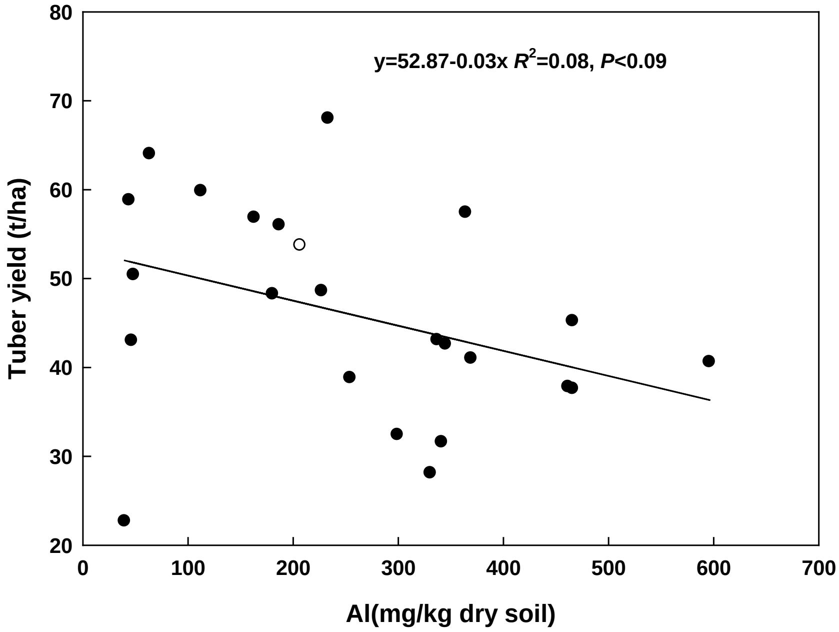

Figure 7.18 Relationship between head yield of cabbage and extractable Al in the soil from a baseline survey of crops in CJ in 2006/2007 (A3 F6.7).

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

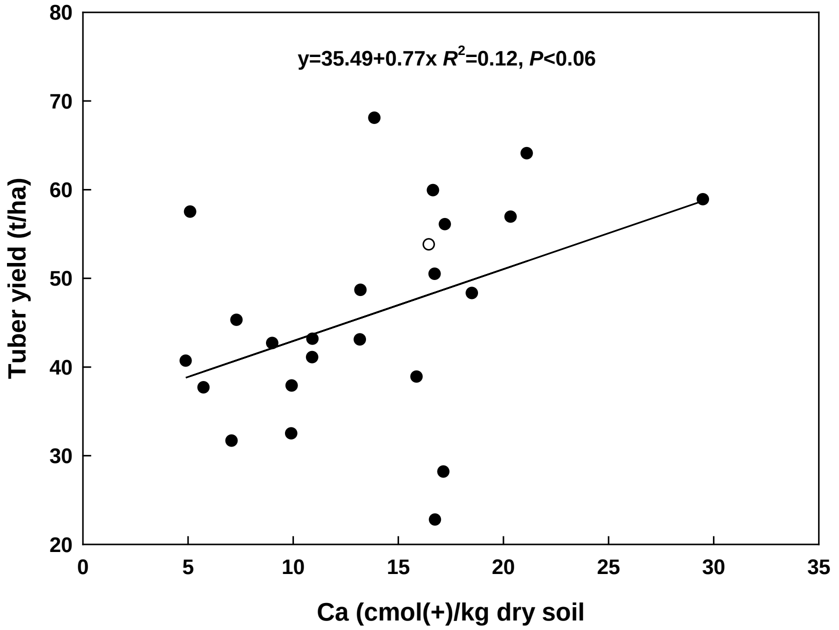

Figure 7.19 Relationship between head yield of cabbage and exchangeable Ca in the soil from a baseline survey of crops in CJ in 2006/2007 (A3 F6.9).

7.1.6 Cabbage ICM farmer initiated learning, 1st cycle

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

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

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

Central Java 2009

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

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

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

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

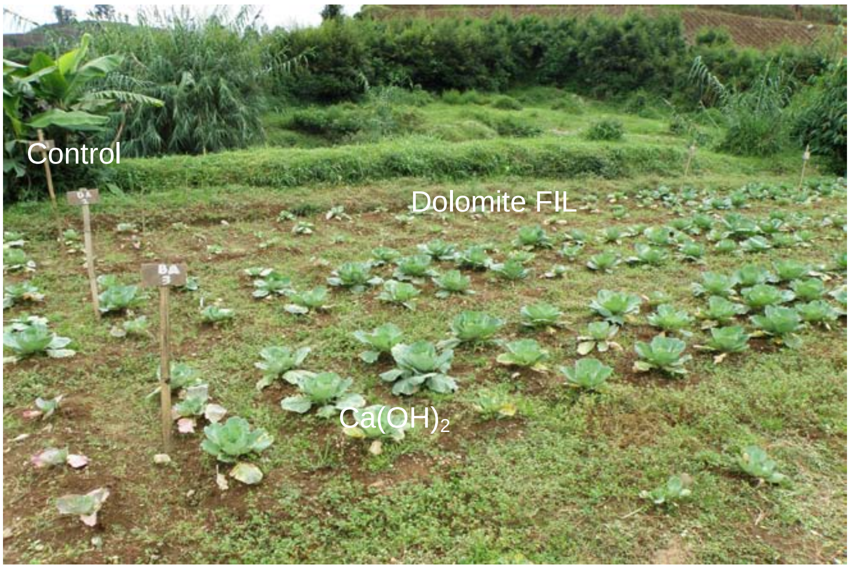

Figure 7.20 The learning-by-doing plots of the Sekar Tani cabbage trial with different lime treatments and rates. Photo taken in Feb 2009. (A11 F6.2).

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

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

7.1.7 Cabbage ICM Farmer initiated learning, 2nd cycle

Central Java and South Sulawesi 2010

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

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

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

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

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

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

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

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

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

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

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

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

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

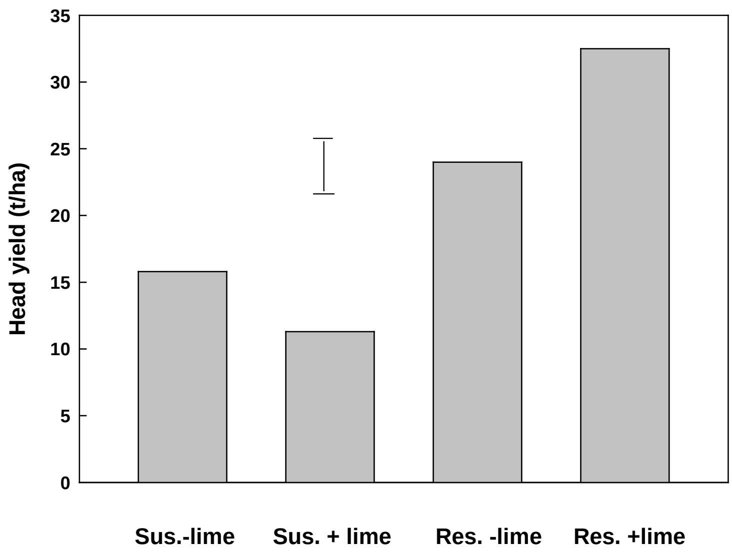

Figure 7.21 Yield of two cabbage varieties on the clubroot infected site of the Bukit Madu farmer FIL group in CJ. The susceptible (Sus) and resistant (Res) varieties were Greenfrosh and Maxfield. The vertical bar is LSD ($P < 0.05$) for yield differences between varieties and lime treatments. Maxfield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

