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Final report

project

Enhancing Papua New Guinea smallholder cocoa production through greater adoption of disease control practices

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2 Abbreviations

Bougainville – Autonomous Region of Bougainville, North Solomons Province

AGB – Autonomous Government of Bougainville

CCI – Cocoa Coconut Institute PNG

CPB – Cocoa Pod Borer

DPI – Department of Primary Industries

ENBP - East New Britain

ENBP – East New Britain Province

IPDM – Integrated Pest and Disease Management

ISD – Industry Services Division (CCI)

Madang – Madang Province

PAR – Participatory Action Research

PNG – Papua New Guinea

VSD – Vascular Streak Dieback

Unitech - University of Technology Lae

3 Executive summary

Seventy two percent of the 5.5 million people in PNG obtain their livelihoods from the agriculture sector (Anon 2006). The sustainable generation of income by smallholders is central to food security, poverty alleviation, access to education and health services, and in Bougainville, to peace consolidation. Sustainable production also reduces pressure on environmental and land resources.

More than 80% of the cocoa in PNG is produced by over 150,000 smallholder farming families. However, the 300-400kg/ha annual harvests are low and cocoa production in PNG has not increased despite the availability and widespread adoption of new genotypes over the past 20 years. In addition, cocoa production from plantations and smallholders in Bougainville, previously 40% of the national total, ceased during the crisis, and is only now being rehabilitated.

Interest in this project from across PNG was significant, with around 300 stakeholders attending the start-up workshop in November 2005. The workshop clearly identified poor adoption of new technologies as the major constraint to improved smallholder outcomes, an assertion supported by subsequent farmer surveys. We identified access to improved farm management information and the motivation to make use of such information as significant limitations to adoption. In particular, the interest and motivation from Bougainville participants was significant. As a result, Bougainville was included in the project from the beginning rather than in Years 2 and 3, as originally planned. Farmers there were especially keen to acquire knowledge and re-establish their livelihoods.

This project used participatory on-farm research techniques and farmer training to disseminate information and technologies to farmers. We aimed to enhance the adoption of integrated disease management systems suited to smallholders as a key strategy for enhancing incomes. Our goal was to transform the cocoa industry from 90% low management input to 50% medium management input, thereby increasing cocoa production and improving farmer incomes.

Reducing disease losses represents a key option for farming families to improve the productivity of existing plantings and encourage greater investment in cocoa. Diseases cause an estimated yield loss of 40% in the PNG cocoa industry (Saul 1989). The major pathogen is *Phytophthora palmivora* which causes black pod rot, stem rot and cushion canker. Other significant pathogens are *Oncobasidium theobromae*, the cause of Vascular Streak Dieback (VSD) and *Erythricium salmonicolor*, the cause of pink disease. Growing conditions that are conducive to disease are relatively similar for black pod, VSD and pink disease.

Losses can be significantly reduced through improved management, including complete harvesting, sanitation, pruning, shade management, fertilisers and targeted use of selected pesticides. Project staff from CCI developed and tested a series of management interventions at different stages of crop development in research station trials. We then packaged these interventions into low, medium, high and very high management levels and monitored input costs, yields and pest and disease losses under each level. Different levels of farm management options were tailored to match the particular circumstances and aspirations of individual farmers and their families. Yields in farmer trials of up to 2,000 kg beans/ha – an eight-fold increase – have been realised. These options are detailed in the training manual prepared during this project (*Integrated Pest and Disease Management for sustainable cocoa production: A training manual for farmers and extension workers*. ACIAR Monograph 131). This manual has since been translated into Bahasa Indonesian, Vietnamese and Fijian and Solomon Island Pidgin for use in those countries.

The appearance of cocoa pod borer (CPB; *Conopomorpha crameriella*) in East New Britain Province (ENBP) soon after the start of this project represented a significant new

threat into the industry, however improved management was also shown to be effective against CPB, and a fifth management option including CPB management was added in CPB-affected areas of ENBP, and formed the basis for the ACIAR/CABI project on CPB management (CP/2006/114 - *Managing cocoa pod borer in PNG through improved risk incursion management capabilities, IPM strategies and stakeholder participatory training*). This demonstrates the flexibility of our approach.

Training programs were formulated and implemented in three cocoa-producing provinces of PNG (East New Britain, Madang and Bougainville) using a participatory on-farm research approach involving smallholder cocoa farmers and, wherever possible, local CCI and extension staff. These programs involved village-level community consultation, information sessions and the establishment of farmer-managed demonstration blocks. Farmers managing these blocks agreed to train other farmers in each village in return for instruction and guidance from project staff. These farmers were known as 'model famers' or “IPDM apostles”. Each model farmer was asked to train a further 12 extended farmers or 'disciples'. One hundred and eight on-farm demonstration blocks were established as trial sites and used to train several thousand farmers in East New Britain (ENBP), Madang and Bougainville. In addition, 20 on-farm demonstration plots were established on New Ireland and used for farmer and extension worker training activities there.

This project has significantly built PNG’s cocoa research expertise. Four PhD projects by CCI staff (Saul-Maora, Epaina, Yinil and Gende) clustered around this project are in various stages of completion at The University of Sydney. Mr Yak Namaliu was transferred to Madang to improve the pathology capacity and training activities at the CCI station on the North Coast. Agriculture students at Unitech in Lae were trained in cocoa IPDM after the rehabilitation of the cocoa garden there and it became an important training resource for the cocoa industry.

Cocoa production in areas where the IPDM technology has been introduced using this approach has risen. National cocoa production has increased steadily since the inception of this project, from a stable 42,000 prior to 2002 to over 56,000 tonnes annually in 2008. This increase has occurred despite the CPB outbreak in ENBP, and partly reflects the rehabilitation of the Bougainville industry. Both events have included IPDM as a key component.

Problems still exist at CCI, particularly with the Industry Services Division (ISD; CCI extension services section) and their capacity for outreach. However this project demonstrates the effectiveness of the participatory action research (PAR) approach in initiating change, and that transfer of knowledge and skills can be achieved with limited resources. The challenge is to extend and sustain improved management across the nation once this project is complete.

4 Background

4.1 The cocoa industry in PNG

Cocoa is PNG's third most important agricultural export crop, following coffee and palm oil. Worth an estimated K168 million ($AU87 million) in 2003, cocoa contributes up to 17% of the national agricultural revenue (42,000 tonnes at K4000/Mt) (Anon. 2006; Simatab 2007).

Over 80% of PNG's cocoa is produced by 150,000 families, each farming less than 5 ha of land, and producing mean yields of 300-400kg dry beans per hectare per annum (Curry *et al.* 2007). The low yields are typical of smallholder production and reflect inadequate management inputs and high losses due to disease (estimated at 40%), particularly due to black pod and canker (*Phytophthora palmivora*), vascular-streak dieback (VSD, *Oncobasidium theobromae*) and pink disease (*Erythricium salmonicolor* syn. *Corticium salmonicolor*) (Guest 2007; Keane 1981; McMahon and Purwantara 2004; Saul 1989).

Most farm management recommendations were developed for well-managed plantations, which because of the high cost of plantation-based production (K2,150/Mt dry beans, four year average 1995-1998; Curry *et al.* 2007) no longer dominate the industry (Connell, 1997). When the plantation sector predominated in PNG, control of Phytophthora and other diseases was based on high-input cultural practices, fungicides and disease resistant clones (Prior 1984). A fall in the world cocoa price in the late 1980s saw the decline in the plantation sector and a reduction in inputs, such as fertiliser and fungicides (Connell 1997). Smallholder cocoa plantings increased after 1965 and by the mid-1980s contributed approximately 70% of national cocoa production. Many former plantations have been returned to traditional landowners who operate under different circumstances. While plantations operated under more intensive input conditions with different labour sources, smallholder growers rely largely on family labour, apply minimal chemical inputs and are likely to spend less money on inputs when the cocoa price falls (Curry *et al.* 2001; Prior 1984).

4.2 Smallholder cocoa farming

PNG smallholder producers often regard cocoa as a means of securing 'ownership' of land and as a 'bank' that provides a source of cash to meet commitments such as school fees. One of the main reasons that cocoa production in PNG remains low is that smallholders grow cocoa as a source of supplementary income, and invest very little time or money into farm maintenance and long-term management, as they might if cocoa was their primary income source.

In a survey of cocoa farmers in ENBP Curry *et al.* (2007) found that farmers changed the way they managed their cocoa depending on the age of the planting. When the seedlings are first planted, the farmer visits the cocoa block regularly to ensure that the trees are established properly. The farmer applies weeding and shade management until the trees are established. This is often because food and market crops are planted in newly established cocoa blocks and weeding is carried out as part of the garden maintenance. Many growers also recognised that young cocoa trees were vulnerable to over shading and to being overgrown by weeds (Curry *et al.* 2007). Once the trees start to flower and yield, the visits made by the farmer are limited almost only to the harvest period. Pest and disease management and inputs of fertiliser, pruning and sanitation are minimal.

One of the consequences of this pattern is that not only do the trees bear few pods but those pods are also heavily infected by diseases, becoming a secondary source of inoculum. Over 82% of farmers identified Phytophthora black pod and canker and VSD as the most important constraints to cocoa production (Omuru *et al.* 2001). Curry *et al.*

(2007) found that up to 74% of trees were affected by canker in ENBP, yet over 95% of farmers had no knowledge of pest and disease management. Low yields reflect the low management inputs, the lack of understanding of the pests and diseases, and the absence of advice on management. While this results in low yields, it also means a very low cost of production (K447/Mt dry beans in 1999; Omuru, 2003) that somewhat insulates the farmers against market price fluctuations. Farmers treated their cocoa block much like an automatic teller machine (ATM) when they needed cash, rather than as a business from which they can derive a consistent and high income.

Other major factors that constrained production, as identified by farmers in ENBP, were the theft of cocoa pods, labour shortages, shortage of farm tools, and limited knowledge of correct management practices (Ghodake *et al.*, 1995; Lummani and Nailina *et al.*, 2001 cited in Curry *et al.*, 2007; Omuru *et al.* 2001). These issues were mirrored in the responses collated during interviews conducted with from farmers in other cocoa provinces in PNG during the current project. A reliance on family labour, conflicting demands for time from other activities, lack of infrastructure hindering access to markets (eg. in remote regions of Madang and central Bougainville) and access to resources and inputs (eg. pesticides or fertilisers may simply not be available due to lack of infrastructure of lack of funds; eg. central Bougainville and the Rai Coast, Madang) and the lack of information about new technologies were commonly identified by farmers as contributing to low yields.

The factors that have been identified as contributing to low cocoa yields experienced by smallholders are compounded by the limited skills of farmers and the lack of an effective extension service, which hinders the availability and transfer of new information and technology. However, when they are presented with new information, smallholder farmers are often very willing to experiment.

4.3 The need for technology transfer

In July 2003, a National Cocoa Summit (NCS) of cocoa industry stakeholders in PNG set a goal of 100,000 tonnes of dry bean production by 2012. While this goal is ambitious, from a market demand perspective, it is feasible because the world market for cocoa tends to be undersupplied. With the return of Bougainville into production, the target is even more achievable. The 2003 cocoa summit considered improvement in disease control as a critical priority for the industry. However, the PNG National Extension Summit held in May 2004 highlighted more broadly the deficiencies in information dissemination and agricultural extension that have hampered delivery of improved technologies. The summit identified farmer-focussed approaches in the delivery of disease management improvements as a clear priority.

Achieving the target of 100,000 tonnes of dry beans by 2012 will involve maintaining market demand for PNG cocoa (through attention to quality), while working to improve productivity in current cocoa growing areas and re-establishing a sustainable industry on Bougainville.

4.4 Technology development and transfer

Despite intensive research into the improvement of cocoa genotypes and cocoa production at CCI, national cocoa production in PNG has remained at around 42,000 tonnes dry beans per year since the 1970s. Shortcomings in the dissemination of information and in agricultural extension restricted the information that was available to farmers, and a new approach for the transfer and delivery of information was required. In assessing grower practice Omuru *et al.* (2001) found that productivity improvement would be boosted by supporting farmer adoption of low to medium cost control options along with the increased uptake of cultivars with resistance to disease (ASEM/2002/014). Disease losses are estimated at 40%, largely due to Phytophthora and VSD (Holderness

1992; Saul 1989). Reducing disease losses represents a key option for farming families to improve the productivity of existing cocoa plantings and to encourage greater investment in the crop to ensure sustainability of higher yields.

Recognising the significant changes in management practices that have accompanied the shift to smallholder production, the PNG Cocoa Coconut Institute (CCI) has focussed on the improvement of germplasm that is productive in low-input systems and the development of low to medium input disease management practices (Efron *et al.* 2005). Based on results from preliminary trials conducted at CCI in ENBP, and baseline information collected through farmer-discussions and industry stakeholder workshops, researchers at CCI developed a range of low, medium and high input options to form the basis of farmer participatory research encompassing on-farm testing and evaluation of disease management strategies.

This project adopted a participatory research approach (based on Participatory Action Research [PAR], Cornwell 1999) to disseminate the disease management options by engaging farmers as participants through on-farm research and application of technologies, to distribute effective disease control options to other farmers and to implement informed changes in cocoa management practices. The approach offers farmers a range of practical and cost effective options from which s/he could choose depending on his or her own situation. By making the decision to adopt a particular management option, the farmer takes ownership of that management choice and participates in the implementation of the management option. Essentially, the farmer becomes the researcher by choosing, implementing and testing the selected management option on his or her own farm. The farmer also becomes the extension worker and disseminates the information to neighbouring farmers, because the farmer has learnt by practical application of the chosen option.

The series of low-, medium- and high-input Integrated Pest and Disease Management (IPDM) options developed at CCI underpinned new farmer-participation-based approaches in the delivery of new information and technologies. Presenting a series of packages of management options allows informed farmers to improve their management at their own pace and capacity. The lowest input options require the least cash input. Higher input options demand more time and more cash. For example, leaving infected pods on cocoa trees increases the inoculum level in the cocoa block, sustaining high levels of disease. Implementing a strategy of harvesting not only ripe pods but also those affected by *P. palmivora* reduces inoculum levels in the cocoa orchard (Gregory and Maddison 1981). While this option is more time consuming, it requires no extra cash input and is ultimately beneficial in producing higher yields of healthy pods in subsequent harvests. Once the farmer engages in improved management, and has higher yields, and consequently more cash, s/he can then go to the next option, which may involve purchasing inputs.

4.5 Industry stakeholders and institutions

This project was built on the expertise at CCI and the outcomes of the Cocoa Breeding Section's and Cocoa Pathology Section's research. The continued development of cocoa research and extension capabilities will improve diagnosis of farming issues, the development and adoption of recommendations and increased production into the future. To support this, the strengthening of the PNG agricultural curriculum and the continued training of extension staff, researchers and agricultural scientists is essential.

The research and development activities at CCI are supported through strategic research inputs and training in Australia (through postgraduate research and coursework programs at Australian universities and agricultural institutions), linked to end-users (the farmers directly, and through private sector companies involved in the cocoa industry such as Farmgate in Bougainville, AgMark throughout PNG, and Mars International).

There is an ongoing need for appropriate disease management strategies to continue to be developed and improved under changing environmental conditions and economic circumstances, and the possibility of threats posed by exotic pests and diseases. There is also a continuing need for the new information to be available to farmers. By improving the extension and implementation of research outputs and recognising that links to other industry stakeholders can foster this process, the process of disseminating information and new technology can be much more effective in reaching its target. Including IPDM in the curriculum at PNG Universities, and training current extension officers at CCI and DPI in the technologies, and in exotic pests and diseases, will ensure that the response to future outbreaks of exotic pests and diseases can be curbed earlier through more rapid identification and targeted, effective responses.