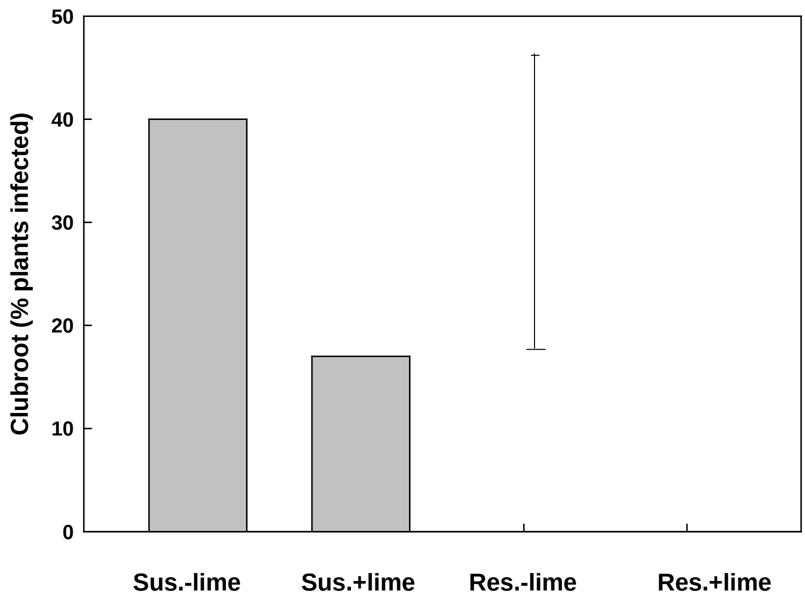

Figure 7.22 Percentage of cabbage plants of 2 varieties infected with clubroot in the Pemuda Tani Vetran farmer group FIL plots in SS on an infected site either un-limed (-) or limed (+). The susceptible (Sus.) and resistant (Res.) varieties were an unnamed local variety and Maxfield respectively. The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

7.1.8 Cabbage post-harvest studies Indonesia

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

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

7.2.1 Baseline surveys of seed potatoes

Seed cost sensitivity analysis

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

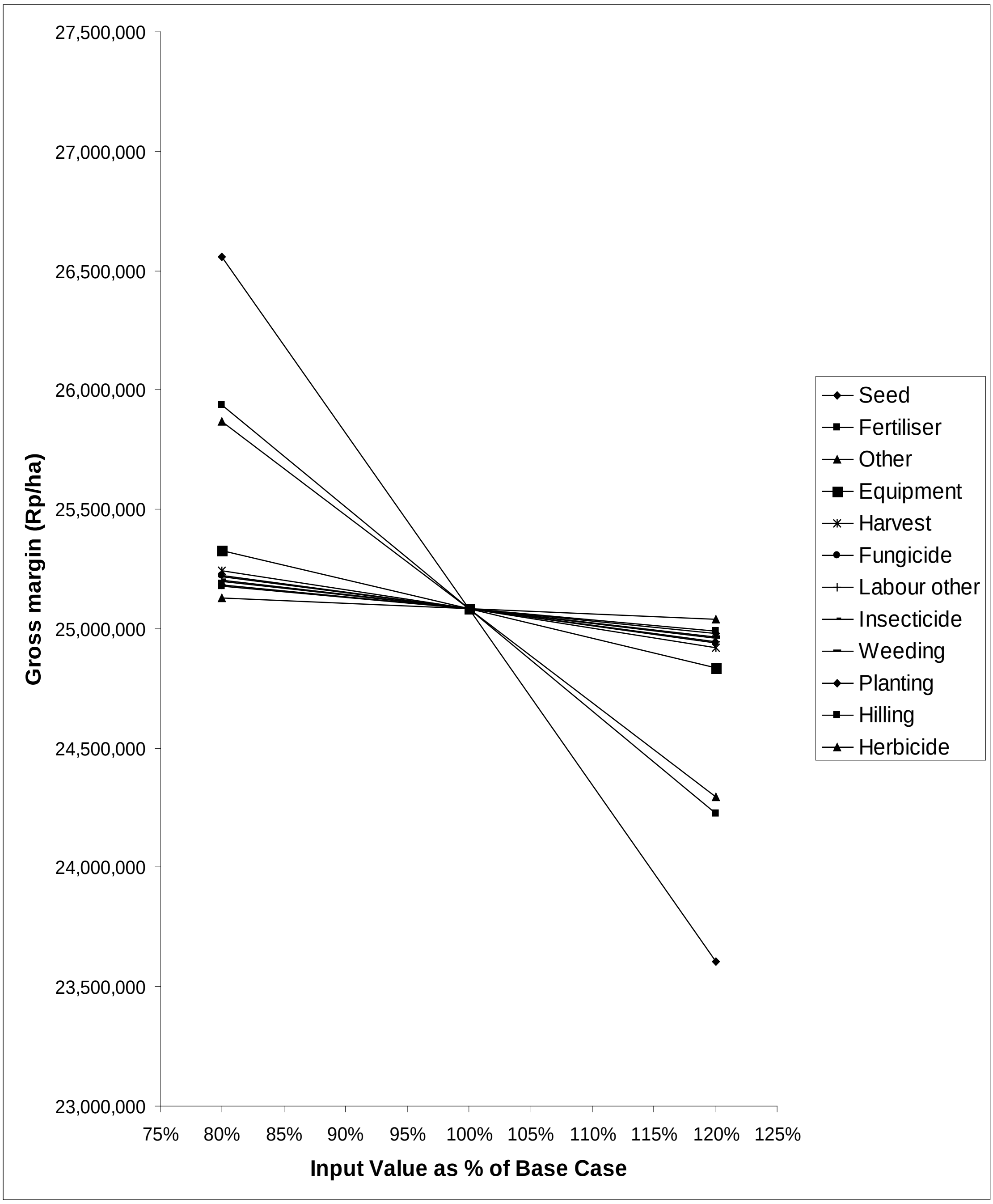

Figure 7.23 Sensitivity Analysis for South Sulawesi of potato gross margin returns to changes in input values. (A2 F 6.1).

Seed quality

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

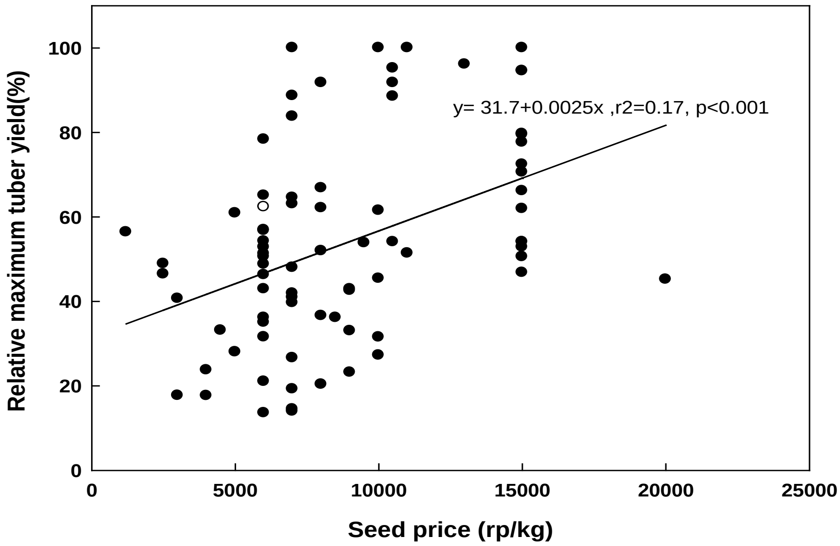

Figure 7.24 Linear regression of tuber yield (relative maximum %) with price (Rpper kg). Relative maximum yield (%) is highest tuber yield in each province/actual yield at each site x 100. (A1 F6.10).

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

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

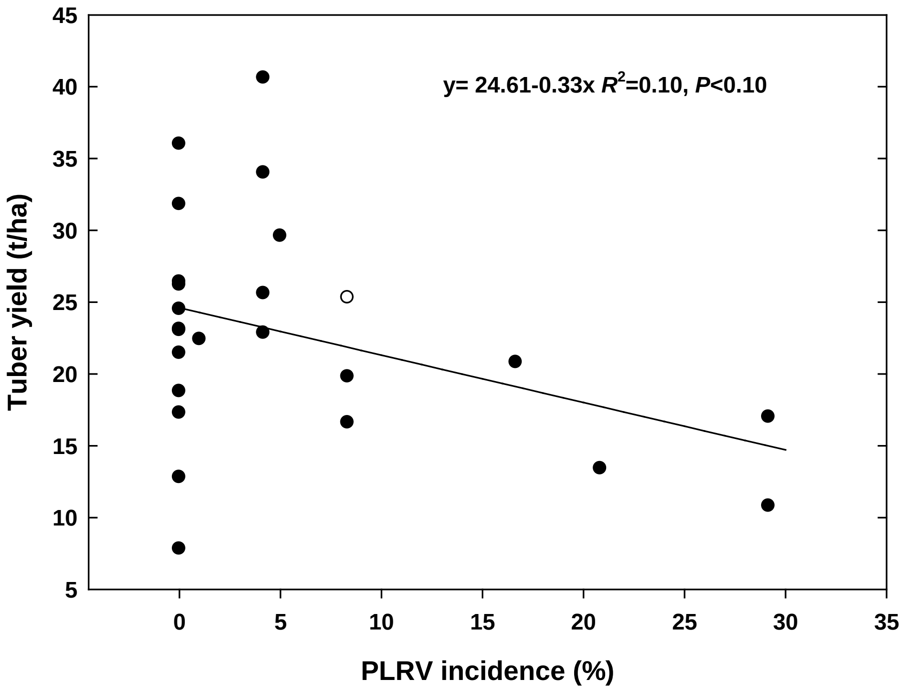

Figure 7.25 Linear regression between incidence of potato leafroll virus (PLRV, %) and tuber yields in WJ. (A1 F6.45).

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

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

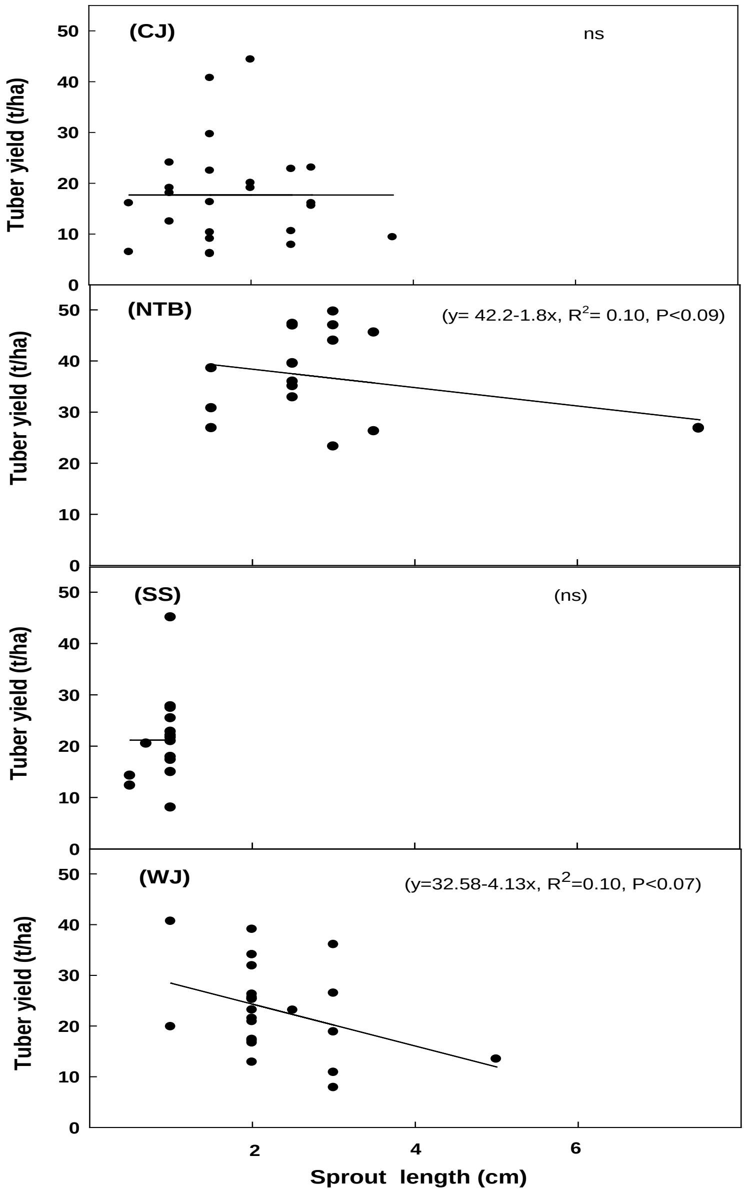

Figure 7.26 Linear regression of tuber yield with sprout length in 4 provinces. (A1 F6.9).

7.2.2 Potato seed farmer initiated learning, 2nd cycle

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

West Java 08/09

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

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

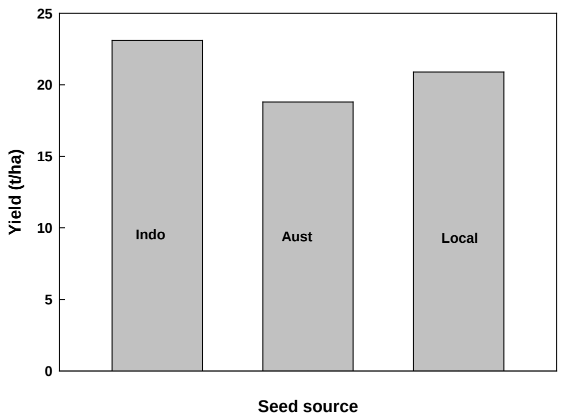

Figure 7.27 Mean potato tuber yield from different sources of Granola seed in the LBD plots in WJ in 2008/2009. 'Indo, 'Aust or 'Local' refers to certified Indonesian G4, certified imported WA G4 or local seed (G unknown) respectively. There was no significant difference between the means. (A8 F6.3).

7.2.3 Potato seed Farmer initiated learning, 3rd cycle

West Java seed sources 09/10

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

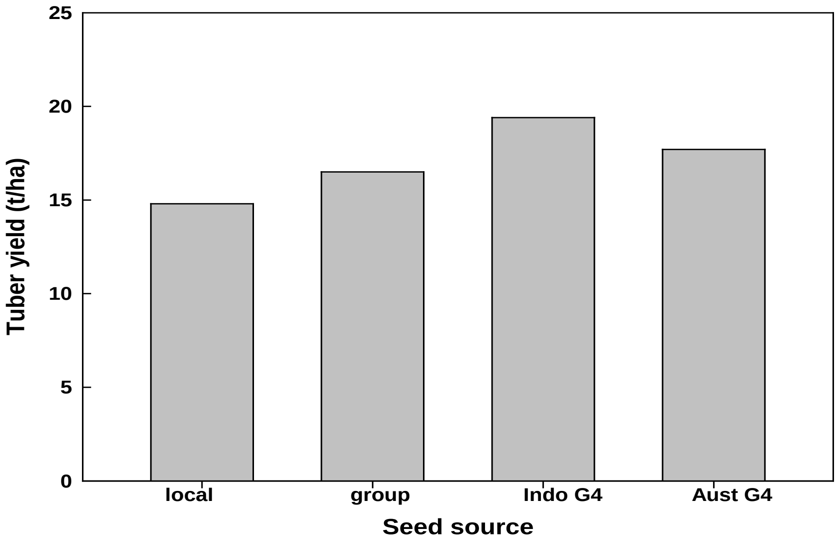

Figure 7.28 Mean tuber yield (t/ha) of Granola crops grown by four farmer groups from different seed sources in LDB plots in WJ 2009/2010. There was no significant difference between means. (A8 F6.5).

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

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

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

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

‡ ns P<0.10

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

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

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

NTB seed sources 2010

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

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

Atlantic seed source	**Tuber number by grade (tubers/50 m²)**				
	< 30 mm	**30 - 50 mm**	**> 50 mm**	**Reject**	**Marketable (No rejects)**
Australian import	160	685	590	13	1,435
Once-grown Aust seed	95	324	241	54	660
	Yield by grade (t/ha)				
	< 30 mm	30 - 50 mm	> 50 mm	Reject	Marketable (No rejects)
Australian import	2.5	10.2	5.6	0.1	18.3
Once-grown Aust seed	1.2	4.9	3.0	0.8	9.1

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

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

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

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

7.2.4 PCN NTB

Status

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

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

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

PCN species identification

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

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

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

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

PCN pathotype identification

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

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

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

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

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

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

PCN decline studies

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

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

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

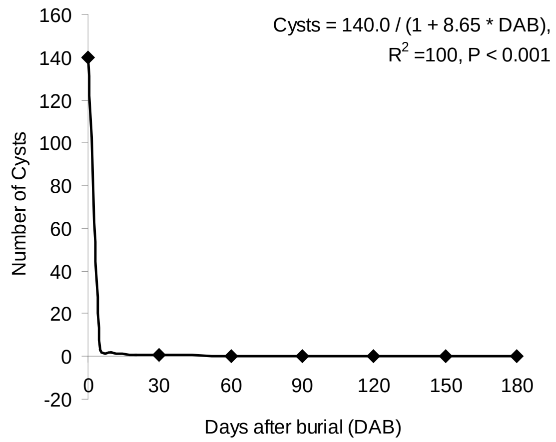

Figure 7.29 Decline equation for PCN cysts buried in highland paddy soils on the Dieng Plateau, CJ, in the absence of a host. (A5 F6.3.2).