5 Objectives

The key objective of the project was to increase the yield and profitability of cocoa production by smallholder producers in PNG through the development and dissemination of effective and affordable management strategies. Industry consultation and surveys focused on recording farmer knowledge of, and attitudes to, disease. This information was used to develop and implement relevant disease management strategies. Training in the field at the farm level enabled farmers to learn to recognise and understand the factors contributing to the major disease threats to cocoa production. Consequently, they were able to appreciate why a management strategy was effective and to extend the information and skills to other farmers.

The project will help meet the CCI goal of transforming the cocoa industry profile from 90% low management input farms to 50% medium management input, thereby increasing cocoa production and improving farmer incomes. In doing so, it will contribute to reaching the PNG cocoa industry goal of realising a national production of 100,000 tonnes of dry beans by 2012. Through the activities in Bougainville, the project will also contribute to the rehabilitation of Bougainville communities.

The objectives of the project were:

1. To document disease losses and smallholder knowledge, skills and attitudes to disease management at selected district sites.
2. To foster evaluation and adoption of a range of integrated disease management strategies in partnership with smallholders.
   - 2.1. Development of a ‘menu’ of integrated disease management options
   - 2.2. Farmer evaluation and adaption of disease control options with PNG farmers
   - 2.3. Foster improvement and adoption of IPDM through participatory on-farm trials and evaluation plots.
3. To enhance research and development expertise at CCI and strengthen industry linkages that foster improvement of smallholder disease management for cocoa industry sustainability.
   - 3.1. Enhance the pathological capabilities at Kerevat, SRS, Madang and UniTech.
     - 3.1.1. Skills and needs audit CCI and UniTech pathology
     - 3.1.2. Enhance screening methodologies for disease resistance
     - 3.1.3. Enhance understanding of the causes and control options for cocoa yield decline and other emergent diseases
   - 3.2. Strengthen participatory research and farmer extension capabilities in evaluation and adoption of disease control strategies.

6 Methodology

6.1 On-farm trial site and model farmer locations

Three villages in each of the three main cocoa growing provinces (Madang, East New Britain and Bougainville) were selected for the implementation of the IPDM trials (Figure 1; Table 1). Twelve farmers were identified in each village to participate in the baseline survey, IPDM training and establishment of their own on-farm demonstration plots. The trial sites and demonstration plots established in each village became the focus for extension activities.

The selected farmers signed Memorandum of Understanding with the CCI team to collect yield and disease data, to apply the inputs as per the IPDM packages and to train an additional 12 farmers in their village. In return, CCI would provide inputs to apply to the cocoa through the project. The farmers trained by CCI staff are referred to as ‘model farmers’ or 'Apostles' and the farmers they trained are the ‘extended farmers’ or 'Disciples'.

Initially it was proposed that the project would progress in two phases, firstly in ENBP and Madang, and then in the second and third years IPDM options would be extended to Bougainville. However, following the interest at the start-up workshop in November 2005, Bougainville was included in the initial establishment phase in year one.

Figure 1. Location of the three main cocoa growing provinces in PNG, Madang, ENBP and Bougainville (circled) in which a total of 12 villages were selected to conduct surveys and implement on-farm IPDM training.

Table 1. Sites at which surveys were conducted and on-farm trials were established in each of three cocoa provinces in PNG. Farmers are listed in Appendix 1.

Province	Village	Number of farmers at begining (# women in brackets)
East New Britain	Tokiala Kareeba Bitagalip	12 (2) 12 12 (4)
Madang	Galeg Kaul 2 Waden	12 12 12
North Solomons (Bougainville)	Malasang, Buka Island Tinputz, Bougainville Island Arawa, Bougainville Island	14 (5) 12 (2) 12 (1)

6.1.1 East New Britain Province

In ENBP Bitagalip, Tokiala and Kareeba villages were selected based on the interest of farmers. Farmers were initially sceptical of the new technologies and recruitment was difficult. Farmers in Bitagalip were already involved in an earlier 'nuclear village' project with Dr George Curry from Curtin University (ASEM 2002/014). All villages are located within a 60 minutes drive of CCI-Tavilo. A list of the farmers involve in the trial is presented in Appendix 1).

6.1.2 Madang Province

In Madang, three agronomically distinct localities were selected, Waden on the north coast of Madang, Kaul 2 village on Kar Kar Island and Galeg village on the Rai Coast. Waden is approximately 40 minutes by car from Madang, Kar Kar Island is 20 minutes by plane, or 3 hours by banana boat, and Galeg, is 40 minutes by plane or 5 hours by banana boat. The Rai Coast is one of the poorest areas in PNG. It was also the least accessible village included in this project. The CCI Stewart Research Station is approximately 30 minutes drive north of Madang. A list of the farmers involve in the trial is presented in Appendix 1).

6.1.3 The Autonomous Region of Bougainville

In Bougainville, the villages selected for participatory research were Malasang on Buka Island and Tinputz and Arawa on Bougainville Island. Malasang village is approximately 20 minutes by car from the CCI station at Kubu. Tinputz was a cocoa plantation area prior to the Bougainville crisis and is approximately 2 hours drive from Kokopau (the town at the Buka-Bougainville channel crossing). Arawa was the mining hub in the centre of Bougainville and was the largest town on Bougainville prior to the crisis. It is approximately 5 hours drive from Kokopau. In 2008, a DPI office was constructed in Arawa by the AGB. The CCI presence in Bougainville is limited to Kubu station on Buka Island. A list of the farmers involve in the trial is presented in Appendix 1. Paul N'nlau at Kubu has been training extension staff throughout the course of this project.

6.2 Documentation of disease losses and smallholder knowledge, skills and attitudes to disease management

The first phase of the project was to document information about the current knowledge and attitudes to farm management practices, inputs, yields, disease severity and disease incidence amongst cocoa industry stakeholders in the three major cocoa growing provinces of PNG (ENBP, Madang and Bougainville). This phase built on ASEM/2002/014 involving Dr Eric Omuru and Dr George Curry. Information was collected in two main

ways: (1) through discussions and consultation with key stakeholders, including the Cocoa Board, industry services representatives and farmers at a start-up stakeholder meeting held at Kabaleo Teachers College in November 2005; and (2) through farmer surveys conducted in villages in ENBP and Madang in 2006 and in Bougainville 2007.

6.2.1 Stakeholder workshop

A three-day start-up workshop was held at Kabaleo Teachers College in ENBP from 14-16 November 2005 to consult with industry representatives, to identify the main constraints on cocoa production, to ascertain the main priorities of the cocoa industry, and, to understand the current level of farmer knowledge and attitudes to disease and farm management strategies.

The aims of the workshop were to:

1. Create an opportunity for cocoa industry stakeholders to discuss current cocoa farming practices, identify smallholder knowledge, skills and attitudes to pest and disease management
2. Discuss constraints and problems affecting cocoa production in terms of crop protection technology
3. Increase awareness of current and potential pest and disease threats to the cocoa industry in PNG
4. Create an opportunity to discuss project plans, seek information and advice from industry representatives and stakeholders to help develop IPDM strategies for smallholder farmers in PNG
5. Explore ideas on how to disseminate IPDM through participatory on-farm trials under a pilot test in selected sites in ENBP, Madang and Bougainville.

The stakeholder workshop included a combination of presentations by cocoa industry representatives and scientists, group discussions and time for discussion, debate and questions.

The following topics were discussed and debated:

- Current farming practices
- Constraints to production
- Main pest and disease problems
- Industry priorities
- IPDM options
- On-farm participatory trials

Following the discussions and debates at the workshop the key attitudes, levels of knowledge, constraints and priorities were collated. This information was used to finalise the IPDM packages for dissemination to farmers, and to organise the participatory on-farm trials.

6.2.2 Farmer surveys

Surveys built on previous information collected by ACIAR project ASEM 2002/014 to better understand farmer knowledge of, and attitudes toward, pests and diseases and implementation of pest and disease management strategies. Farmer surveys were designed to determine the reasons for the observed farmer practices in disease management and assess attitudes and resources available/used for adoption of IPDM (Appendix 2).

Baseline economic, social and farm management data was collected from 'model' cocoa farmers in Madang and ENBP in 2006 and in Bougainville in 2007. The initial surveys determined the farmers' existing level of knowledge of cocoa growing, farm management practices, levels of disease in the cocoa block as well as social and economic wellbeing. A minimum of eight farmers were surveyed in each of the three participating villages in ENBP, and at least 12 farmers were surveyed in each of the three villages in Bougainville and Madang.

Plant Pathology staff from CCI, and colleagues from ISD and DPI, spent several days in each village to gather socio-economic and agricultural information. The most effective way to conduct the surveys was to spend time with the farmers in their villages, observing their practices rather than directly questioning them. By spending time with farmers 'true' or genuine answers were derived through conversation, rather than through responses prompted by a series of direct questions, which can often result in answers the interviewees believed the interviewer wanted to hear. The baseline information was used to identify the strengths and weaknesses of the current practices and to provide additional information for the development of approaches to enhance farmer adoption of management strategies, and to select farmers and villagers to be involved in the participatory on-farm trials.

Follow-up surveys were conducted in ENBP and Madang in January 2009, two and a half years after the initial introduction of IPDM. Comparison of initial data with data collected in the follow-up survey allowed the short-term changes in productivity and socio-economic activities to be assessed. The follow-up survey in Bougainville was not conducted until June 2009 and the analysis is not included in this report. It will be analysed for publication.

6.3 Fostering the evaluation and adoption of a range of integrated disease management strategies in partnership with smallholders

Once the information was gathered from the farmers, the next stage was to develop plans for implementation of disease management strategies. New information or technology options were discussed with farmers during the survey visits by CCI, ISD and DPI staff. Constraints were identified and questions answered. The support required to implement the action plan was then identified.

6.3.1 Development of a menu of integrated disease management options

Packages of culturally and economically appropriate disease control options were developed for dissemination to farmers based on preliminary research conducted at CCI, and in consultation with industry stakeholders (Table 2). The first option was the traditional practice of no inputs (basically, farmers only visit trees to harvest pods); the second option was a medium input requiring pruning, weed management, sanitation and weekly regular harvesting; the third option added manure or fertiliser application to Option 2; while the highest level included Option 3 plus the use of herbicides for weed management, fungicides and insecticides for diseases and insect pests, including disease vector control.

Pilot trials showed that a farmer implementing Option 1 would expect around 24 pods per tree annually and losses to Phytophthora pod of at least 40%. In implementing the second option the farmer would expect an increase in yield to around 32 pods per tree, and pod rot losses of 25%. A cost-benefit analysis equated this to an increase in income of 34% (Table 3, Lummani 2008). The addition of fertiliser in Option 3 increased yield to 37 pods per tree and reduced pod rot losses to 16%. This leads to a 55% increase in income over Option 1. In the final option the yield further increased to around 43 pods per tree and Phytophthora pod rot losses remained at around 16%. The benefit of Option 4 to the farmer was an 80% increase in income over the income obtained from Option 1 (Table 3). This analysis is very conservative. Annual harvests of 60-100 pods/tree are more typical

of the yields achieved under Option 4 in village demonstration plots, while trees under conventional smallholder management (Option 1) commonly yield less than 5 pods/tree annually.

Table 2. IDPM Options and inputs

Option	Activity
1 Low	Current practice, start with good planting materials
2 Medium	Weekly harvest, sanitation, manual weed management, cocoa & shade pruning related to crop cycle
3 High	Weekly harvest, sanitation, weed management, cocoa & shade pruning related to crop cycle. Chemical inputs include Glyphosate & Gramoxone (Herbicide), Urea/NPK (Fertiliser)
4 Maximum	Weekly harvest, sanitation, weed management, cocoa & shade prune related to crop cycle. Chemical inputs include: Ridomil+Dichlorvos (Fungicides & Insecticides), Glyphosate & Gramoxone (Herbicide), Urea/NPK (Fertiliser), Chloropyrifos (Insect Vector Control).
5 Maximum + CPB	Option 4 + targeted pod sprays of Chloropyrifos used whenever CPB is reported.

The low, medium and high input options were discussed with industry stakeholders and designed so that farmers from a range of social and economic backgrounds could implement them. Packing management options as packages also enables the farmers to implement management strategies at their own pace and capacity. Option 2 requires only increased labour and time inputs and requires no financial investment. Once the farmer engages in improved management, and receives higher yields, and consequently more cash, s/he can then choose to raise their management level to the next level, which may involve purchasing inputs. For example, farmers with little money, but time and motivation could implement Options 2 and 3 for which few inputs need to be purchased, but for which time to conduct manual work was required. Conversely, farmers with enough money or willingness to invest financially, Options 3 and 4 included the application of chemicals that needed to be purchased.

Table 3. Potential incomes from the different IPDM options (adapted from Lummani 2008)

IPDM Option	Annual harvest (pods/tree)	Kg dry beans/tree	Kina/tree (@K4/kg)	Annual return (Kina/ha)	% change in gross income
Option 1	24	1.04	4.16	2,600	-
Option 2	32	1.39	5.56	3,478	34
Option 3	37	1.61	6.44	4,026	55
Option 4	43	1.87	7.48	4,675	80

Where appropriate, CCI-bred cocoa cultivars with resistance to Phytophthora or VSD were used to replace missing trees in the cocoa block in on-farm trial sites. Application of inputs and activities were scheduled according to the cocoa cropping cycle calendar (Appendix 3) that was developed by Pathology Section staff at CCI. The applied IPDM strategies disrupted the pest and disease cycle and optimised the targeted application of pruning, nutrients and shade control.

Elements of the IPDM options include:

(a) Low input management (Option 1)

- Sanitation practices to reduce sources and levels of disease inoculum, including weekly harvesting of ripe and diseased cocoa pods
- Timely and appropriate pruning of cocoa and shade trees
- Timely and regulated manual weed control

(b) Medium, high and maximum input management (Options 2-4)

- Measures recommended for low input management plus:
  - Application of chemical fungicides to paint cankers
  - Timely and appropriate application of fertiliser to improve tree health in relation to the cropping cycle
  - Timely and regulated weed control using manual and chemical interventions
  - Chemical control of canker associated flying insects (longicorn and other wood boring insects)
  - Control of termites, disease vector ants and flying beetles

(c) Maximum inputs + CPB management (Option 5)

- Developed following the CPB outbreak in ENBP, this option adds CPB-specific control measures (targeted pod spraying) to the other components of maximum level management. The effectiveness of this option is being evaluated in CP/2006/114.

6.3.2 Establishment of on-farm trials to foster improvement and adoption of IPDM through participatory research

The IPDM recommendations were implemented in three villages in each of the three main cocoa growing areas of PNG (Madang, ENBP and Bougainville; Section 5.1). The IPDM package developed for cocoa contained the four options developed at CCI (Section 5.3.1 and Section 7.2.1). In each province three villages were identified to conduct farmer surveys and to establish on-farm trials (Section 5.3.1). The trial sites were established at no financial cost to the farmers. All material was to be purchased and supplied by CCI through this project.

At each site 12 'model' farmers were identified during the baseline surveys. CCI staff conducted extension training by supervising establishment of the IPDM options on the cocoa blocks by extension staff and 'model' farmers. Farmers were trained by practical application of skills during the day (“Classroom in the cocoa block”). In the evenings farmers learnt about the biology and epidemiology of the diseases. Information for the farmer surveys was often gathered at these evening meetings.

On-farm trials were established in Madang and ENBP by June 2006 and in Bougainville by March 2007. At each participatory on-farm demonstration site a maximum of 48 trees per option were included (192 trees in total). Where possible the on-farm IPDM trials sites were established near roadsides, tracks or public spaces clearly visible to passing traffic (Appendix 4).