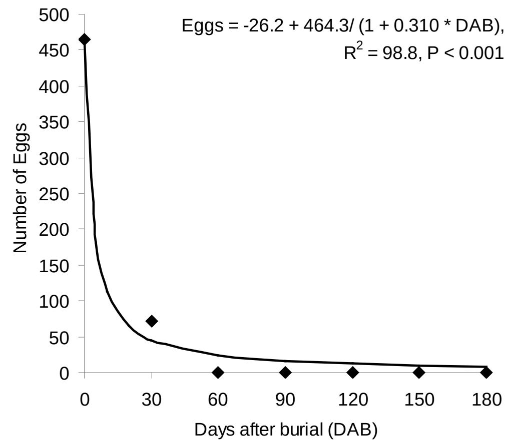

Figure 7.30 Decline equation for PCN eggs buried in highland paddy soils on the Dieng Plateau, CJ, in the absence of a host. (A5 F6.3.3).

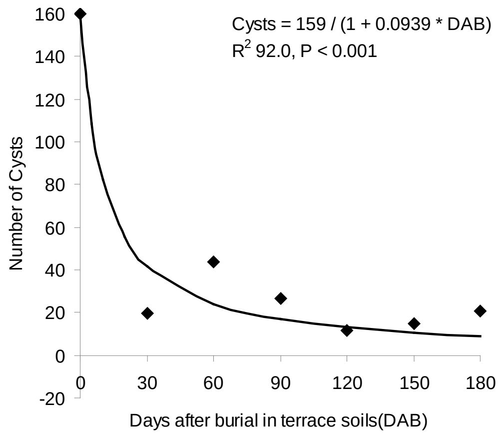

Figure 7.31 Decline equations for PCN cysts buried in highland terrace soils on the Dieng Plateau, CJ, in the absence of a host. (A5 F6.3.4).

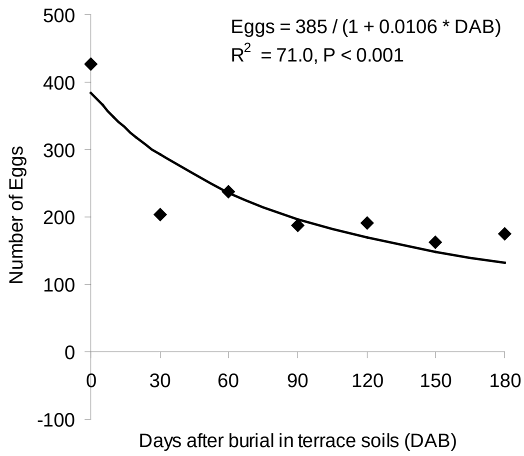

Figure 7.32 Decline equations for PCN eggs buried in highland terrace soils on the Dieng Plateau, CJ, in the absence of a host. (A5 F6.3.5).

7.2.5 Potato post-harvest studies Indonesia

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

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

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

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

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

7.2.6 Potato post-harvest studies Australia

Varietal differences in bruising response to impacts

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

Crop harvest and post-harvest measurements

Atlantic

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

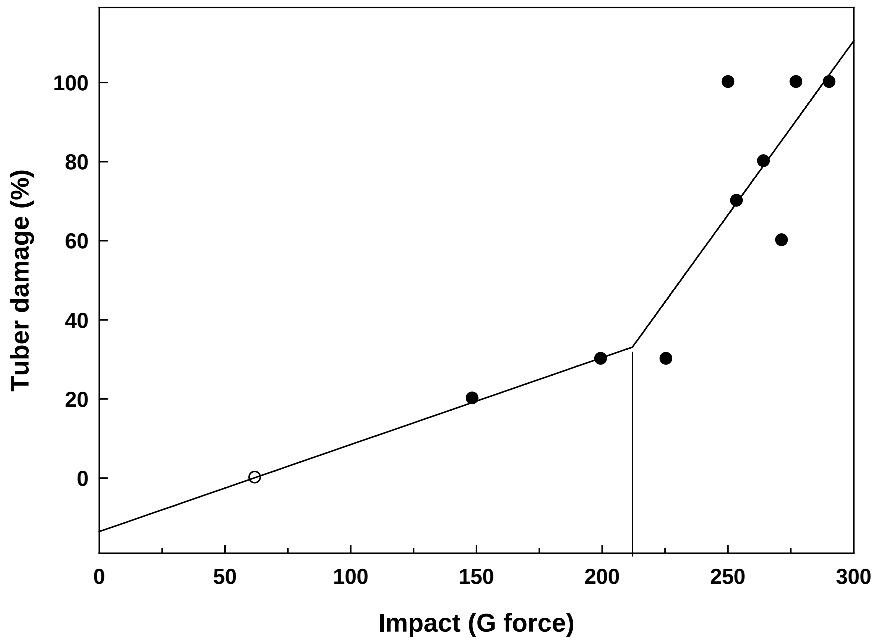

Figure 7.33 Relationship (2 split lines) between tuber impact (G force) and % bruising in Atlantic tubers with a pulp temperature of 15°C. The vertical line intercepts the x axis at the level of impact (212 G) above which significant tuber damage is first observed (threshold). Equations:

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

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

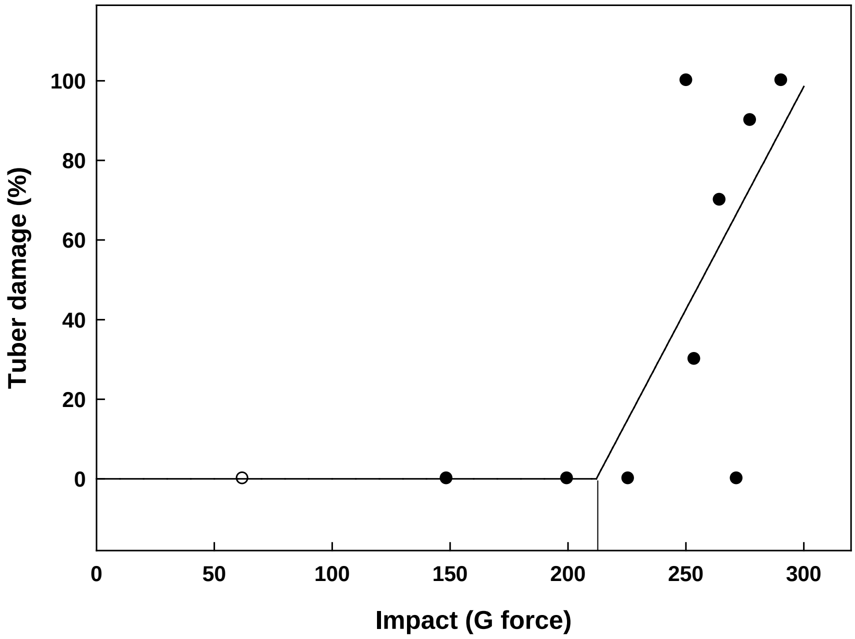

Figure 7.34 Relationship (2 split lines) between tuber impact (G force) and % bruising in Granola tubers with a pulp temperature of 15°C. The vertical line intercepts the x axis at the level of impact (212 G) above which tuber damage is first observed (threshold). Equations:

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

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

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

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

Granola

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

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

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

Crop verse G force > 50

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

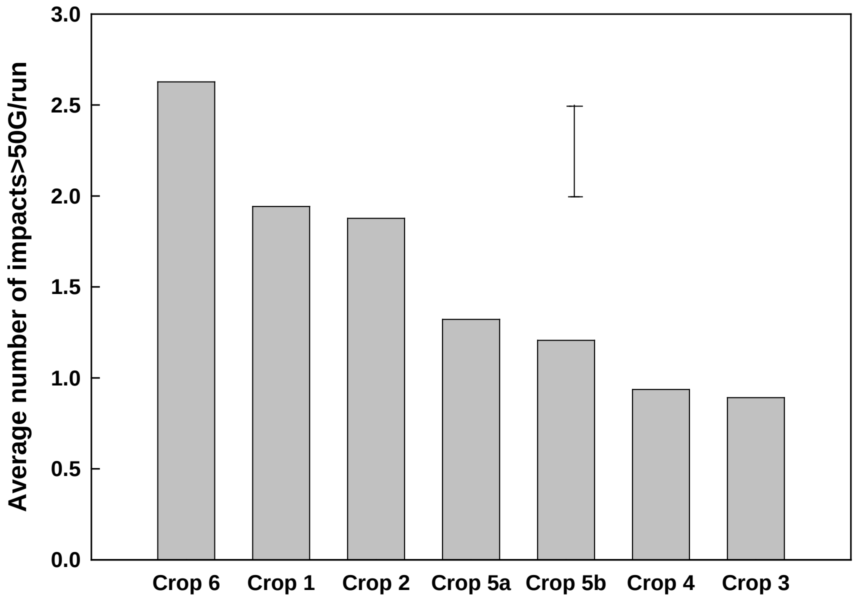

Figure 7.35 The average number of combined impacts > 50 G per run for all crops. LSD = 0.53. Average number of impacts > 50 G was significantly lower in crops 5, 4 and 3 compared with crops 6, 1 and 2. (A6 F6.7)

Bunker versus harvest.

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

Actions to reduce bruising

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

7.2.7 Partial seed system to augment Indonesian certified seed

Indonesian farmers obtain seed from the following sources:

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

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

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

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

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

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

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

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

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

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

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

PCN protection

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

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

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

Reduced degeneration

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

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

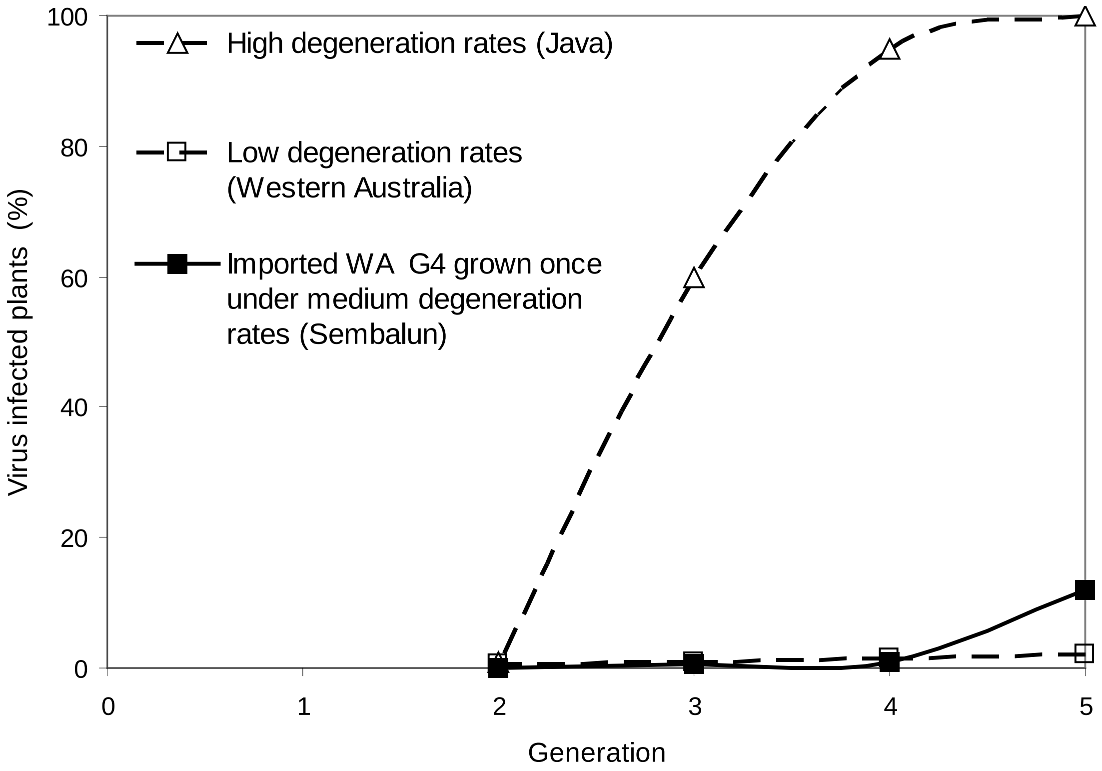

Figure 7.36 Estimated virus infection of Atlantic seed sources grown under different degeneration conditions. Under high degeneration conditions of Java the virus infection of Atlantic reaches over 60% in G3, the first field generation. If the Atlantic is grown from imported G4 seed where the infection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

Reduced cost

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

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

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

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

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

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

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

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

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

Partial seed scheme conclusions

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

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

However the horticulturist group will need:

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

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

8 Impacts

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

8.1 Scientific impacts – now and in 5 years

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

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

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

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

8.2 Capacity impacts – now and in 5 years

8.2.1 Farming knowledge and skills

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

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

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

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

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

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

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

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

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

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

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

8.2.2 Changing FFS methodology to FIL

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

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

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

8.2.3 Crop management

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

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

8.2.4 New seed production plan

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

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

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

However the horticulturist farmer group will need:

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

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

8.2.5 Seed handling in Australia

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

8.2.6 Integrated pest management

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

8.2.7 PCN

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

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

8.3 Community impacts – now and in 5 years

8.3.1 Economic impacts

Yield

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

Input costs

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

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

Marketing

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

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

Improved clubroot control

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

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

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

PCN free seed supply for South Sulawesi

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

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

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

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

Improved potato late blight management

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

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

8.3.2 Social impacts

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

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

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

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

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

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

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

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

Gender - Men's and women's roles

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

Gender - Men's and women's decision making

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

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

Sprayer health and safety

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

8.3.3 Environmental impacts

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

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

8.4 Communication and dissemination activities

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

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

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

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

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

9 Conclusions and recommendations

9.1 Conclusions

The main aims of the project were to:

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

All aims were achieved.

Adapt and apply integrated crop management systems for potato and cabbage

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

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

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

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

Develop partners capacity to use adaptive research and development strategies

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

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

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

9.2 Recommendations

9.2.1 Farmers' recommendations

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

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

9.2.2 Other recommendations

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

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

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

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

PCN should also be tackled by other means:

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

10 References

10.1 References cited in report

Adiyoga, W R Suherman, A Asgar & Irfansah (1999) The Potato System in West Java, Indonesia: Production, marketing, Processing, and Consumer Preferences for Potato Products. International Potato Center: Lima, Peru.

Badan Pusat Statistik (2011a) Luas Panen, Produksi dan Produktivitas Kubis, 2009 (Indonesian cabbage area, production and yield 2009 by province) http://www.bps.go.id/tab_sub/view.php?tabel=1&daftar=1&id_subyek=55&notab=11 accessed 12 April 2011.

Badan Pusat Statistik (2011b) Luas Panen, Produksi dan Produktivitas Kentang, 2009 (Indonesian potato area, production and yield 2009 by province) http://www.bps.go.id/tab_sub/view.php?tabel=1&daftar=1&id_subyek=55&notab=10 Accessed 12 April 2011.

Blaesing D and Kirkwood I (2004) PT01030 Potato Seed Handling and Storage – Implementing Best Practice. Horticulture Australia Limited.

BPTP NTB (2009a) Laporan. Sosial Ekonomi Kentang Sembalun. (Balai Pengkajian Teknologi Pertanian NTB Narmada)

BPTP NTB (2009b) Laporan Kegiatan Sekolah Lapang Pengelolaan Tanaman Terpadu Optimalisasi Produktivitas Kentang Di Dataran Tinggi Sembalun. (Balai Pengkajian Teknologi Pertanian NTB Narmada)

Bray RH & Kurtz (1945) Determination of total organic and available forms of phosphorus in soils. Soil Science 59:39-45.

Cáceres PA, M Pumisacho, GA Forbes & JL Andrade-Piedra (2007) Learning to control potato late blight – A facilitator's guide. International Potato Centre (CIP), Instiuto Nacional de Ciencia y Technologia del Ecuador (SENACYT). Quito, Ecuador. 142 pages (English version available).

Collins S, V Vanstone & X Zhang (2010) PCN "Area Freedom" for WA: Evaluation of the current status of Potato Cyst Nematode (Globodera rostochiensis) in Western Australia. Final report for project MT04004 & MT04000. (Horticulture Australia Ltd, Sydney)

Crissman CC (1989) Seed Potato Systems in The Philippines: A Case Study (CIP Lima) 82 p.

DAFWA (2010a) Potato Technical Toolkit. (ACIAR Project ABB/2005/167). Also Indonesian edition Kentang Peralatan Teknis (ACIAR Proyek ABB/2005/167).

DAFWA (2010b) Cabbage Technical Toolkit. (ACIAR Project ABB/2005/167). Also Indonesian edition Kubis Peralatan Teknis (ACIAR Proyek ABB/2005/167).

Darmawan DA & E Pasandaran (2000) Dynamics of vegetable production, distribution and consumption in Asia. Asian Vegetable and Research and Development Centre, Taiwan: 139-171.

Dawson P (2008) Western Australian Certified Seed Potato Scheme; An international comparison. Farmnote 338. (Department of Agriculture and Food Western Australia, Perth)

Dawson P, I McPharlin & B Dharmadi (2004) A Partnership to Build Indonesian Crisping Potato Capacity and Australian Seed Potato Sales. Horticulture Australia Limited Final Report Project PT02018 (HAL Sydney)

Dawson P, I McPharlin & M Howes (2003) Sekilas tentang Kentang hidangan meja dan Kentang bibit dari Australia Barat. Bulletin 4597 (Department of Agriculture and Food Western Australia, Perth)

de Vries SC (2004) Country report on the late blight in Indonesia. *In* Proceedings regional workshop on potato late blight for East and Southeast Asia and the Pacific Eds: Lizárraga C. Proceedings of the regional workshop on potato late blight for East and Southeast Asia and the Pacific, Yezin, Myanmar, 24-25 August 2004. GILB, International Potato Center (CIP), Lima, Peru. 87pp.

Dixon GR (2009) The Occurrence and Economic Impact of *Plasmodiophora brassicae* and Clubroot Disease. Journal of Plant Growth Regulation 28:194–202

Dobson RL, RL Gabrielson, AS Baker & L Bennett (1983) Effects of lime particle size and distribution and fertilizer formulation on clubroot disease caused by *Plasmodiophora brassicae*. Plant Disease 67:50–52

Donald EC, IJ Porter, R Faggian & RA Lancaster (2006) An Integrated Approach to the Control of Clubroot in Vegetable Brassica Crops. Acta Horticulturae 706: 283-300.

Donald EC & IJ Porter (2009) Integrated Control of Clubroot. Journal of Plant Growth Regulation 28:289-303

Duriat OT, OS Gunawan & N Gunaeni (2006) Penerapan teknologi PHT pada tanaman kentang (Applying/practising IPM technology in growing potatoes) Monograph 28 (Institute Vegetable Crops Research, Centre of Research and Development of Horticulture, Agency of Research and Development of Agriculture)

Floyd R (1986) Rapid vegetative propagation of potatoes and native plants. (DAFWA Final Report to Australian Special Rural Research Fund)

Forbes GA (2009) Late blight in developing countries and the role of the Global Initiative on Late Blight (GILB). *In* Proceedings of the eleventh Euroblight workshop, Hamar, Norway, 28-31 October 2008. PPO-Special report No. 13. Schepers HTAM (Ed).

Fuglie KO (2007). Priorities for Potato Research in Developing Countries: Results of a Survey. *American Journal of Potato Research* 84: 353-365.

Fuglie KO, W Adiyoga, R Asmunati, S Mahalaya & R Suherman (2005) Supply and Demand for Quality Potato Seed in Indonesia: Farmers" Perspectives and Policy Options. UPWARD Working Paper Series No. 8 CIP-UPWARD, Los Baños, Laguna, Philippines. 53 pages.

Gupta UC, JA MacLeod, JB Sanderson & RP White (1995) Nutrient status of potato grown on fine sandy loams of Prince Edward Island. *Communications in Soil Science and Plant Analysis* 26, 1247-55

Halseth DE (2006) Development and adoption of biological and management control strategies for the golden nematode-resistant potato. Accessed 11 October 2010. http://vivo.cornell.edu/individual/vivo/individual30957

Hadisoeganda AWW (2006) Nematoda Sista Kentang: Kerugian, Deteksi, Biogeografi, dan Pengendalian Nematoda Terpadu. Monografi 29 (Balitsa, Lembang).

Hodda M & DC Cook (2009) Economic impact from unrestricted spread of potato cyst nematodes in Australia. Phytopathology 99:1387-1393.

Holland M & D Spencer (2009) Western Australian certified seed potato scheme production rules. (DAFWA Perth) Also available at: http://www.agric.wa.gov.au/objtwr/imported_assets/aboutus/as/spp-1_wa_certified_rules.pdf

Huett DO, Maier NA, Sparrow LA and Piggot TJ (1997) 'Chapter 8, Vegetables' *In* 'Plant Analysis: An interpretation manual, second edition, 'Reuter DJ, Robinson JB and Dutkiewicz C, eds (CSIRO Melbourne), p385-464.

Indarti S, RTP Bambang, Mulyadi, B Triman (2004) First record of potato cyst nematode Globodera rostochiensis in Indonesia. Australasian Plant Pathology 33: 325-426

Jayasinghe U (2005) Potato seed system in Indonesia: A baseline survey. *In* Supply and demand for quality potato: Farmers' perspectives and policy options. Eds: Fuglie KO, Adiyoga W, Asmunati R, Mahalaya S, Suherman R. UPWARD working paper series No.8. CIP-UPWARD, Los Bańos, Laguna, Philippines pp70-78.

Lologau BA, S Kadir, Nurjanani, M Thamrin, Wahdaniah B (2003) Pemanfaatan Fungisida Nabati Dalam Pengendalian Penyakit Busuk Daun, Phytophthora infestans Pada Tanaman Kentang. Laporan hasil penelitian, Departemen Pertanian, Badan Penelitian Dan

Pengembangan Pertanian, Pusat Penelitian Dan Pengembangan Sosial Ekonomi Pertanian, Balai Pengkajian Teknologi Pertanian Sulawesi Selatan.

Maier NA (1986) Potassium nutrition of irrigated potatoes in South Australia. 1 Effect on tuber yield and the prediction of tuber yield response by soil analysis. *Australian Journal of Experimental Agriculture*, 26: 717-25.

Maier NA & KL Shepherd (1998) 'Plant Analysis: An interpretation manual for potato' (SARDI: Adelaide), page 201.

Marshall JW (1997) Potato cyst nematode in New Zealand and Australia. Chapter 20. *In* Potato Cysts Nematode. Biology, Distribution and Management pp 353-359 (CAB International)

Maynard DN and Hochmuth GJ (2007) 'Knott's Handbook for Vegetable Growers', 5th Edition (John Wiley and Sons: New Jersey), page 622.

McPharlin IR, PD Dawson, TC Tuyen & PX Tung (2003) Best management practice evaluation *In* 'Increasing the capacity of the Food Crops Research Institute to enhance the production and management of potatoes in the Red River Delta'. Final Report AusAID project (DAFWA, Perth) Appendix 12, p 108.

Mulyadi, RTP Bambang, B. Triman and S Indarti. 2010 Population Increase And Decrease Of Potato Cyst Nematodes. Research Report, Nematology Laboratory, Department of Plant Protection, Faculty of Agriculture, Gadjah Mada University, Yogyakarta.

Olsen SR, CV Cole, FS Watan & LA Dean (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United States Department of Agriculture Circular Number 939.

Rauf A, D Prijono, Dadang, IW Winasa & DA Russel (2005) Survey on pesticide use by cabbage farmers in West Java, Indonesia. Report of Research collaboration between Dept. of Plant Protection-IPB with LaTrobe University, Australia.