To foster the evaluation of the management options, local extension personnel and village farmers were required to monitor their own yields and disease incidence with regular timely supporting visits by Plant Pathology personnel. The data was to be collected by the coordinator in each province and then sent to CCI-Tavilo for collation. Unfortunately, the absence of leadership following the departure of the PNG project leader and uncertainty associated with the vacant CCI CEO position, as well as the outbreak of CPB in ENBP,

trial establishment, data collection, compilation and analysis was disrupted. In ENBP the CPB outbreak and subsequent compulsory eradication program (involving the removal of all leaves and pods from cocoa trees) led to several farmers abandoning their cocoa blocks.

6.3.3 Encouraging farmer evaluation and adoption of disease control options

A key component of the participatory on-farm approach to dissemination of information and technology is that the farmers can evaluate and discuss the management options at the family and village levels then select those practices that best suit their own needs and capacity. Monitoring and review of how the management options were being implemented was done through meetings with farmers and other industry stakeholders, both those implementing the IPDM options and those continuing with traditional practice. Farm visits and stakeholder meetings presented an opportunity to review and update management options and discuss what was, and what was not working, what was more difficult or easier than first expected. Evaluation of the adoption of the IPDM was conducted through stakeholder meetings, farm visits and follow-up surveys of model farmers.

Extension activities, field days and farm-walks

On-farm participatory IPDM trial sites were utilised to involve smallholder model farmers to encourage spillover of project outputs to other cocoa industry members including extension personnel, provincial agencies, community groups and lead farmers from other provinces. The on-farm IPDM sites were used as locations for farmer field days, field walks and other extension activities. The field days were followed with training from CCI staff for other interested farmers.

On-farm field days and field walks were held at Bitagalip and Kareeba in November 2007 and in Madang at Garus in March 2006 and on Kaul 2 in November 2007.

Stakeholder meetings

Stakeholder meetings were held at Kabaleo Teachers College in ENBP on 5 November 2007, in Arawa, Bougainville, on 8 November 2007and at Hani's Inn, Buka on 9 November 2007. The meetings provided an opportunity for stakeholders to provide feedback on the IPDM packages and their implementation. The meetings were attended by representatives from CCI, DPI government ministers and farmers.

Farm visits

Project members visited model farmers in each of the provinces throughout the project to observe implementation of the technologies and ensure they were continuing correctly. The visits also enabled project staff to gauge the farmers opinions and expectations of the management options and modify them where required.

Follow-up surveys

Follow-up surveys were conducted two and a half years following the initial introduction of the IPDM technology to assess how farmer understanding and farmer practices have changed (Section 5.2).

6.4 To enhance research and development expertise at CCI and strengthen industry linkages that foster improvement of smallholder disease management for cocoa industry sustainability

6.4.1 Enhance the pathological capabilities at Kerevat, SRS, Madang and UniTech.

Enhance screening methodologies for disease resistance.

Dr Josephine Saul-Maora completed her postgraduate study at the University of Sydney in 2008. Her PhD project study examined the morphological and genetic variation in *Phytophthora palmivora* isolates collected from cocoa growing in Madang, ENBP and Bougainville. Her results showed little genetic variability across PNG, validating the centralisation of the breeding program in ENBP.

Mr Peter Epaina is undertaking postgraduate study at the University of Sydney. His PhD study will develop genetic markers for disease resistance to assist in the cocoa breeding program at CCI.

Enhance understanding of the causes and control options for cocoa yield decline and other emergent diseases

Mr David Yinil is undertaking PhD studies at The University of Sydney to investigate the role of agronomic practices and plant nutrition under the different management options to yield decline in hybrid cocoa.

Genetic diversity and management of CPB in ENBP

Mr Paul Gende is commencing a PhD at The University of Sydney to investigate the origin and diversity of CPB in cocoa and natural forests of ENBP. His studies will test the proposition that CPB is endemic to ENBP, and the recent outbreak is a result of a change in feeding preference. This study has significant implications for IPDM recommendations in different parts of PNG.

CCI-SRS Madang

Mr Yak Namaliu was relocated to PNG-CCI SRS-Madang to run the Madang operations of the project and to strengthen the pathology presence outside of ENBP. Unfortunately, the planned establishment of a pathology laboratory there has not been eventuated in the absence of CCI leadership.

PNG University of Technology - Lae

Mr Macquin Maino the key collaborator at the PNG University of Technology (Unitech) in Lae took up postgraduate study in Australia shortly after the initiation of the project. Mr Maia Wamala took over the responsibility as ‘key implementer’ of the project component at UniTech.

IPDM was incorporated into the curriculum at UniTech through cocoa block rehabilitation exercises in which selected final year students actively participated. The four IPDM options were applied to an existing cocoa garden at UniTech by students and labourers. The block then served as a demonstration block for training of vocational and degree students. Cocoa budding, pruning and pest and disease control skills were taught to UniTech staff and students with assistance from staff from SRS Madang.

Final year UniTech students were also engaged to assist in conducting the baseline farmer surveys.

Students from Vudal University in ENBP assisted with IPDM training in West New Britain.

7 Achievements against activities and outputs/milestones

Objective 1: Document disease losses and smallholder knowledge, skills and attitudes to disease management at selected district sites.

No.	Activity	Outputs/ Milestones	Completion date	Comments
a.	Consultation with stakeholders and smallholders	Stakeholder meeting reports/action plans and affirmation of enhanced industry support	November 2005	*ENBP* First project stakeholder workshop held at Kabaleo Teachers College from November 14-16 2005. Anticipated 35 people but approximately 300 people attended including CCI extension personal, Provincial DPIs, farmers and provincial government representatives, national planning representatives, cocoa exporters and plantations representatives, representatives from national agriculture and livestock from PNG sustainable development Corporation, National Agriculture Research Institute, PNG Growers Association, Vudal University, University of Technology Lae, PNG Cocoa Board, PNG Kokonas Indastri Kopoerasin, Minister for Agriculture and Livestock, AusAID. Participants came from: East Sepik Province, Madang Province, West New Britain Province, East New Britain Province, New Ireland Province and Bougainville. Key issues that arose from the meeting included: •The lack of knowledge of cocoa management practices •Deficiencies in the cocoa extension service A second stakeholder meeting was held at Kabaleo in November 2007.
				Bougainville Stakeholder meetings were held in Buka and Arawa in November 2007. Issues arising from the stakeholders meeting included: • The need to develop mechanisms for the sustainability of the IPDM program in Bougainville. • A need for better infrastructure so that cocoa farmers can obtain equipment and materials to implement IPDM, and transport inputs and beans to the point of sale and still make a profit. • A CCI research station should be established in Bougainville and the number of extension staff there increased. • Need for alternatives for Dichlorvox, and training workshops covering Environmental Health and Safety. • Interest in niche products, including organic cocoa.

b, c, d, e	Prepare, undertake and interpret surveys Training of extension staff and other stakeholders Survey representative smallholder farmers in selected provinces Collation and interpretation of survey data	Completion of farmer surveys Survey analysis Data on socio-economic characteristics and disease losses under different farmer management practices Crop loss and disease status in Madang, ENBP and Bougainville determined	2007	*Preparation of surveys and consultation with extension staff* The baseline farmer survey (socio-economic and agricultural) questionnaire was finalised in consultation with project members from ASEM 2002/014. CCI staff conducting the surveys spent several days in selected villages in ENBP, NPS and Madang gathering socio-economic information. Crop loss and disease data was collected at the same time as the socio-economic data. Through the process of farmer training, project staff also learnt more effective methods of conducting surveys and extending the management options to farmers. *ENBP* Twelve baseline surveys for socio-economic and management data at each of the three IPDM sites (Kareeba, Bitagalip and Tavilo) were completed in November 2006. Follow-up surveys were completed in December 2009. Many farmers in ENBP dropped out of the program because of the devastation caused by CPB – they felt their pods were not worth harvesting. *Madang Province* Twelve (up to 16 farmers in some villages) baseline surveys were completed at each of the IPDM sites on Galeg, Kaul 2 and Waden. Follow-up surveys were completed in January 2009. *Bougainville* Mr Paul N'nlau (CCI Buka) visited CCI-Tavilo in September 2006 where he was trained in running the baseline farmer surveys. Staff from CCI-Tavilo travelled to Bougainville in March 2007 to complete surveys and assist in training and establishing IPDM on-farm trials. Both Paul N'nlau and Wendy Sawa of CCI-Buka were be trained in conducting the surveys and establishing the IPDM options. Follow-up data was collected in June 2009.

c	Training of extension staff and other stakeholders	Training workshops for extension staff	2006-2007; ongoing	*Training workshops for extension staff* Training of extension staff targeted to three levels: (1) Direct training through involvement in the establishment of IPDM demo plots and PAR trials. This program began in April 2006 for extension and other interested staff at CCI-Tavilo and SRS-Madang. Twelve extension officers and seven other staff at CCI-Tavilo and another 12 staff participated in Madang. Participants learnt by assisting the project team in activities including pruning and removing diseased pods as outlined in the management options schedule. (2) Direct training of regional extension staff and model farmers through establishment of demo plots in selected villages. The trained farmers will share their knowledge with other farmers in their village. (3) The future generation of extension officers will be trained through UniTech Lae and other universities. The following were trained at CCI in December 2006: ISD (Industry Services Division) staff from Bougainville, NIP along with the Tavilo (CCI) plantation manager, and Agronomy Section staff and DPI staff from across ENBP. Over 72 extension officers and farmers were trained in Bougainville by CCI-Tavilo staff during the visit in March 2006. In Bougainville, Paul N'nlau at CCI-Kubu has set aside plots in the budwood garden he is using to train new extension officers. Each officer has his or her 'own' block to look after. Regional extension staff and model farmers were trained during the establishment of on-farm trials in the selected villages. The trained farmers shared their knowledge with other farmers in their village through an extended farmer system. The model farmers were each asked to train 12 neighbouring farmers about the IPDM options and the practices involved in managing their cocoa block. Some extension staff were very reluctant to participate in training (particularly in ENBP) and it took over a year to attract participants. Twelve month training programs were initially planned for March 2006, but were postponed to March 2007 due to the CPB eradication program. Participants were to be certified upon completion of the training program. These are yet to be completed. Once the current extension staff saw that the uptake of the technology was increasing and there was a noticeable difference in the cocoa tree productivity, they were also more eager to learn about IPDM. At the 2008 Research and Extension Review held at CCI, the Acting Head of ISD (Alfred Nongkas) announced that the rollout of IPDM would be the priority for ISD following the completion of the CPB campaign. Several IPDM farmers have gone on to become extension officers, particularly in Bougainville. In the villages, the community became involved as each model farmer was asked to train a further 12 farmers (‘extended farmers’).

		Selection of representative farmers for PAR trials	June 2006 (ENBP, Madang), May 2007 (Bougainville)	Representative farmers (36 in each province) were selected to partake in the surveys and IPDM trials in ENBP (Kareeba, Bitagalip and Tokiala), Madang Province (Galeg, Waden and Kaul2) and Bougainville (Malasang, Arawa, Tinputz).
e, f, g	Resurvey farmers from initial sample Collate data and compare with initial survey results	Preliminary indication of farmer uptake of recommendations and success of the project	ENBP, Madang: Jan 2009; Bougainville: June 2009	Follow-up surveys were completed in Madang and ENBP in December 2008. Follow-up surveys in Bougainville were completed in June 2009. Analysis of surveys from Bougainville is yet to be finalised.
		Dissemination of results and implications to extension agencies and industry stakeholders (at end of project)	Ongoing	A training manual for IPDM in cocoa was published in 2008 (Konam *et al.* 2008).

PC = partner country, A = Australia

Objective 2: To foster evaluation and adoption of a range of integrated disease management strategies in partnership with smallholders.

Objective 2i. Develop integrated pest and disease management strategies

no.	activity	outputs/ milestones	completion date	Comments
a	Evaluation of stakeholder recommendations and survey data and planning of disease management options	Development of IPDM packages for implementation including monitoring checklist	March 2007	*IPDM Package* An IDPM package offering four options of different input levels to cater for a range of farmer situations was developed after considering information collected during stakeholder workshops and surveys. Feedback on the adoption of IPDM was obtained through stakeholder workshops held in 2005, and 2007, through field visits by project staff throughout the project, through direct consultation with farmers and by interviews for the surveys conducted by CCI staff in 2006 (Madang, ENBP), 2007 (Bougainville). Follow-up surveys were conducted in ENBP in December 2008, in Madang in January 2009 and in Bougainville in June 2009. A monitoring checklist was developed and 'block reports' with advice for the farmers about which inputs were required in their block were prepared by CCI staff following their visits to conduct surveys and IPDM training.
b	Development of recommendations and "disease evaluation and adoption strategies " for ENBP, Madang and Bougainville smallholders	A range of improved management strategies for adoption by smallholder farmers Feedback on and adoption of disease control options by PNG farmers Strategies for fostering wider adoption of IPDM strategies developed through PAR	2006	To promote a wider uptake of IPDM model farmers were asked to train an additional 12 farmers. This has contributed to the dissemination of the technologies. *ENBP* A total of 36 model farmers in three locations: Kareeba, Bitagalip and Tokiala were initially involved in the IPDM on-farm trials. The site at Kareeba was within the CPB "Hotspot" area near NARI. The IPDM site at Bitagalip was not affected by the CPB eradication campaign. The site at Tokiala was affected by the CPB eradication, but was rehabilitated using the IPDM options. This was to test the IPDM options in a CPB situation. Unfortunately, because of the high impact that CPB had on pod losses, many farmers dropped out and yield and disease incidence were not recorded regularly.

				Madang Province A field day was held at Garus in July 2006 to demonstrate the IPDM options to cocoa growers. Demonstration plots were prepared in advance, and the benefits of implementing the IPDM options such as reduced disease incidence and improved yields were discussed. Approximately 400-500 farmers participated, indicating the high level of interest raised by the improved management options. Thirty six IPDM plots were established with 12 farmers each at Galeg, Waden and Kaul 2. The trials on Kaul 2 were established in collaboration with Derek Middleton (plantation owner) and Sulu (CCI-ISD). Sites were established at easily-accessible and visible sites (eg. roadsides). The establishment of the IPDM demonstration at Waden had increased cocoa income from K6,000-K12,000 per month, and that the extra income was used to fund the maintenance of options 3 and 4 at the site and for training activities. Village crop protectionists were trained in Galeg and local staff were trained at CCI-Madang. These staff assisted with the baseline surveys and establishment of on-farm IPDM trials as part of their training. The involvement of the extension workers provides a link between CCI and the village community and aims to foster evaluation and adoption of the IPDM options. A community resource centre was funded and built by villagers in Galeg village on the Rai Coast to host IPDM training and trainers.
				Bougainville Mr Paul N'nlau (ISD, CCI-Buka) visited CCI-Tavilo and assisted in setting up IPDM demo plots in Kareeba, ENBP as part of his training in IPDM. IPDM on-farm plots were established at Malasang village on Buka Island and in Arawa and Tinputz on Bougainville Island. We had expected to be able to establish additional satellite sites on Bougainville with the assistance of the UNDP, however the unexpected departure of the UN representative has stopped this. IPDM training is being conducted and demonstration sites have been established with support from the Autonomous Government of Bougainville (AGB) in Buin, in the far south of Bougainville Island. An IPDM farmer from Tinputz is employed by DPI/CCI to lead the training.
				Lae IPDM options were established in the UniTech Cocoa garden consisting of 3 ha of SG2 hybrids previously abandoned and unused. This demonstration plot was used by fourth year undergraduate students, with one group of 9 students managing one of the options for 3 weeks, then rotating to another option. As a result, graduates will now be experienced in the four IPDM options presented to farmers.

c	Establishment of a CCI Pathology Laboratory at SRS Madang	Establish Pathology at SRS, Madang	2007	Mr Yak Namaliu relocated to Madang in 2007 strengthen the Cocoa Pathology Section in Madang and the coordinate the IPDM activities in the region. Discussions concerning the establishment of a Pathology Laboratory at SRS continue.
d	Develop linkages with other projects	Coordination with other projects		In 2005, the ACIAR project had active links with the AIGF 1048 project in ENBP. AIGF 1048 finished in 2006. Both projects made significant impacts on smallholder cocoa farmers. The PNG Project leader and team were awarded third prize (2nd runner up) in the South Pacific Extension Excellence Award. Links were established with the Madang Smallholder Development Project (MSDP) to target women for cocoa protection officer training in villages. MSDP includes CCI-ISD, DPI, provincial, farmer and women's representatives. The group promotes smallholder farmer activities in Madang province. The need to transfer responsibility for IPDM from CCI to provinces and to farmers was emphasised. Linkages with the UNDP were explored in early 2006, including activities such as supporting additional training of extension officers. Following the replacement of the UN representative later in 2006, some further discussions were held between the new representative and Dr Konam. Prof. Guest is involved in a CABI/ACIAR project to develop and implement management strategies for CPB (CP 2006/114). CP 2006/114 and this current project have a number of common goals and approaches, particularly the need promote good farming practices among smallholder farmers. He is also involved in SMAR 2005/074 which aims to improve sustainable cocoa production in Sulawesi, and has fostered a number of exchanges of information and networking between the two projects.