Ridland P, A Rauf, IW Supartha, La Daha, D Sembel, E van de Fliert, M Malipatil, AA Hoffmann & J La Salle (2000) *Liriomyza huidobrensis* leafminer: developing effective pest management strategies for Indonesia and Australia (ACIAR Final Report Project CP/2000/090, Canberra)

Rimmer SR, VI Shattuck & L Buchwaldt (Eds) (2007) Compendium of brassica diseases. The American Phytopathological Society, St. Paul, Minnesota.

Sastrosiswojo S & W Setiawati (1992) Biology and Control of *Crocidolomia pavonana* in Indonesia. *In* Diamond back moth and other crucifer pests, Proc. Second Intl Workshop. Tainan (Taiwan), 11-15 March 1985 (Taipei: AVRDC), Griggs TD and Talekar NS ed., p 81-87.

Shepard BM & NA Schellhorn. (1997) A *Plutella* / *Crocidolomia* management program for cabbage in Indonesia. *In* Proceedings for the 3rd International Workshop on the Management of Diamondback Moth and Other Cruciferous Pests. Kuala Lumpur, Malaysia.

Shurtleff MC & CW Averre III (2000) *Diagnosing Plant Diseases Caused by Nematodes*. (American Pytopathological Society, St Paul Minnesota)

Skantar AM, ZA Handoo, LK Carta, & DJ Chitwood (2007) Morphological and molecular identification of *Globodera pallida* associated with potato in Idaho. *J. of Nematology* 39 (2): 133-144.

Struik PG & SG Wiersema (1999) Seed potato technology, (Wageningen press: Wageningen), page 78.

Subhan & A Sumarna (1998) Pengaruh dan pemupukan fosfat terhadap pertumbuhan dan hasil tanaman kentang. Journal of Horticulture 7: 879-885. (In Indonesian).

Tantowijoyo W and E van de Fliert (2006) All About Potatoes. An ecological guide to Potato Integrated Crop Management. (CIP-ESEAP & FAO).

van de Fliert E, Warsito and Lagnaoui A (1999) Participatory needs and opportunity assessment for potato IPM development planning: the case of Indonesia. *In*: *Impact on a Changing World.* CIP Program Report 1997-98. Lima, Peru. pp 171-178

van Lierop W, TS Tran, G Banville & S Morisette (1982) Effect of Liming on Potato Yields as Related to Soil pH, Al, Mn, and Ca. *Agronomy Journal* 1982 74:1050-1055)

Wahyuning S, W Tantowijoyo & E van de Fliert (2006) Farmer Field School for Potato Integrated Pest Management. A Facilitator's Field Guide. (CIP-ESEAP & FAO).

Walker T, Y Bi, JH Li, PC Gaur & E Grande (2001) CIP's Contribution to Varietal Change in Potatoes in Developing Countries. CIP Program Report 1999-2000. pp 219-224.

Walkley A & I Black (1934) An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science 37, 29-38.

10.2 List of publications produced by project

Adiyoga, W R Suherman, A Asgar & Irfansah (1999) The Potato System in West Java, Indonesia: Production, marketing, Processing, and Consumer Preferences for Potato Products. International Potato Center: Lima, Peru.

Badan Pusat Statistik (2011a) Luas Panen, Produksi dan Produktivitas Kubis, 2009 (Indonesian cabbage area, production and yield 2009 by province) http://www.bps.go.id/tab_sub/view.php?tabel=1&daftar=1&id_subyek=55&notab=11 accessed 12 April 2011.

Badan Pusat Statistik (2011b) Luas Panen, Produksi dan Produktivitas Kentang, 2009 (Indonesian potato area, production and yield 2009 by province) http://www.bps.go.id/tab_sub/view.php?tabel=1&daftar=1&id_subyek=55&notab=10 Accessed 12 April 2011.

Blaesing D and Kirkwood I (2004) PT01030 Potato Seed Handling and Storage – Implementing Best Practice. Horticulture Australia Limited.

BPTP NTB (2009a) Laporan. Sosial Ekonomi Kentang Sembalun. (Balai Pengkajian Teknologi Pertanian NTB Narmada)

BPTP NTB (2009b) Laporan Kegiatan Sekolah Lapang Pengelolaan Tanaman Terpadu Optimalisasi Produktivitas Kentang Di Dataran Tinggi Sembalun. (Balai Pengkajian Teknologi Pertanian NTB Narmada)

Bray RH & Kurtz (1945) Determination of total organic and available forms of phosphorus in soils. Soil Science 59:39-45.

Cáceres PA, M Pumisacho, GA Forbes & JL Andrade-Piedra (2007) Learning to control potato late blight – A facilitator's guide. International Potato Centre (CIP), Instiuto Nacional de Ciencia y Technologia del Ecuador (SENACYT). Quito, Ecuador. 142 pages (English version available).

Collins S, V Vanstone & X Zhang (2010) PCN "Area Freedom" for WA: Evaluation of the current status of Potato Cyst Nematode (Globodera rostochiensis) in Western Australia. Final report for project MT04004 & MT04000. (Horticulture Australia Ltd, Sydney)

Crissman CC (1989) Seed Potato Systems in The Philippines: A Case Study (CIP Lima) 82 p.

DAFWA (2010a) Potato Technical Toolkit. (ACIAR Project ABB/2005/167). Also Indonesian edition Kentang Peralatan Teknis (ACIAR Proyek ABB/2005/167).

DAFWA (2010b) Cabbage Technical Toolkit. (ACIAR Project ABB/2005/167). Also Indonesian edition Kubis Peralatan Teknis (ACIAR Proyek ABB/2005/167).

Darmawan DA & E Pasandaran (2000) Dynamics of vegetable production, distribution and consumption in Asia. Asian Vegetable and Research and Development Centre, Taiwan: 139-171.

Dawson P (2008) Western Australian Certified Seed Potato Scheme; An international comparison. Farmnote 338. (Department of Agriculture and Food Western Australia, Perth)

Dawson P, I McPharlin & B Dharmadi (2004) A Partnership to Build Indonesian Crisping Potato Capacity and Australian Seed Potato Sales. Horticulture Australia Limited Final Report Project PT02018 (HAL Sydney)

Dawson P, I McPharlin & M Howes (2003) Sekilas tentang Kentang hidangan meja dan Kentang bibit dari Australia Barat. Bulletin 4597 (Department of Agriculture and Food Western Australia, Perth)

de Vries SC (2004) Country report on the late blight in Indonesia. *In* Proceedings regional workshop on potato late blight for East and Southeast Asia and the Pacific Eds: Lizárraga C. Proceedings of the regional workshop on potato late blight for East and Southeast Asia and the Pacific, Yezin, Myanmar, 24-25 August 2004. GILB, International Potato Center (CIP), Lima, Peru. 87pp.

Dixon GR (2009) The Occurrence and Economic Impact of *Plasmodiophora brassicae* and Clubroot Disease. Journal of Plant Growth Regulation 28:194–202

Dobson RL, RL Gabrielson, AS Baker & L Bennett (1983) Effects of lime particle size and distribution and fertilizer formulation on clubroot disease caused by *Plasmodiophora brassicae*. Plant Disease 67:50–52

Donald EC, IJ Porter, R Faggian & RA Lancaster (2006) An Integrated Approach to the Control of Clubroot in Vegetable Brassica Crops. Acta Horticulturae 706: 283-300.

Donald EC & IJ Porter (2009) Integrated Control of Clubroot. Journal of Plant Growth Regulation 28:289-303

Duriat OT, OS Gunawan & N Gunaeni (2006) Penerapan teknologi PHT pada tanaman kentang (Applying/practising IPM technology in growing potatoes) Monograph 28 (Institute Vegetable Crops Research, Centre of Research and Development of Horticulture, Agency of Research and Development of Agriculture)

Floyd R (1986) Rapid vegetative propagation of potatoes and native plants. (DAFWA Final Report to Australian Special Rural Research Fund)

Forbes GA (2009) Late blight in developing countries and the role of the Global Initiative on Late Blight (GILB). *In* Proceedings of the eleventh Euroblight workshop, Hamar, Norway, 28-31 October 2008. PPO-Special report No. 13. Schepers HTAM (Ed).

Fuglie KO (2007). Priorities for Potato Research in Developing Countries: Results of a Survey. *American Journal of Potato Research* 84: 353-365.