Objective 2ii. Farmer evaluation and adoption of disease control strategies.

No.	Activity	Outputs/ milestones	Completion date	Comments
a. and b.	Selection and establishment of 2-5 PAR sites in each area (total of 10) Establish monitor and assess on-farm trials	Training of local extension personnel and village extension workers On-farm PAR trials established and completed	2007	Farmers who participated in the on-farm trials were selected during the time in which surveys were conducted. Initially 12 farmers in three villages in each ENPB, Madang and Bougainville were selected. Some farmers had to be 'replaced'. By 2009 not all 12 farmers were available to be interviewed. *ENBP* A total of 36 PAR sites have been established in ENBP. Twelve farmers were initially involved in each of Kareeba, Tokiala and Bitagalip. Due to CPB and the dramatic eradication program, many farmers did not see cocoa as viable any more and dropped out. As a consequence of CPB eradication, one site in WNB was replaced with a site in a CPB "hotspot" at Kareeba. Due to the CPB incursion, site establishment at the three locations occurred at different times from September 2006 to February 2007. Application of NPK fertiliser was delayed until March 2007 at all three sites. *Madang Province* Thirty-six on-farm trials were established in Waden, Galeg and Kaul 2 villages by June 2006 by Yak Namaliu and his team at CCI, SRS-Madang. *Bougainville* Sites on Bougainville were established by March 2007 by a six-person team from CCI-Tavilo. This team worked with Paul N'nlau and Wendy Sawa from CCI-Buka to conduct surveys and establish IPDM on-farm trial sites in Malasang (Buka), Tinputz and Arawa (Bougainville) with 12 farmers model farmers surveyed and trained in each village. Local extension staff were trained in IPDM options through their participation in the establishment of the PAR sites.
			2006 - 2009	ISD staff from Bougainville and NIP travelled to CCI-Tavilo for training in December 2006. *New Ireland* Anthon Kamuso from CCI-Tavilo (Pathology Section) travelled to NIP in 2007 and 2008 to train ISD staff and farmers in IPDM. Twenty demonstration sites were subsequently established on New Ireland by Kula Daslogo (CCI Kavieng). Extension staff and farmers were trained during the establishment of the on-farm trials.

Objective 2c. Foster improvement and adoption of IPDM through participatory on-farm trials and evaluation.

No.	Activity	Outputs/ milestones	Completion date	Comments
a.	Revise and review disease control options based on farmer feedback and trial outputs.	Documentation of progress and farmer uptake of recommendations	2009	Farmer knowledge and attitudes toward cocoa block and disease management were documented during the start-up workshop in November 2005, and in surveys conducted in 2006 (Madang, ENBP) and 2007 (Bougainville) View expressed during surveys and stakeholder workshops were taken into consideration for the final design of the IPDM packages. Farmer uptake of the recommendations has been high, particularly in Bougainville. Farmers still face difficulties in obtaining chemical inputs. In remote areas, the difficulties of infrastructure for access to inputs, resources, cocoa transport and processing are significant. For example, difficulties in fermenting, drying or transporting beans can hamper quality and can pose significant costs to farmers.
b.	Train local extension personnel and village extension workers and undertake trial site monitoring.	Additional farm demos, field days, field walks conducted for dissemination of information	2006-2009	Direct training of regional extension staff and model farmers took place during the establishment of demo plots in the selected villages. Training of extension personal in ENBP, Madang and Bougainville occurred by including staff in the establishment of IPDM plots. Extension officers were trained (and are still being trained) according to the annual cocoa cropping calendar that has been designed to include the input options. This strategy simultaneously provides labour for the establishment of the on-farm demonstration plots. *ENBP* ISD officers had been allocated a block at Tavilo but the training was disrupted due to the CPB incursion. The IPDM blocks for training of extension officers in Tavilo was rescheduled and training was to resume in late February 2007. Field days and field walks were conduced by CCI staff and farmers throughout the project. In November 2007, a field walk was organised by model farmers in Bitagalip, ENBP. A second field day was held in Kareeba in November 2007, with farmers able to view display boards, and travel to model farmer sites on buses provided by CCI.

				Madang "Village Crop Protectionists" were trained in Madang to coordinate field days, baseline surveys and IPDM demonstration plots under supervision Yak Namaliu Two "awareness" days have been held in Galeg village on the Rai Coast. Outreach activities supported by the Cocoa Board are being conducted in Madang, the West Sepik region and Morobe Province. These activities are organised and run by IPDM farmers and were requested by farmers in the other cocoa growing areas. Field days were held in Madang in July 2006 with over 500 participants and in Kaul 2 village on Kar Kar in November 2007.
c.	Foster stakeholder workshops and establish/broaden use of on-farm evaluation, field days, posters.	Preparation of information pamphlets		*IPDM Training Manual* An IPDM training manual and husbandry manual was developed through this project with support from the AIGF Project 1048 (Konam *et al.* 2008). The manual has been distributed to participants of training workshops and field days. The manual has been translated into Bahasa Indonesia, Fijian Pidgin, Solomon Islands Pidgin and Vietnamese. *Cocoa Cropping Calendar* A calendar detailing the timing of the application of the various inputs required for the IPDM in PNG has been developed and is included in IPDM training activities (Appendix 3).

PC = partner country, A = Australia

Objective 3: To enhance research and development expertise at CCI and strengthen industry linkages that foster improvement of smallholder disease management for cocoa industry sustainability.

Objective 3i: Enhance the plant pathology research capability

No.	Activity	Outputs/ milestones	Completion date	Comments
a. and b.	Training audit and strengthening of pathology expertise at Kerevat, SRS Madang and NSP, and PNG UniTech	Pathology base strengthened in Madang Audit report on training needs and user brief for infrastructure improvement	2006 – ongoing	*Establishment of Pathology Present at CCI SRS Madang* Yak Namaliu relocated to Madang from ENBP in 2006 enhancing the cocoa pathology presence in the province. He was also responsible for coordinating IPDM activities in Madang.
				UniTech Students from UniTech have participated in various IPDM-related activities (eg. West New Britain CCI in 2006) Students from Unitech established a demo block at the University and being trained in the IDPM options through their coursework and final year projects.
		Pathology and extension presence in Bougainville (North Solomons Province)		*Establishment of Pathology Presence in Bougainville* The extension presence in Bougainville has been significantly enhanced. Prior to this project the pathology and extension expertise in Bougainville was largely limited to Buka, where CCI-Kubu is based. Farmers generally had to travel to Buka for planting material and advice. Thirty-six model IPDM farmers have been trained directly through this project. These farmers have been involved in training 'extended' farmers in their villages. Several of the IPDM model farmers have been employed by DPI and CCI in Bougainville in Arawa and Buin. Buin is beyond the geographic location of this project, in the south of Bougainville. Training of more extension officers is continuing at Kubu station on Buka. There is still a need and desire from local authorities for a more substantial CCI presence on Bougainville. It is difficult for CCI staff to travel around Bougainville (in the absence of a vehicle on the island) and as a result visits from extension staff are limited. Bougainville also has its own set of disease and management issues. For example VSD is not a problem in the Province. However, much of the island is covered in cloud for much of the year, creating different requirements for shade and disease management. A research station on Bougainville would enable to development of more specific targeted management strategies and more appropriate breeding programs. Paul N'nlau was responsible for the coordination of this project in Buka/Bougainville. He actively contributed through the organisation of the Workshop attended by John Konam in February 2005 and the coordination of visits by project members to Bougainville. He and his staff have been involved in training more than 1000 farmers and extension officers across Bougainville.

Objective 3ii: Enhance screening methodologies

No.	Activity	Outputs/ milestones	Completion date	Comments
a., b. and c.	Renew and strengthen collaboration between pathology and cocoa breeding and strengthen role/links for UniTech Re-evaluate and improve field screening methods Assess pathogen variability	New progenies screened for Phytophthora resistance Establish and validate resistance screening technology and methodology	2008; continuing	Screening cocoa breeding lines for pest and disease resistance forms part of Peter Epaina's PhD project and is still continuing. Josephine Saul completed her PhD studies in 2008. She found that *Phytophthora palmivora* was the only Phytophthora species associated with black pod, bark canker and leaf blight in cocoa in PNG. Other Phytophthora species have been implicated in causing the disease in other cocoa growing countries. She also discovered that genetic variation was low across the country, and that two mating types were present in Madang. The presence of two mating types could have significant implications for the evolution of genetic diversity through sexual reproduction in the pathogen, and needs to be considered for future quarantine measures. Josephine is now the Head of the Plant Pathology Section at CCI.

Objective 3iii: Enhance understanding of emergent diseases and control options

No.	Activity	Outputs/ milestones	Completion date	Comments
a.	Training by Australian partners	Trained CCI pathology staff capable of diagnosis exotic disease		CCI staff have undertaken postgraduate study in Australia and participated in international conferences. Josephine Saul completed her PhD in 2008. Peter Epaina and David Yinil are continuing their studies. Paul Gende will commence PhD studies in 2010. John Konam, Yak Namaliu and Josephine Saul participated in the 2007 Australasian Plant Pathology conference in Adelaide. Josephine Saul was awarded the prize for best student oral presentation. The capacity of CCI staff to undertake research has significantly increased through hands-on training in IPDM activities, including management practices and conducting surveys.
c.	Enhance understanding of hybrid decline			Hybrid yield decline is being investigated by CCI staff who are completing postgraduate studies at The University of Sydney. David Yinil is investigating the effects of nutrition on hybrid decline, and Peter Epaina is examining the influence of genetics.
b. and d.	Provide strategic inputs for work on emergent disease threats Undertake Government and Cocoa Board briefings (PC)	Improved knowledge of existing and potential disease threats that constrain production Trained CCI pathology staff capable of diagnosing exotic disease Alert government authorities, Cocoa Board and growers of quarantine risks and response planning		*Improved knowledge of potential threats* Risks posed by exotic threats, including CPB, were presented and discussed at the start-up workshop at Kabaleo Teachers College in November 2005. The workshop was attended by industry stakeholders including representatives from government organisations and the PNG quarantine services. Industry stakeholders were told to contact authorities if they thought they had a new pest or disease on their cocoa. *Visit by CPB experts* Following the discovery of CPB in ENBP Dr Endang Sulistyowati from Indonesia and Dr Smilja Lambert from Mars Symbioscience visited CCI to assist in confirming the identity of CPB. They also trained staff in procedures for monitoring of CPB using pheromone traps and in control and eradication of the pest. *CPB Workshop* A two day workshop organised by CCI-PNG was held in response to the recent incursions of CPB in ENBP and WSP. Approximately 100 stakeholders participated to discuss current threats, monitoring, management recommendations and future directions. Additional support for the CPB program was provided by scientists from Australia, Indonesia, Malaysia and from Industry (Mars Symbioscience) who also participated at the two day CPB workshop.

Objective 3b: Strengthen participatory research and farmer extension capabilities in evaluation and adoption of disease control strategies.

No.	Activity	Outputs/ milestones	Completion date	Comments
a.	Survey planning and targeted training of extension staff to assist with on-farm sites in Madang and Bougainville	Development of disease control strategies and adoption processes for farmers and training modules Enhanced uptake of research outputs	2006	*IPDM options for disease control* Four IPDM options, from low-input through to high-input were developed to improve cocoa management in PNG. An additional option was developed for CPB-affected areas. A participatory research approach, working alongside farmers with practical on-farm training and demonstration encouraged uptake of research and farmer to participation in the transfer of information.
b.	Utilise trial sites and smallholder co-operators to communicate project outputs to other provinces, farmers and relevant groups	Support farmer led evaluation and adoption activities	2006-2009 ongoing	Farmer led adoption of disease management options was high. Following the start-up workshop in November 2005 many farmers returned to their cocoa block and implemented techniques learnt during the workshop. They in turn taught neighbouring farmers. This is evidence that the participatory research based extension is very effective as the farmers have initiated this on their own with little direct involvement from CCI. *Farmer led adoption activities* Trial sites have been used as the focal point for field days and farm walks throughout the project. For example, in 2007, farmers on the Gazelle Peninsula in ENBP organised a field walk where participants walked through the IPDM blocks and were shown how to conduct various IPDM-related activities at stations throughout the walk. Smallholders from villages neighbouring the Bitagalip IPDM site implemented the IPDM options after observing results of the options in the on-farm demonstration trial blocks at Bitagalip. The Kopoko and Gazelle districts administrations have indicated their interest to support IPDM options and expand them to the entire district as part of its priority district agriculture program. Discussions were initiated in 2007 to develop plans for implementation in the Kokopo district. Mr Peter Woolcott, a large plantation-owner in ENBP funded his own IPDM trial on his property. Dr Konam and Plant Pathology staff visited him and stayed a night to establish an IPDM PAR trial plot at Klin Wara plantation. Mr Woolcott remains a strong advocate of the ACIAR IPDM project. The Oro Campus of Vudal University expressed interest in establishing IPDM PAR trial blocks in Popodetta. Mr Robert Kee, the farm manager visited Dr Konam in 2007 to discuss how to proceed. Three students from Vudal University, ENBP, assisted with the surveys conducted in ENBP in 2006.

				Madang More than five IPDM "outreach" groups have been established to implement IPDM options independent of this project. Two awareness days were held in Galeg on the Rai Coast and more awareness and training has been conducted by the Outreach farmers from the north coast of Madang who are training farmers around Madang, and in the West Sepik region and Morobe Province. The aims and activities of the ACIAR project were discussed (and warmly received) with members of the Madang Smallholder Development Project. This group promotes smallholder farmer activities in Madang province, and includes CCI-ISD, DPI, provincial, farmer and women's representatives. Links were established to target women for cocoa protection officer training in villages.
c.	Work with Unitech to review cocoa disease teaching modules and to involve students in surveys and on-farm trials	Revision of cocoa teaching modules at UniTech	2006	IPDM options were established in the UniTech Cocoa garden, 3 ha of abandoned SG2 hybrids. Cocoa blocks were rehabilitated by students and used in training of vocational and degree students. The demonstration plot was used to train fourth year undergraduate students. Graduates will be experienced in the four IPDM options presented to farmers. Ultimately, the existing trees will be replaced by elite selections. Students from UniTech have participated in various IPDM-related activities including establishment of IPDM plots in ENBP and field days in NIP
d.	Field days and industry liaison	Field days for dissemination of information	2009	Field days were held in ENBP, Madang and NIP: ENBP: November 2007; Madang: July 2006, November 2007 NIP: November 2008 (included "IPDM Launch") Numerous awareness and training days were organised and run by CCI pathology staff in ENBP, Bougainville, Madang, New Ireland Province and West New Britain.

PC = partner country, A = Australia

8 Key results and discussion

Survey data presented throughout the results section is the national average compiled from surveys conducted in Madang, ENBP and Bougainville. Follow-up data for Bougainville has not been included as it was collected in June 2009. Responses to all questions are presented in Appendix 2.

8.1 Documentation of disease losses and smallholder knowledge, skills and attitudes to disease management at selected district sites

8.1.1 Stakeholder workshops

The startup workshop held at Kabaleo Teachers College in ENBP in November 2005 was attended by over 300 cocoa stakeholders from across PNG and Bougainville. Participants came from ENBP, Bougainville, Madang, East Sepik Province, New Ireland Province and West New Britain Province as well as other cocoa growing areas in PNG. The three-day workshop enabled widespread consultation with industry representatives including farmers, researchers, suppliers, cocoa advisors and government representatives. The key objectives of the workshop were met (Table 4).

The workshop stimulated animated and extensive discussion of issues facing the cocoa industry in PNG. Constraints of cocoa production and industry priorities were identified during the start-up workshop held at Kabaleo, ENBP in November 2005 (Table 5). These issues were captured in the rapporteur's report, which was included in an amended version of the Workshop Manual submitted with the 2006 Progress Report. Discussions and debates held during the workshop helped to refine the disease management options developed for this project.

Table 4. Aims and outcomes of the start-up stakeholder workshop held at Kabaleo Teachers College, ENBP from 14-16 November 2005.

Aim	Outcome
Meet with cocoa industry stakeholders	More than 300 stakeholders attended three-day workshop
Identify problems and constraints faced by the cocoa industry	Constructive discussions and debates were held to identify problems and constraints affecting cocoa production in PNG.
Identify current practices and farmer knowledge about pests and diseases.	Overview of current practices and farmer knowledge about pests and diseases following group discussions.
Strengthen relationships with industry	Established stronger relationship to develop and more research and development-based approach for the industry
Assist CCI to develop realistic and effective cocoa research, development and technology delivery programs	Streamline the normal research down to packaging of productive technologies targeted to reach and be implemented by farmers Researchers, extension officers and farmers as end-users, must participate in developing new technologies and in the development of technology delivery systems focused on a community-based learn-by-doing approach.

Table 5. Constraints of cocoa production and industry priorities identified during the start-up workshop held at Kabaleo, ENBP in November 2005.

The PNG cocoa industry	No plan on how to reach the 2012 target of 100,000 dry beans Focus on planting material and dry bean quality, but low yields Support from Cocoa Board Need for stakeholders to work together
Research at CCI	Maximise benefits of research at CCI Translate research outcomes to increased production Participation of stakeholders to derive benefits of research outcomes Improved planting materials – increased yields are often not translated to farmer cocoa blocks
Agronomic practices	Farmers skills Farmer attitudes toward adoption and implementation of technology Farmer knowledge of correct tools and chemicals Perception of a high cost of tools and chemicals.
Extension	Need for promotion and dissemination of new technology Rate of adoption is low
Farmer attitudes	Low level of investment by farmers Lack of knowledge of pests and diseases Poor time management by farmers and poor use of family resources Attitude to change
Training needs	All extension (DPI, ISD), economists, researchers, plantation managers farmers etc all should be trained in the technologies and their implementation How to certify trainees Community based training Awareness of exotic pest and disease threats

Summary of group discussion on current yields and pests

Participants were divided into groups representing various sectors of the cocoa industry; smallholder farmers, plantations, extension, suppliers, and government. A summary of the group discussion to determine current yields and constraints to production is presented in Table 6. Participants were divided into groups for the yield question. Reported annual yields were less than 500kg/ha. Many participants at the workshop were uncertain of their yields, and guessed. Only plantation representatives recorded, and therefore knew what their yields were. This highlighted the need for farmer training in record keeping. IPDM farmers in this project were asked to keep records of their cocoa yields under the four options that were implemented in their blocks so that they could assess the difference in yield themselves.

Over 50% of constraints to production reported by workshop participants were farm-based and addressable. Most farmers said that they would continue to farm if a pest or disease came in because this was their only source of income.

Table 6: Current yields and constraints to production.

Group	Current average yield/ha (kg)	Three major constraints you face	Three major pests and diseases in your cocoa block	Will you still farm if there is a new pest/disease?
Smallholder farmers	500-600	Infrastructure Lack of training Farmers not business-minded Social and cultural commitments Lack of technical information Farmer attitude problems Expensive planting materials Poor market access Availability of planting materials Lack of processing facilities Labour shortages or costs Stealing Lack of knowledge Lack of extension services Pests and diseases Land shortage Lack of basic book keeping Over commitment by farmers	Diseases (in order of importance): Blackpod, pink disease, VSD, canker Pests: (in order of importance): Longicorn, capsid, grey weevil, pantorhytes, green parrots, bats, mirids	Yes, as long as the problem is being addressed Report to authorities if serious Abandon block if costs are too high Continue because it is the only source of income
Plantations	1000-1500			
Extension	300 (farmers), 1100 (plantation)			
Suppliers/dealers	200-700			
Government	500			

Summary of group discussion to develop a set of management options for cocoa

The workshop organisers asked groups of participants to develop a set of options for management of cocoa. Workshop participants had little knowledge of management strategies for the control of pests and diseases in cocoa (Table 7). This task highlighted the deficiencies in the dissemination of information and skills to farmers, and other members of the cocoa industry.

Table 7. Group Discussion: Management options, compilation of PAR packages, objectives. The participants were asked to design a series of management options for cocoa.

Question	Farmer groups (summary of 3 groups)	Plantation	Extension	Suppliers/dealers	Government /bureaucrat
How do you control weeds?	Manual slashing Chemical Ring weeding Intercropping	Mechanical slashing Chemicals	Manual slashing is common for smallholders	Slashing Farmers more likely to slash in young plantings than old plantings	Slashing Ring weeding Strip weeding
Do you manage cocoa shade?	Ring-bark Set fire to tree base Pruning	Ring-bark and thin with a bush knife	Partial pruning Heavy pruning No pruning	Pruning Difficult where there is a labour shortage	Thinning at irregular intervals Ring-barking Alternate or complete removal
How do you control black pod if it is a problem?	Remove dead pods manually Shade control Prune branches with black pods Harvesting Fungicides Ignore it, it is normal Waste of time to remove black pods	Plantation – remove blackpod when harvesting	Rausim or lusim	Removal mainly in harvest periods	Manual removal
Do you look for technology	Yes (10%) and no (90%) Own knowledge Farmer to farmer or friends Self taught CCI, DPI Slow response from sources	Yes, and using technology	Yes through farmers, friends, field days and resource books.	Isolation and transport costs to seek technology	Yes/no
Do you prune your cocoa?	Yes (Bougainville) Twice a year No Don't know how to prune	Sometimes	Liklik tasol A little	Yes, after the main flush	Few yes, majority no
Do you know that chemical use can increase production?	Yes/No Very expensive Don't know how Only know that chemicals kill weeds	No	No awareness and no knowledge	Yes, but isolation and transport costs are too high	
Do you have a work program for your family and block?	Yes No No consistent work program Depends on market price	No	Yes/no	Yes, but other cultural and social activities disrupt the program	No 18 month plan

Farmer testimonials

Farmers who were already implementing the IPDM options on their cocoa farms were asked to provide testimonials to the workshop. The farmers' opinions and experiences are highly respected amongst other farmers and provide a valuable reinforcement of the technology. The farmers who presented at the start-up workshop were:

1. Peter Woolcott – Klin Wara and Kabanga Plantations, North Bainings, ENBP

2. Marex Marika – Usino Bundi district, Madang Province

3. William Luaina – Kadaulung, Warangoi district, ENBP; The farmers at Kadaulung established their own trials.

Requests for further training

Following the workshop in ENBP government agencies and CCI-ISD staff in Bougainville and New Ireland expressed interest in holding workshops/field training days. CCI-pathology staff followed up training requests. The workshop also inspired several farmers returned to their cocoa blocks and implement elements of the IPDM options. The workshop highlighted the need for extension and the desire for learning among the cocoa farming community. The workshop particularly highlighted the desire and enthusiasm of Bougainville cocoa industry to increase its production following years of conflict.

8.1.2 Farmer surveys to determine smallholder knowledge, skills and attitudes

The farmer surveys conducted in ENBP, Madang and Bougainville supported findings by previous socio-economic studies conducted with cocoa farmers in ENBP (Curry *et al*. 2007). The individual results of surveys from Madang, ENBP and Bougainville will be analysed and published when the Bougainvillean data has been collated. The follow-up surveys were conducted 2 ½ years after implementing the IPDM technologies. The results of the final survey from Bougainville are yet to be collated and analysed as the survey was conducted in June 2009.

The surveys supported the findings during the start-up workshop – that farmers, and other cocoa industry representatives, lacked skills and knowledge of pests and diseases and crop management. In 2005, only 25% of farmers surveyed knew that pests and diseases contribute to crop losses. Following training in IPDM, farmers learnt skills to manage their cocoa (Figure 2).

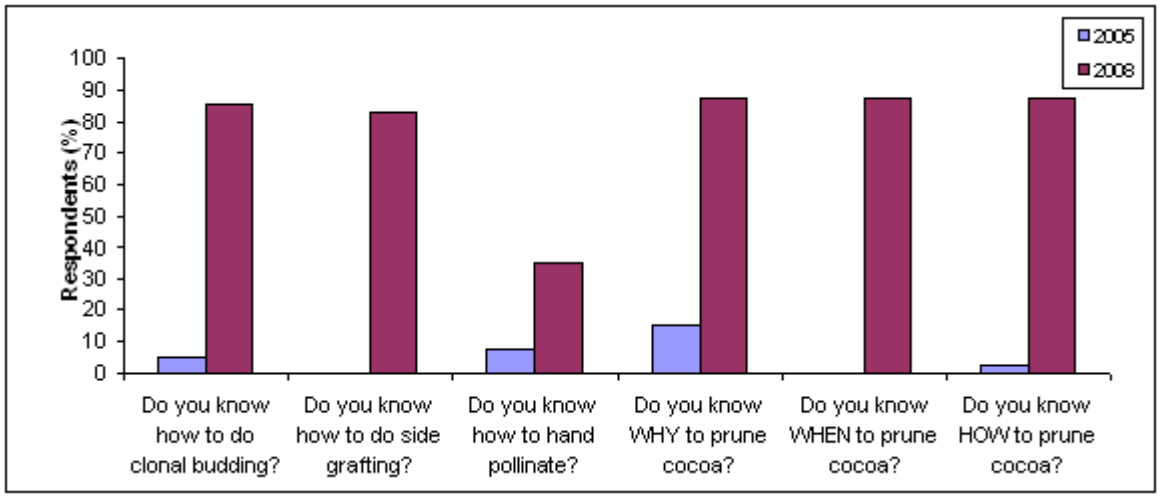

Figure 2. Change in farmer's cocoa management skills from 2005 to 2008, following IPDM training.

Commitment to the cocoa block by farmers is influenced by other income sources, household activities, family, village and church commitments, labour availability and the level of knowledge of block management. The five major constraints given by farmers limiting their ability to manage their cocoa block were consistent with those reported by Curry *et al.* (2007) (Figure 3). The top three constraints in 2005 were:

1. lack of labour,
2. lack of training,
3. other commitments and activities.

In 2006, the most common three reasons why farmers were not attending their cocoa blocks were (Figure 4):

1. lack of training,
2. lack of knowledge of pests and diseases and
3. lack of labour.

In 2009 lack of labour and many other commitments still rated highly as reasons why farmers were not attending their cocoa. Lack of training was not as common. Instead, but lack of tools, lack of money and poor time management featured as constraints and reasons why farmers were not managing their cocoa.

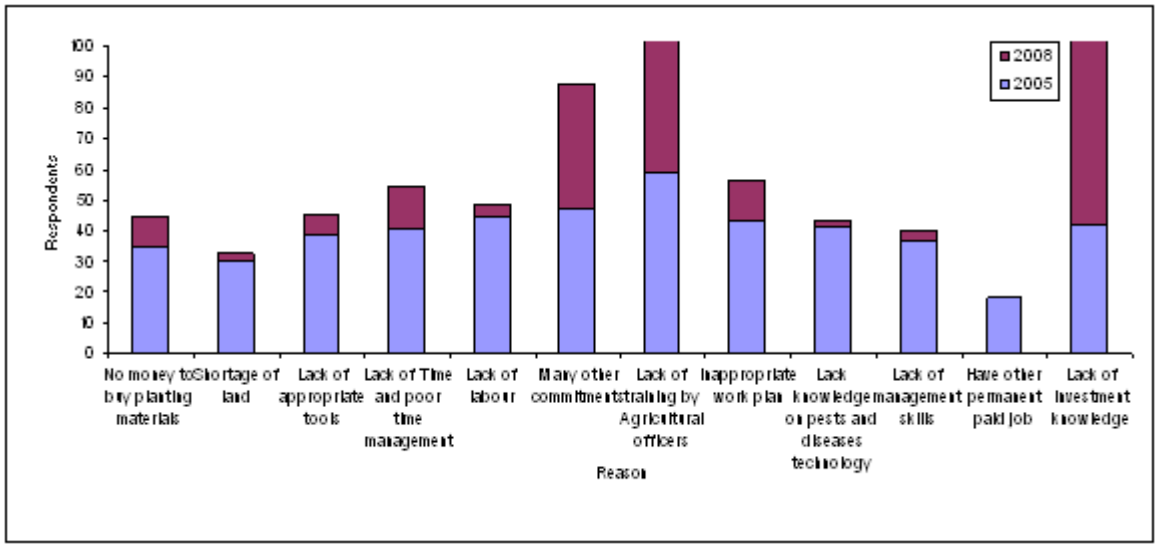

Figure 3. Major constraints, as determined by model farmers, limiting the farmer's ability to manage his or her cocoa block.

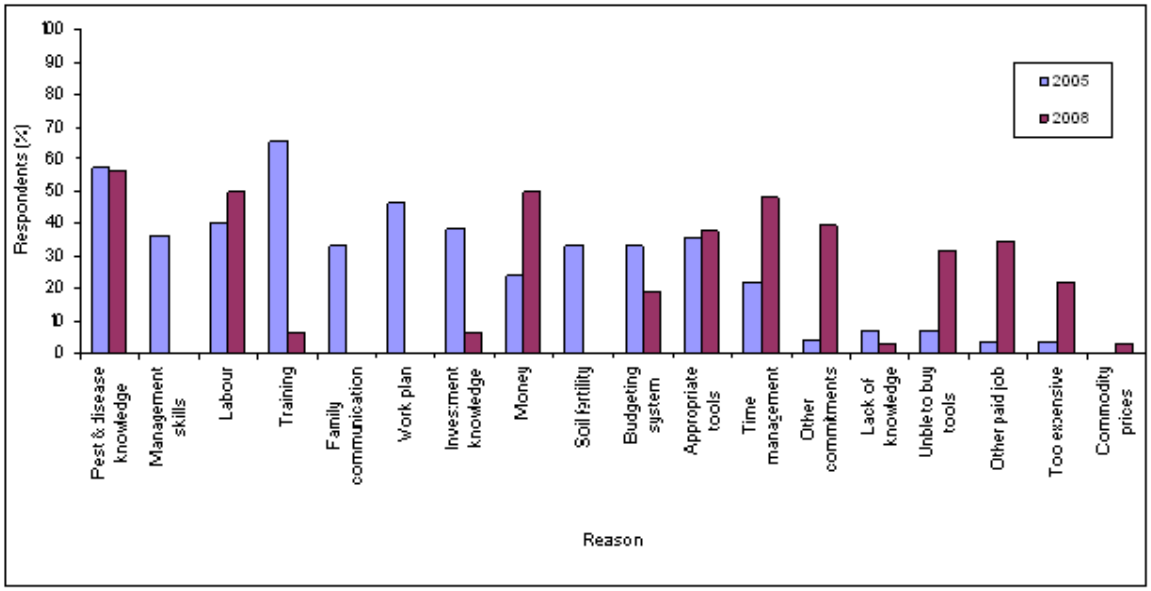

Figure 4. Reasons given by farmers as to why they are not attending their cocoa, despite knowing that pests and diseases are limiting production.