Fuglie KO, W Adiyoga, R Asmunati, S Mahalaya & R Suherman (2005) Supply and Demand for Quality Potato Seed in Indonesia: Farmers" Perspectives and Policy Options. UPWARD Working Paper Series No. 8 CIP-UPWARD, Los Baños, Laguna, Philippines. 53 pages.

Gupta UC, JA MacLeod, JB Sanderson & RP White (1995) Nutrient status of potato grown on fine sandy loams of Prince Edward Island. *Communications in Soil Science and Plant Analysis* 26, 1247-55

Halseth DE (2006) Development and adoption of biological and management control strategies for the golden nematode-resistant potato. Accessed 11 October 2010. http://vivo.cornell.edu/individual/vivo/individual30957

Hadisoeganda AWW (2006) Nematoda Sista Kentang: Kerugian, Deteksi, Biogeografi, dan Pengendalian Nematoda Terpadu. Monografi 29 (Balitsa, Lembang).

Hodda M & DC Cook (2009) Economic impact from unrestricted spread of potato cyst nematodes in Australia. Phytopathology 99:1387-1393.

Holland M & D Spencer (2009) Western Australian certified seed potato scheme production rules. (DAFWA Perth) Also available at: http://www.agric.wa.gov.au/objtwr/imported_assets/aboutus/as/spp-1_wa_certified_rules.pdf

Huett DO, Maier NA, Sparrow LA and Piggot TJ (1997) 'Chapter 8, Vegetables' *In* 'Plant Analysis: An interpretation manual, second edition, 'Reuter DJ, Robinson JB and Dutkiewicz C, eds (CSIRO Melbourne), p385-464.

Indarti S, RTP Bambang, Mulyadi, B Triman (2004) First record of potato cyst nematode Globodera rostochiensis in Indonesia. Australasian Plant Pathology 33: 325-426

Jayasinghe U (2005) Potato seed system in Indonesia: A baseline survey. *In* Supply and demand for quality potato: Farmers' perspectives and policy options. Eds: Fuglie KO, Adiyoga W, Asmunati R, Mahalaya S, Suherman R. UPWARD working paper series No.8. CIP-UPWARD, Los Bańos, Laguna, Philippines pp70-78.

Lologau BA, S Kadir, Nurjanani, M Thamrin, Wahdaniah B (2003) Pemanfaatan Fungisida Nabati Dalam Pengendalian Penyakit Busuk Daun, Phytophthora infestans Pada Tanaman Kentang. Laporan hasil penelitian, Departemen Pertanian, Badan Penelitian Dan Pengembangan Pertanian, Pusat Penelitian Dan Pengembangan Sosial Ekonomi Pertanian, Balai Pengkajian Teknologi Pertanian Sulawesi Selatan.

Maier NA (1986) Potassium nutrition of irrigated potatoes in South Australia. 1 Effect on tuber yield and the prediction of tuber yield response by soil analysis. *Australian Journal of Experimental Agriculture*, 26: 717-25.

Maier NA & KL Shepherd (1998) 'Plant Analysis: An interpretation manual for potato' (SARDI: Adelaide), page 201.

Marshall JW (1997) Potato cyst nematode in New Zealand and Australia. Chapter 20. *In* Potato Cysts Nematode. Biology, Distribution and Management pp 353-359 (CAB International)

Maynard DN and Hochmuth GJ (2007) 'Knott's Handbook for Vegetable Growers', 5th Edition (John Wiley and Sons: New Jersey), page 622.

McPharlin IR, PD Dawson, TC Tuyen & PX Tung (2003) Best management practice evaluation *In* 'Increasing the capacity of the Food Crops Research Institute to enhance the production and management of potatoes in the Red River Delta'. Final Report AusAID project (DAFWA, Perth) Appendix 12, p 108.

Mulyadi, RTP Bambang, B. Triman and S Indarti. 2010 Population Increase And Decrease Of Potato Cyst Nematodes. Research Report, Nematology Laboratory, Department of Plant Protection, Faculty of Agriculture, Gadjah Mada University, Yogyakarta.

Olsen SR, CV Cole, FS Watan & LA Dean (1954) Estimation of available phosphorus in soils by extraction with sodium bicarbonate. United States Department of Agriculture Circular Number 939.

Rauf A, D Prijono, Dadang, IW Winasa & DA Russel (2005) Survey on pesticide use by cabbage farmers in West Java, Indonesia. Report of Research collaboration between Dept. of Plant Protection-IPB with LaTrobe University, Australia.

Ridland P, A Rauf, IW Supartha, La Daha, D Sembel, E van de Fliert, M Malipatil, AA Hoffmann & J La Salle (2000) *Liriomyza huidobrensis* leafminer: developing effective pest management strategies for Indonesia and Australia (ACIAR Final Report Project CP/2000/090, Canberra)

Rimmer SR, VI Shattuck & L Buchwaldt (Eds) (2007) Compendium of brassica diseases. The American Phytopathological Society, St. Paul, Minnesota.

Sastrosiswojo S & W Setiawati (1992) Biology and Control of *Crocidolomia pavonana* in Indonesia. *In* Diamond back moth and other crucifer pests, Proc. Second Intl Workshop. Tainan (Taiwan), 11-15 March 1985 (Taipei: AVRDC), Griggs TD and Talekar NS ed., p 81-87.

Shepard BM & NA Schellhorn. (1997) A *Plutella* / *Crocidolomia* management program for cabbage in Indonesia. *In* Proceedings for the 3rd International Workshop on the Management of Diamondback Moth and Other Cruciferous Pests. Kuala Lumpur, Malaysia.

Shurtleff MC & CW Averre III (2000) *Diagnosing Plant Diseases Caused by Nematodes*. (American Pytopathological Society, St Paul Minnesota)

Skantar AM, ZA Handoo, LK Carta, & DJ Chitwood (2007) Morphological and molecular identification of *Globodera pallida* associated with potato in Idaho. *J. of Nematology* 39 (2): 133-144.

Struik PG & SG Wiersema (1999) Seed potato technology, (Wageningen press: Wageningen), page 78.

Subhan & A Sumarna (1998) Pengaruh dan pemupukan fosfat terhadap pertumbuhan dan hasil tanaman kentang. Journal of Horticulture 7: 879-885. (In Indonesian).

Tantowijoyo W and E van de Fliert (2006) All About Potatoes. An ecological guide to Potato Integrated Crop Management. (CIP-ESEAP & FAO).

van de Fliert E, Warsito and Lagnaoui A (1999) Participatory needs and opportunity assessment for potato IPM development planning: the case of Indonesia. *In*: *Impact on a Changing World.* CIP Program Report 1997-98. Lima, Peru. pp 171-178

van Lierop W, TS Tran, G Banville & S Morisette (1982) Effect of Liming on Potato Yields as Related to Soil pH, Al, Mn, and Ca. *Agronomy Journal* 1982 74:1050-1055)

Wahyuning S, W Tantowijoyo & E van de Fliert (2006) Farmer Field School for Potato Integrated Pest Management. A Facilitator's Field Guide. (CIP-ESEAP & FAO).

Walker T, Y Bi, JH Li, PC Gaur & E Grande (2001) CIP's Contribution to Varietal Change in Potatoes in Developing Countries. CIP Program Report 1999-2000. pp 219-224.

Walkley A & I Black (1934) An examination of the Degtjareff method for determining soil organic matter, and a proposed modification of the chromic acid titration method. Soil Science 37, 29-38.

11 Appendixes

11.1 Appendix 1: Baseline agronomic survey of potatoes

11.2 Appendix 2: Baseline economic survey of potatoes

11.3 Appendix 3: Baseline agronomic survey of cabbage

11.4 Appendix 4: Baseline economic survey of cabbage

11.5 Appendix 5: Potato seed system development – PCN

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

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

11.8 Appendix 8: FIL – potatoes Java

11.9 Appendix 9: FIL – potatoes South Sulawesi

11.10 Appendix 10: FIL – potatoes NTB

11.11 Appendix 11: FIL – cabbage

11.12 Appendix 12: Post harvest

11.13 Appendix 13: Impact assessment - farmer conference

11.14 Appendix 14: Impact assessment - social impact study

11.15 Appendix 15: Abbreviations

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

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