The surveys highlighted the diverse income sources and a broad range of activities in which the farmers participate. Almost all farmers surveyed interplant their cocoa with other crops, or have blocks with other crops. The cultivation and sale of vegetables and other produce to sell at the village market was a common activity among surveyed farmers (Figure 5) and a regular source of family income. Cocoa increased as a source of income for surveyed farmers from 2005 to 2008 (Figure 5).

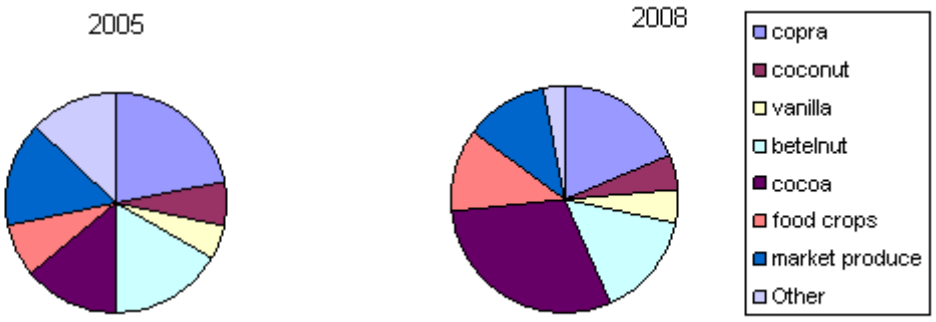

Figure 5. The range of income sources on which farmers rely in PNG as determined by surveys conducted in 2005 (left) and 2008 (right).

8.2

Evaluation and adoption of a range of integrated disease management strategies in partnership with smallholders

8.2.1 Development of integrated pest and disease management strategies

Following preliminary trials at CCI and consultation with stakeholders through workshops, discussions and farmer surveys an IPDM package was finalised for management of cocoa by PNG smallholder farmers. The options were based on four levels of input ranging from low (current level where the farmer visits to harvest only) through to higher input options requiring more time inputs and the purchase of more tools and chemicals (Table 2).

The range of options was designed so that farmers for different social and economic backgrounds could select those inputs and activities that best suited their situation, priorities and ability. For example, a wealthy farmer in Bougainville now has 30 ha under Option 4 because he is able to afford labour and inputs to manage his cocoa in such a way. Conversely, a highly motivated farmer in ENBP relies on family labour and has slowly worked up from Option 2 to Option 3, plus target spraying for CPB. He has reinvested some of his income from cocoa to work up to the higher options over time. Many farmers in Bougainville apply Option 2 because of limited access to inputs such as fertilisers, chemical pesticides and even tools, and because there is a high awareness of organic cocoa.

8.2.2 Improvement and adoption of IPDM through participatory on-farm trials and evaluation

Adoption of management options was encouraged using an approach based on participatory training and research in the cocoa block (Participatory Action Research, PAR). IPDM plots demonstrating each of the four Options were established with participating model farmers at Kareeba, Bitagalip and Tokiala in ENBP, Galeg, Waden and Kaul 2 in Madang, and in Malasang, Tinputz and Arawa in Bougainville. The selected model farmers in each village were shown how to apply each of the inputs required for each option by CCI staff and extension officers. Extension officers were trained simultaneously participating in the establishment of demonstration plots. Surveys conducted by project staff showed that initial farmer knowledge was generally acquired by observation or from farmer-to-farmer highlighting the limited exposure to extension agents and new information that the farmers experienced (Figure 6). The fact that information is often disseminated among farmers highlights the benefits of using a participatory on-farm approach to extend information.

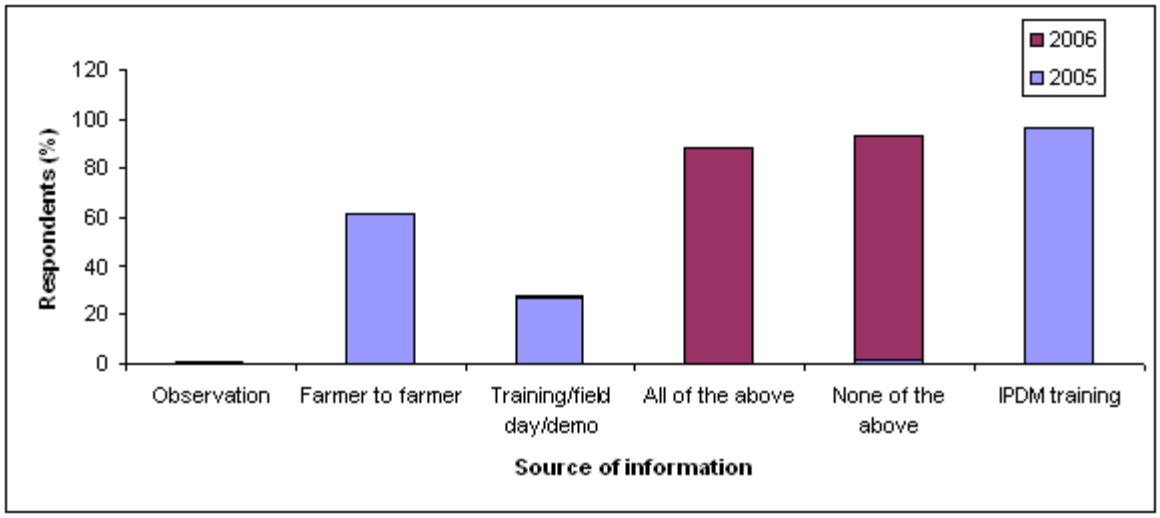

Figure 6. Source from which farmers received information about disease management in 2005 and 2008. The source of information was in response to a question 35: "Are you using methods of managing cocoa diseases? Do you recognise, have knowledge of and control/implement a range of management inputs".

Model farmers were to receive continued mentoring from CCI and extension staff. They were also to be supplied with inputs required for maintaining all the options in their cocoa block. Unfortunately, the leadership vacuum following the departure of the project leader and absence of a CEO, as well as the incursion of CPB, funds and inputs were not regularly transferred to the extension staff coordinating operations in Madang and Bougainville and inputs were not applied as planned. In ENBP, the CPB incursion also led to several farmers abandoning their cocoa blocks following the compulsory eradication program implemented in 2006 that involved the removal of all leaves and pods from cocoa trees.

Engaging farmers in the establishment of on-farm participatory trials enhanced their skills in applying inputs (Figure 7). In this way the farmers learn by doing, and their neighbours see the results following implementation of the management options in the farmer's cocoa block. On-farm training also enhanced farmer understanding of disease epidemiology, pests and the cropping cycle (Figures 8, 9, 10), which helped to foster farmer-to-farmer promotion. The result is a more educated farmer, enhanced uptake of technology and improved incomes. The key element of this approach was that once the options were developed, the farmers decided which option was best for them and their family, they learnt the skills by training and they then taught each other. Essentially, the trained farmers became the extension agents. The farmers, by making the choice of management options they wished to implement, also owned the knowledge and were responsible for their own actions. Data of the number of extended farmers in each village was not recorded.

Figure 7. Training received, and confidence to apply, various cocoa management activities, and determined by farmers responding to survey questions. Where:

1= Cocoa formation pruning; 2= Cocoa sanitation pruning; 3= Cocoa rehabilitation pruning; 4= Shade management; 5= Cocoa fertilizer application; 6= Fertiliser application; 7= Weed control; 8= Agriculture related training; 9=RDB related visit; 10= Pests management demonstration; 11=Longicorn associated canker treatment; 12=Management demonstration; 13= Black pod diseases management; 14=Bark canker disease management; 15=VSD management.

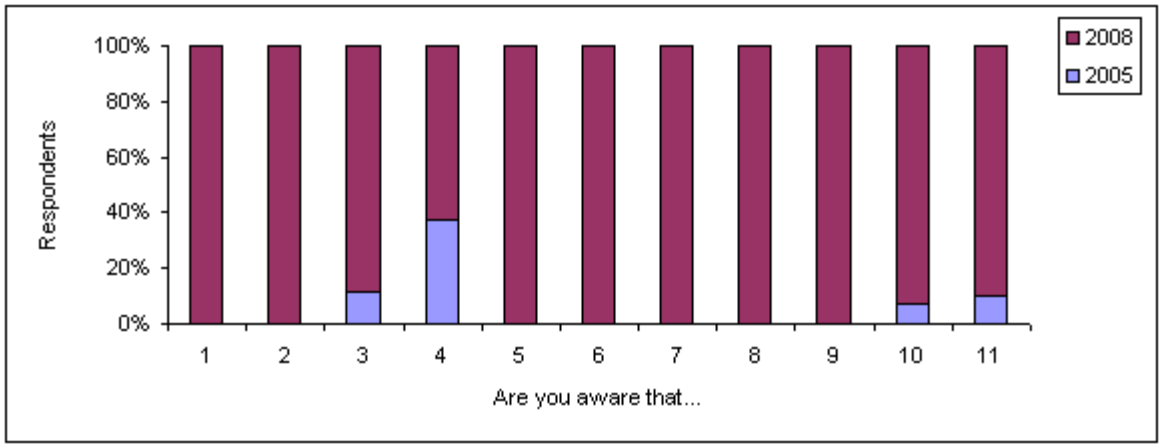

Figure 8. Changes in the farmer's knowledge of the epidemiology of pests and diseases in cocoa management in 2005 and 2008. Where:

1=All cocoa diseases produce seeds?; 2=Seeds spread and cause new sickness; 3=Seeds are numerous?; 4=Wet weather increases diseases?; 5=Poor block management promotes Colletotrichum?; 6=; 7=Pathogens can increase in poorly managed blocks? 8=Botriodiplodia theobroma?; 9=Saprophytes infect feeder roots?; 10=Nematodes?; 11=Poor soil nutrients and water logging lead to stress and diseases?; 12=Physical injuries can create avenues for entry of insects and pathogens?

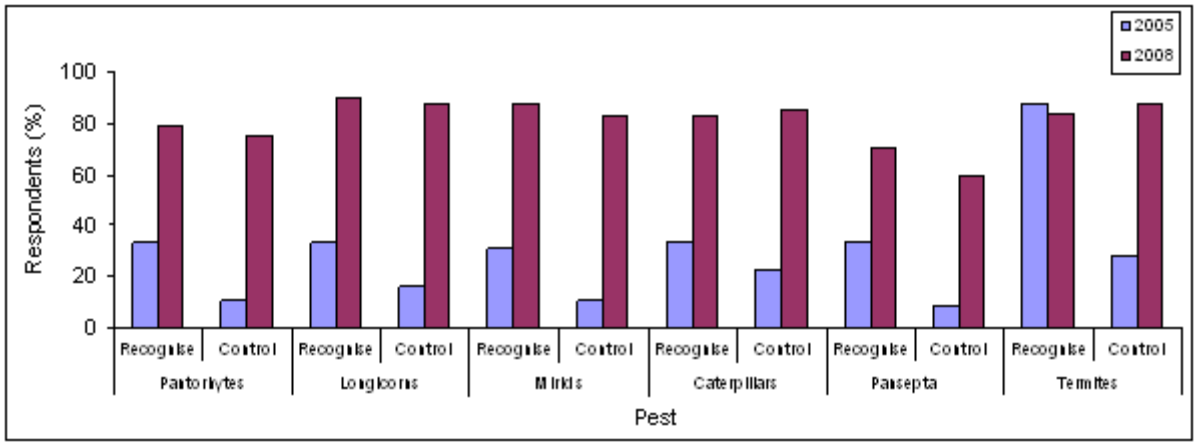

Figure 9. Changes in the ability to recognise pests in the cocoa block diseases by farmers who participated in IPDM training in ENBP, Madang and Bougainville.

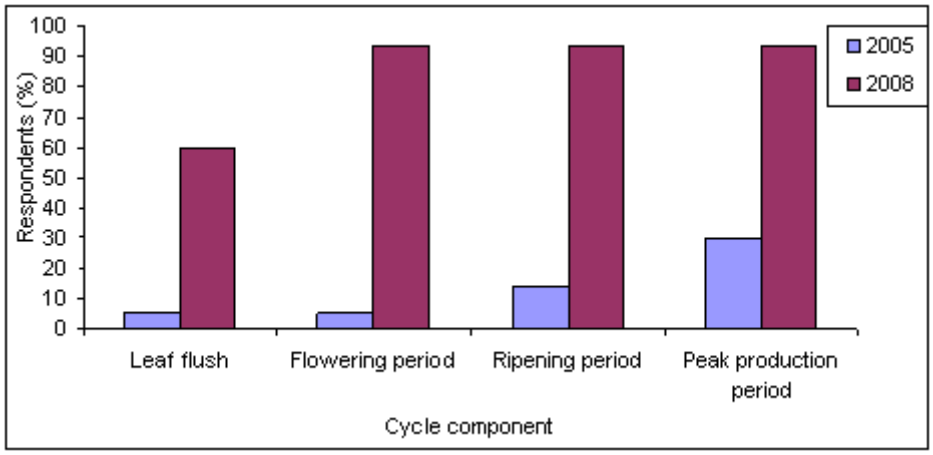

Figure 10. Change in the IPDM farmers' knowledge of the cocoa cropping cycle as determined by surveys conducted in 2005 and 2008.

To foster the evaluation of the management options, local extension personnel and village farmers were required to monitor their own yields and disease. The data was to be collected by the coordinator in each province and then sent to CCI-Tavilo for collation. Follow-up training and support was not provided in all areas after the incursion of CPB and the departure of the project leader. Similarly, collection of yield and disease data did not continue as plannedMonitoring of these sites for disease incidence and yield began in March 2007. IPDM demonstration plots in Bougainville were established in Buka, Arawa and Tinputz. Mr Paul N'nlau of CCI-Kubu was trained in conducting baseline surveys and in implementing the IPDM options in cocoa gardens at CCI-Tavilo in March 2006. Staff from CCI-Tavilo travelled to Bougainville March 2007 to complete the baseline surveys, train extension officers and to establish the PAR trial sites.

Where possible, management options were established in cocoa blocks in high thoroughfare areas to attract as much attention from passers by as possible. As the villagers passed the sites they became curious as the noticed that the trees were responding to the implemented management options and they wanted to know what the farmer had done. The model farmer was engaged because s/he had participated in implementing the options and was proud and enthusiastic in sharing his or her knowledge. In this way, 36 model farmers were trained across PNG, along with hundreds of extended farmers and extension agents. Farmers from neighbouring villages, not directly involved in the project, are implementing the new options in their own plots, with no direct input from CCI project staff. In Bougainville, Paul N'nlau estimates over 1000 farmers have been trained in IPDM. It is important, particularly for those farmers that implement IPDM, that

their neighbours also apply management strategies so that diseases and pest do not build-up in neighbouring, unmanaged blocks.

The transfer of information has been through farmer-farmer communication, particularly where positive outcomes in yield and disease management have been demonstrated. Many farmers may hesitate in implementing the new technologies until they have seen that the results are positive. Then they themselves will apply the management. Conversely, some farmers are motivated and not as tentative and apply the highest option before seeing the evidence that the technology works.

8.2.3 Farmer evaluation and adoption of disease control strategies

More than 132 farmers and extension staff have participated in IPDM training in ENBP. In Madang, more than the expected number of model farmers had been trained. In Bougainville over 1000 farmers and extension staff have been trained in IPDM. These farmers train and foster the adoption of IPDM improvements in other cocoa blocks in their village. The IPDM demonstration blocks are used to extend IPDM options to other farmers. IPDM plots visually demonstrate the difference between the options and the costs and benefits of each option are discussed.

Stakeholder meetings in Buka, Arawa and Kabaleo, November 2007

Key issues raised by stakeholders during follow-up meetings in Bougainville and ENBP included:

Issue raised	Reason for importance
How to ensure that all farmers adopt the technology?	If a farmer is implementing IPDM and his/her neighbour is not, there is a build-up of pests and diseases adjacent to the IPDM-farmer's block
The need for an official launch of the technology	A launch represents the 'handover' of the technology to the extension service and the cocoa industry. In 2007, there was still a belief by some industry stakeholders that results were needed to show that the technology is working
Certification of model farmers to become 'official' IPDM trainers	Several farmers are contemplating or actively establishing IPDM consultancies, charging for a service in training farmers in IPDM skills. There is currently no certification system to suggest someone has been appropriately trained.
Service providers	Particularly in Bougainville and on the Rai Coast in Madang, there is a need to improve access to inputs, tools and transport infrastructure. The cocoa industry has set a target of 100,000 tonnes of beans by 2012, but there are no signs of expanding infrastructure to cope with the increase in cocoa yield. This is already evident in NIP, where the implementation of IPDM technologies has already led to a shortage of ships to transport beans to ENBP for export.
Most research conducted at Tavilo – need more research in other provinces, especially presence on Bougainville	The majority of cocoa research is conducted in ENBP, and there is a feeling amongst industry representatives in other provinces that conditions vary between provinces, and that there is a need for research into pests and diseases and breeding to be conducted in other regions of the country. Currently, there is limited research capacity in Bougainville.
Farmers need continuing support and technology	There is a continuing need to support cocoa growers. This is important not just to provide information to maintain productivity, but also to maintain moral in the industry so that farmers feel they have continuous support and new technology.
Need to work with NARI to establish integrated farming systems because farmers grow more than one crop	Most farmers grow more than one crop. There is a need to conduct research into intercropping systems with cocoa. Currently coconut and glyricidia are grown as shade trees for cocoa.
Need continued training of extension workers	The continued training of extension workers is essential for the sustained dissemination of new and relevant information to farmers.
Need to improve quarantine between Bougainville and ENBP	Bougainville is currently free of VSD and CPB, two potentially devastating threats to the Bougainvillean cocoa industry. The implementation of appropriate and effective quarantine measures is urgent.

Field days

Madang 2006

In July 2006 a field day was held in Garus near Madang to demonstrate the IPDM options to cocoa growers. Farmers were lead through the IPDM options and the benefits of these options, disease management and improved yields were discussed. Industry service providers displayed additional information. Approximately 400-500 farmers participated, indicating the high level of interest raised by the new management options. Demonstration plots had been prepared by Mr Namaliu in advance and the benefits of implementing the IPDM options, disease management and improved yields, were on display, along with stalls set up by service providers including AgMark, Farmset and NuFarm. Approximately 400-500 farmers participated, indicating the high level of interest raised by the improved management options. Farmers were led through the demonstrations by CCI staff and Professor Guest.

Madang 2007

A wet and rainy field day, attended by approximately 100 farmers and stakeholders was held in Kaul 2 village on Kar Kar Island in November 2007. IPDM technologies including pruning and fertiliser application were demonstrated.

ENBP 2007

Two field days, funded by the Gazelle Peninsula and the Kokopo District Administrators, and supported by CCI, were held on 1 and 2 November 2007, respectively. At the Gazelle Field day, the approximately 300 participating farmers, Vudal University staff, government employees were divided into groups and taken in buses to up to 6 IPDM trial farms in Tavilo and Kareeba. The farmers at the blocks described their experiences of the IPDM options, demonstrated techniques to the visitors and answered questions.

Approximately 400 farmers and industry stakeholders attended the field day in Bitagalup village, Kokopo District. People from outside of Bitagulup village that attended included Smilja Lambert and Martin Gilmore from Masterfoods, Dasloko Kula, from CCI ISD New Ireland, Edward Lamur, the District Administrator for the Kokopo District and Blaze Magaga the adviser for the DPI of ENBP. Participants walked through the cocoa blocks of the IPDM farmers in the village. The IPDM options were demonstrated in the cocoa blocks, including strip weeding between trees, bud- and top- grafting, fertiliser application, heavy pruning of older cocoa trees for rehabilitation and light pruning of trees to maintain good ventilation. Extension workers from DPI that attended the field day began to realise that the IPDM farmers knew more than they did about IPDM and were keen to be trained.

New Ireland Province 2008

In 2008 Anthon Kamuso travelled from CCI-Tavilo to help conduct IPDM training in New Ireland Province (NIP). Anthon and Daslogo Kula from ISD, CCI-Kopkop in NIP initially trained all of the ISD staff and 62 cocoa farmers. Twenty of the 62 cocoa farmers were then selected as model farmers for further training and implementation of IPDM as demonstration sites on their cocoa blocks. These model farmers were given tools to establish options 2, 3 and 4 on their cocoa blocks. The remaining farmers still implement IPDM on their cocoa blocks. In September 2009 mini field days were held at the 20 model farm sites to extend the IPDM options into the wider community.

On 19 November 2008, IPDM technologies were launched in New Ireland Province. The field days and IPDM launch were promoted on local radio. Over 300 cocoa industry stakeholders, including farmers, agricultural supply companies and cocoa buyers attended. On the second day, practical demonstrations of the IPDM activities were held in the cocoa block at the ISD station.

IPDM and CPB management in ENBP

Discussions with farmers affected by the attempt at CPB eradication in ENBP reported that while the containment methods had caused a loss of production for a least a year, their surviving trees were now yielding better than before the CPB outbreak. They explained this as a consequence of improved management due to IPDM implementation. Farmers are now encouraged to manage tree health intensively and individually on one or two hectares rather than trying to farm several hectares of trees scattered over several properties. This means the farmers have trees with higher production in a smaller area. This represents a significant change in attitudes to land ownership and farming practice in PNG, and means there is a move to fewer, more productive cocoa farmers. This experience demonstrates that the IPDM technology is robust and resilient in the face of new pests and diseases, and is facilitating a fundamental shift in farming practice.

Madang extension activities

Mini-field days, or “awareness days”, have been held in Madang and ENBP to extend the IPDM options. In Madang ‘village cocoa protectionists’ have been trained in IPDM and

are involved in the coordination of field days and IPDM demonstration plots under supervision from Yak Namaliu (cocoa pathologist in Madang). A CCI-ISD extension officer based on Kar Kar Island is being trained in IPDM technologies through PAR. In Madang, PAR "outreach" groups have been established to implement IPDM options outside the direct control of the project.

In Madang, at least five PAR "outreach" groups have been established to implement IPDM options outside the direct control of the project. In ENBP, the Kokopo district and the Gazelle district have expressed interest to support the IDPM program. Plans are now underway to implement the options, outside of the direct objects of this project.

8.3 Enhanced CCI Pathology research capability

8.3.1 Enhanced pathological capabilities at Kerevat, SRS, Madang and UniTech.

CCI-Tavilo

Several CCI research staff have undertaken PhD studies in Australia. Networking with peers in the Indonesian Coffee and Cocoa Research Institute has been improved.

Research capabilities at CCI-Tavilo were strengthened through the purchase of two vehicles, GPS instruments to enable recording of field site locations and a research microscope.

CCI-SRS-Madang

Research and development opportunities and capacity in plant pathology were strengthened through the relocation of Mr Yak Namaliu from Kerevat, ENBP to establish a cocoa base at SRS-Madang in 2007. CCI also contributed to the cost of a vehicle for Mr Namaliu to enable him to travel to field sites.

In Madang and ENBP 'village crop protectionists' have been trained in conducting surveys, establishing IPDM plots and extending information about the management options as part of their accreditation program. Direct training of regional extension staff and model farmers is taking place during the establishment of demo plots and mini-field days in selected villages in ENBP and Madang.

The majority of cocoa research in PNG is conducted at CCI-Tavilo in ENBP. However, the cocoa growing conditions in Bougainville and Madang differ from those in ENBP. For example, VSD is more severe on the North Coast, possibly because soils are limestone-based rather than volcanic and thus less fertile, while the south of Bougainville has a heavy cloud cover for much of the year, causing a high incidence of black pod, pink disease, cockatoos and longicorn. The establishment of a cocoa pathology base at SRS Madang improves the capacity for the diagnosis of farmer's problems, the development of locally-targeted recommendations and more rapid responses to farmer queries. A similar deficiency still exists on Bougainville Island.

PNG University of Technology - Lae

IPDM was incorporated into the curriculum at UniTech through cocoa block rehabilitation exercises in which selected final year students actively participated.

The four IPDM options were applied to an existing cocoa garden at UniTech by students and labourers. The block then served as a demonstration block for training of vocational and degree students. Cocoa budding, pruning and pest and disease control skills were taught to UniTech staff and students with assistance from staff from SRS Madang.

In 2006 final year Agricultural Science students were involved in field work including nursery establishment of cocoa seedlings and clones, establishment of glyricidia shade trees and shade management.

Oisca, a Japanese aid program, is keen to take up the IPDM options and include them in their curriculum. Oisca has already visited CCI Plant Pathology and discussions are underway for Oisca students to spend time at CCI for IPDM training.

Final year UniTech students were also engage to assist in conducting the baseline farmer surveys.

CCI-Kubu, Bougainville

The extension presence in Bougainville has been significantly enhanced. Prior to this project the pathology and extension expertise in Bougainville was largely limited to Buka, where CCI-Kubu is based. Farmers had to travel to Buka for planting material and advice.

Mr Paul N'nlau (CC-Kubu) was trained in baseline surveys and IPDM at CCI-Tavilo in September 2006. Wendy Sawa of CCI-Buka was also trained in conducting the surveys and establishing the IPDM options. Paul N'nlau was responsible for the coordination of this project in Buka/Bougainville. He actively contributed through the organisation of the IPDM training and the coordination of visits by project members to Bougainville. He and his staff have been involved in training more than 1000 farmers and extension officers across Bougainville.

Two of the IPDM model farmers on Bougainville have been employed by DPI and CCI in Bougainville in Arawa and Buin. Buin is beyond the geographic location of this project, in the south of Bougainville. Training of more extension officers is continuing in the demonstration seed garden at Kubu station on Buka. There is still a need and desire from local authorities for a more substantial CCI presence on Bougainville. It is difficult for CCI staff to travel around Bougainville (in the absence of a vehicle on the island) and as a result visits from extension staff are limited.

Bougainville also has its own set of disease and management issues. For example VSD is not a problem in the Province. However, much of the island is covered in cloud for much of the year, creating different requirements for shade and disease management. A research station on Bougainville would enable to development of more specific targeted management strategies and more appropriate breeding programs.

9 Impacts

9.1 Scientific impacts – now and in 5 years

9.1.1 Inclusion and adaptation of IPDM package in ACIAR Project CP/2006/114

While the discovery of Cocoa Pod Borer in Tavilo, ENBP in April 2006 resulted in significant disruptions to this project as attention was diverted away from extension of IPDM to the monitoring and eradication of CPB, the IPDM technology and participatory research approach developed in this project is now being used by ACIAR Project CP/2006/114 to promote the management of CPB. CP/2006/114 has added a fifth option to the IPDM package: application of insecticides to cocoa pods. Farmers are reporting higher yields despite the CPB outbreak, because of the successful implementation of IPDM.

ASEM 2003/015 project members Anthon Kamuso and Yak Namaliu (from CCI) presented the IPDM technologies at the CP/2006/114 inception workshop in April 2008. The IPDM technology was included in the Training Manual distributed at the 'Training of Master Facilitators' course held at CCI-Tavilo in November 2008.

The strategy to manage CPB reported by the CP/2006/114 is to emphasise the use of cultural practices including weekly harvesting, central coordinated pod breaking, pod burial and pruning (Trip Report 1, April 2008). These activities are key components of the IPDM technology developed and promoted during this project. The key to maximising adoption by farmers is to improve farmer awareness using a community participatory approach in training and extension.

9.1.2 Introduction of IPDM into Indonesia through ACIAR Project SMAR 2005/074

The IPDM training manual has been translated into Bahasa Indonesia and will be incorporated into farmer training under SMAR 2005/074 *Improving cocoa production through farmer involvement in demonstration trials of potentially superior and pest/disease resistant genotypes and integrated management practices*.

9.1.3 Variation in the population of *Phytophthora palmivora*, the cause of Black pod

Phytophthora palmivora is the major cause of cocoa diseases in PNG, although other *Phytophthora* species including *P. arecae*, *P. megakarya*, *P. nicotianae*, and *P. citrophthora* have also been suggested as potential pathogens. The success of disease control strategies depends on a thorough knowledge of the pathogen and its population biology. Furthermore, all cocoa planting material is bred in ENBP and distributed throughout the country, without any comprehensive understanding of the distribution of the pathogen and the mating types. This PhD study by Josephine Saul confirmed that *P. palmivora* is the sole *Phytophthora* species causing disease on cocoa in PNG and that there is variation between *P. palmivora* populations from different cocoa growing locations in PNG. Both mating types A1 and A2 were present in Madang increasing the chance of genetic variation.

The presence of a single species means concentrating cocoa breeding in one location is acceptable; however mixed cocoa cultivars should be deployed and integrated disease management promoted. Strict quarantine should be imposed, particularly in Madang where both mating types are present. This project has significant potential scientific impacts for Quarantine services who can use the information to develop more effective

quarantine regulations to reduce the introduction of different mating types of *P. palmivora* into areas of PNG where only one mating type was found. Additional pathogenicity testing of the isolates would be beneficial for plant breeding scientists to identify cocoa varieties with higher levels of resistance against more pathogenic races of *P. palmivora*.

Dr Saul-Maora was awarded Best Student Presentation at the 2007 Australasian Plant Pathology Conference for her work.

9.1.4 Translation of IPDM Manual

The manual 'Integrated Pest and Disease Management for Sustainable Cocoa Production: A training manual for farmers and extension workers' has been translated into Bahasa Indonesia, Fijian Pidgin, Solomon Islands Pidgin and Vietnamese.

9.1.5 South Pacific Award for Extension Excellence

Dr John Konam and the project team were awarded third prize (second runner up) in the South Pacific Extension Excellence Award for their work with cocoa farmers using IPDM technology.

9.2 Capacity impacts – now and in 5 years

9.2.1 A Plant Pathology presence at Stewart Research Station (SRS), Madang

One of the objectives of this project was to enhance research and development capacity at CCI. In the past, a key issue has been the limited dissemination of information to regions beyond the main area of activity at CCI, Kerevat in ENBP. To enhance the plant pathology capacity in areas outside of ENBP, CCI intended to develop a plant pathology laboratory at its SRS, Madang. CCI staff member Mr Yak Namaliu was relocated to Madang in 2006, strengthening the pathology presence in Madang, and coordinating the IPDM farmer trials and training in the region. The provision of a vehicle through the project enabled Mr Namaliu and his team to regularly visit farmers and conduct IPDM training.

There is an ongoing need for accurate disease diagnosis, rapid and appropriate responses to new disease and pest incursions, and the dissemination of effective and suitable disease management strategies in all areas of PNG. This has been demonstrated with the incursion of CPB, and more recently a new, yet to be identified disease on coconut in Madang. While CCI, Kerevat has up-to-date facilities and resources, CCI has yet to convert space allocated at SRS Madang into a working pathology laboratory for Mr Namaliu and his team. It is expected that with the identification of a new disease in coconuts, currently referred to as 'Bogial Coconut Syndrome (BCS), a pathology laboratory will ultimately be constructed.

9.2.2 Capacity through increases in IPDM training through the Cocoa Board

Since 2008, a group of IPDM farmers from Madang have been contracted through a program supported by the Cocoa Board to extend IPDM training to more villages in the west of Madang Province, the Yangaroo District in East Sepik and to Morobe Province. The training request was initially made by farmers in the East Sepik and Morobe Provinces.

9.2.3 Capacity building through training

As outlined elsewhere in this report, several CCI research scientists have undertaken PhD studies related to this project. In addition, technical and extension staff employed by CCI and the Cocoa Board have been trained in IPDM technology. Several farmers trained in IPDM are now employed by CCI, DPI or private industry to lead IPDM training at the village level.

9.2.4 Training of extension officers at CCI-Kubu Staion on Buka Island

Paul N'nlau, the project member based at CCI-Kubu station in Bougainville, has employed seven new trainee extension staff. The new staff members have each been allocated a block at Kubu station on which they are being trained in IPDM. The investment in extension staff will promote the dissemination of IPDM into the wider cocoa community, beyond the immediate farmers involved in this project.

9.2.5 Capacity building through infrastructure and equipment

The capacity to disseminate research outcomes and implement IPDM on-farm trials was strengthened through the purchase of two vehicles, one in ENBP and the second in Madang. GPS instruments were purchased to enable to location of field sites be recorded and mapped. These instruments turned out to be crucial during the CPB delimitation surveys. A research microscope and digital camera was purchased to replace the previous inverted microscope system at CCI-Tavilo. Josephine Saul-Maora, who returned to head the Plant Pathology Section at CCI-Tavilo in September 2008 used a similar system at Sydney University and will be able to assist CCI staff with use of the new equipment. Several laptop computers and cameras were provided and used to assist in data collection and analysis.

9.2.6 Model farmers employed as DPI officers and extension staff in Bougainville

Two of the model farmers initially identified in this project (Elma Maxwell, Arawa and Joseph Toumo, Tinputz) have been employed as extension staff by DPI and CCI in Bougainville. Elma Maxwell is based in a new DPI office at Arawa. The DPI office has been established by the Bougainville Government in 2008 and has employed several extension officers for a range of crops. Mobility is also limited by the lack of a vehicle.

Joseph Toumo, previously an IPDM farmer from Tinputz, is based in Buin in the southern ‘no-go zone’ of Bougainville, training farmers in IPDM technology. This is a significant achievement as IPDM has transcended the boundaries into areas that we are not permitted to enter.

9.2.7 Expansion of IPDM into New Ireland Province

In November 2005 Kula Daslogo (Industry Services Division, CCI Kavieng, NIP) and his extension officer Andrew attended the ACIAR IPDM start-up workshop in Kabaleo. Daslogo has been working at CCI-ISD since 2000 and began to question why the cocoa yields in New Ireland Province (NIP) did not meet those reported for the planting material that was being developed and released by CCI. Similarly, the yields did not reflect the number of seedlings and seeds sold by the station.

In 2005 Anthon Kamuso travelled from CCI-Tavilo (ENBP) to establish a demonstration plot at Kopkop CCI station. Anthon could not return to conduct training until 2008 because of the CPB eradication program. In February 2008, Anthon and Daslogo trained all of the ISD staff and 62 cocoa farmers. Twenty of the 62 cocoa farmers were then selected as model farmers for further training and implementation of IPDM as demonstration sites on their cocoa blocks. These model farmers were given tools (pole pruner, pruning saw and secateurs) and chemical inputs to establish options 2, 3 and 4 on their cocoa blocks. Follow-up visits were made in May 2008 to ensure the farmers were conducting the IPDM activities correctly. In June, the 20 IPDM farmers visited each others blocks. The farmers are also collecting yield and disease (black pod) data that will be collected by Daslogo in March 2009. The farmers that were trained but not selected as model farmers have still implemented IPDM on their cocoa blocks.

In September 2009 15 mini field days were held at the 20 model farm sites to extend the IPDM options into the wider community. The model farmers each train other 'extended' farmers. For example, Damien Simbago, whose cocoa block is in Mangai Village, approximately 1 hour from Kavieng, is training and mentoring 25 extended farmers.

On 19 November 2008, the IPDM package was officially launched in New Ireland Province, signifying the handover of the technologies to the industry. The field days and IPDM launch were promoted on local radio. Over 300 cocoa industry stakeholders, including farmers, agricultural supply companies and cocoa buyers attended. On the second day, practical demonstrations of the IPDM activities were held in the cocoa block at the ISD station at Kavieng.

New Ireland provides an outstanding example of motivation and uptake of the IPDM technologies outside of the ACIAR funded project. All costs for the introduction of IPDM to NIP were funded by ISD revenue from seedling and seed sales, and fully supported by the Provincial Government. Daslogo is currently recommending Option 2 to be implemented across NIP.

9.2.8 Extension of IPDM into private industry

Farmgate was established by farmers in Buka to support their cocoa production by selling beans. It also operates as a bank providing savings opportunities and finance to member farmers. Farmgate has around 10,000 registered members in northern Bougainville and Buka.

Farmgate has employed ex-CCI (ENBP) Plant Pathology labourer Richard Kuman to train its members in IPDM technologies. Richard travelled with the CCI team to Bougainville in March 2007 to help with surveys, training and to establish on-farm trials. When the effects of the various IPDM options became apparent, Farmgate offered Richard a job. Richard travels to the Wards within Local Government areas in Buka and Bougainville where he spends a week at a time demonstrating IPDM activities to train local farmers on one block in the village. The trainees are offered the following alternatives for their own blocks:

(a) Replant the cocoa block with new planting material from CCI

(b) Bud or graft existing trees in the block with new planting material from CCI

(c) Under-plant the existing trees with new planting material

(d) Rehabilitate existing trees (usually Trinitario) with Option 2 from the IPDM package.

Most farmers choose to rehabilitate the existing trees with Option 2. The IPDM options are then demonstrated to the village chief and five village farmers are on one block. The farmers then return to their blocks and implement the IPDM option 2 on their farm.

The first alternative of replanting the entire block is considered by most to be too expensive. Based on the responses from the baseline surveys, it also appears that many farmers favour 'bush cocoa' or their own selection because they find that those varieties to be productive. Option 2 also appears to be the most commonly implemented option in Bougainville because of a high promotion or positive perception of organic cocoa. Farmers in more remote areas also have difficulty in accessing chemicals due to them being unavailable in the agriculture supply store, the distance to the store, the lack of a desire or funds by the farmer to purchase the chemicals.

By investing in the IPDM training itself, the company obviously believes in the IPDM technology, and the potentials for yield increases that the farmers can expect.

9.2.9 Outreach groups in Madang

In Madang, at least five PAR "outreach" groups have been established to implement IPDM options outside the direct control of the project. In ENBP, the Kokopo district and the

Gazelle district have expressed interest to support the IDPM program. Plans are now underway to implement the options, outside of the direct objects of this project.

9.3 Community impacts – now and in 5 years

Leading up to and following the start up workshop in Kerevat in November 2005, the IPDM project drew significant interest from stakeholders across the cocoa growing community, acquiring significant momentum. A significant amount of interest from Bougainville led to the immediate inclusion of the region into the project from the start rather than the initial proposal of expanding the on-farm trials to Bougainville in the third year of the trial. A visit to PNG and Bougainville by project members in March 2006 showed the rapid rate of uptake of new information and the impact the new management options were having, even within such a short time period. Furthermore, farmers that had adopted the new technologies were sharing their knowledge with their neighbours.

9.3.1 Economic impacts

This project will enhance the adoption of integrated disease management systems suited to smallholders as a key strategy for enhancing incomes. The economic impacts will become more apparent over time as the impact of the technology filters through the cocoa growing community.

9.3.2 Social impacts

Some of the social impacts of this project were particularly novel and creative, and the IPDM technology has served as a nucleus for a number of community initiatives aimed at improving the quality of life in cocoa-growing villages. Examples include the Sunam Circuit Project, a church initiative started in ENBP in 2008 and supported by OISCA. This initiative emphasises environmental stewardship, poverty alleviation, the importance of family and community and respect for the law, and uses IPDM technology as a mechanism to create employment and generate wealth.

For similar reasons IPDM technology has been employed as a vehicle to improve community health, particularly in the AusAID-sponsored campaign against HIV/AIDS in PNG.

The social stability resulting from improved health and wealth is also seen as a way of improving community resilience in the face of disasters such as volcanoes, tsunamis and exotic pests and diseases. It is also seen as an insurance against climate change.

9.3.3 Environmental impacts

Encouraging farmers to adopt and implement IPDM on fewer trees without sacrificing production and income reduces the pressure on remaining natural forests. Using IPDM trees become more productive, so more pods can be harvested from a smaller area of land. Environmental damage caused by excessive use of pesticides and fertilisers is also reduced under IPDM.

9.4 Communication and dissemination activities

9.4.1 Workshops and stakeholder meetings

- 14-16 November 2005, Kabaleo Teachers college
  - Stakeholder meeting to start project and publicise activities
- 20 March 2006 - CCI-Kubu, Buka

  - Presentation of IPDM technology and discussion with farmers and staff
- 23 March 2006 - Project meeting with ABG representatives
  - AGB promised support for the ACIAR project in staff and funds
  - AGB would like to see research planting materials tested in Bougainville
- March 2007 – Meeting with AGB representatives
  - Meeting between project leader (Dr John Konam) members of the AGB to discuss support for the project
  - CCI staff received permission to travel to sites in Bougainville to conduct IPDM training

9.4.2 Farmer field days and field walks

- 4 July 2006 - Garus, Madang Province
  - Field day to demonstrate IPDM options to cocoa growers
  - Approximately 400 farmers participated
- November 2006 - Vudal, Kerevat, ENBP
  - Two day workshop organised by CCI-PNG to discuss the current and future management recommendations for CPB in ENBP and West Sepik Province.
  - The experiences of farmers, researchers and industry members from other countries were presented. Participants discussed future research priorities, appropriate extension strategies, international and industry linkages and where future funding will come from.
- 2 November 2007 - Bitagalip Ward, Kokopo/Vunamami LLG
  - Organised by IPDM farmers in Bitagalip
  - Approximately 400 people participated in a field walk through IPDM farms. Farmers demonstrated techniques including budding, grafting and pruning at 'stations' throughout the walk. The day culminated in prizes (tools) being award to the best IPDM farmers.
- 1 November 2007 - Gazelle Peninsula field day
  - More than 300 participants visited IPDM farms in Tokiala and Kareeba, Gazelle Peninsula
  - Following initial demonstrations and talks at Kokopo, busses were provided to transport farmers between farms.
- November 2007 – Galeg (Madang) Field Day
- November 2007 - Kaul 2 Village, Kar Kar Island Field day
  - >100 participants

9.4.3 Print and radio media

Radio

In 2007, farmer Evelyne Otto appeared on the radio in Bougainville each month to tell people about IPDM and how to implement the options that were du at that time of the cocoa cropping cycle. She invited people back to her block to learn the skills required to implement IPDM.

March 2007 – John Konam and Paul N'nlau presented IPDM activities on Radio Bougainville twice. The radio talk show covered all aspects of IPDM and also transmitted the message to IPDM farmers in Tiputz and Arawa. The show included presentations from DPI staff and farmer testimonies.

Anthon Kamuso is scheduled by ISD to present on Radio East New Britain and talk about IPDM in the third quarter of 2009.

Articles directly related to the ACIAR project and IPDM technologies appeared in the 'Post Courier' in PNG:

7 November 2007 - 'Cocoa experts visit'

15 November 2007 - 'Cocoa man admires gold'

15 November 2007 - 'B'ville cocoa 'best''

Articles about the IPDM technologies appeared in the 'The National' in PNG:

- 26 November 2008 – ‘PNG cocoa is of best quality, says scientist’

9.4.4 IPDM training manual

- Konam J, Namaliu Y, Daniel R and Guest D (2008). Integrated Pest and Disease Management of Sustainable Cocoa Production: A Training Manual for Farmers and Extension Workers. Canberra, Australian Centre for International Agricultural Research, ACIAR Monograph No. 131.

10 Conclusions and recommendations

10.1 Conclusions

The PAR approach has enabled us to accurately identify research priorities, and has provided better feedback about the problems that farmers are facing and what is and is not working. It demonstrated the impact of technology to farmers in a very direct way and gave the farmers more responsibility because they were actually involved in implementing and then explaining the improved management to their neighbours. Establishing demonstration plots and conducting field days has increased the profile of research and extension agencies, which are now much more engaged with the day-to-day problems faced by the farmers. The feedback from farmers has in turn improved the capacity of supporting researchers at CCI to focus their research on industry needs.

The project has not been without problems. Project staff were seriously injured in a bus crash in Kokopo before the project startup workshop. The vehicle provided for the pathologist at SRS-Madang was stolen, restricting his ability to visit farms and villages. The vehicle was eventually recovered. The PNG project leader left in 2008 to take up a senior position in the South Pacific Community in Fiji. CCI has been without a CEO since the start of the project, and this has made many aspects of the project logistically difficult, and the uncertainty has occupied a lot of time and energy of CCI staff. The outbreak of CPB in ENBP in 2006 seriously disrupted our planned activities. Nevertheless, the enthusiasm of project staff and cocoa stakeholders has ensured that the IPDM technology has spread autonomously – especially in Bougainville and NIP - and is having a huge positive impact on cocoa production.

The question remains: 'how has this programme worked in PNG?'. In the areas where demonstration sites were established farmers report significant increases in yield, and these claims are backed up by statistics from local fermentaries. Increased yields are also reported in “outreach” areas where the technology is spreading through farmer-farmer contact. National production reached 50,000 Mt in 2007, 56,000 Mt in 2008, and the trend is upwards. It is still a long way from the target of 100,000 Mt by 2012 but the trend since the start of this project has been consistently upwards, and given the number of farmers involved, the motivation and enthusiasm of those farmers, the rapidity with which the options have been adopted, and the time lag between implementation and realised benefits of improved management, it is expected that the increase in yields will continue.

10.2 Recommendations

10.2.1 IPDM options

- Need to continue to review and refine IPDM options through continued research at CCI
- Look for replacement for dichlorvos
- Need to ensure that the extension section (ISD) takes over the IPDM transfer to allow scientists to return to their research. Some farmers know that the original research comes from the scientists and so prefer to get their information straight from the source rather than ISD.
- Need continuous, regular follow up with farmers to ensure correct implementation and to get feedback on IPDM and to identify new directions for research. How will the transfer of new information continue?

- Pod case disposal and leaving leaf litter on the ground to protect roots. Many farmers sweep the leaves in their cocoa block because it looks tidier. This exposes roots and removes organic matter. Leaving pod cases on the orchard floor results in a build up of inoculum and insects that disperse inoculum.
- Need to apply IPDM in the CCI-plantation to prove to farmers that CCI is using the same practice.
- Need for stronger Cocoa pathology and breeding expertise in Bougainville to meet local environmental conditions
- Infrastructure -does the Cocoa Board have the capacity to handle the target of 100,000 tonnes of cocoa? Will the infrastructure be available to ensure the continued production and availability of high quality beans for which PNG cocoa is known? Already, with increased production in NIP, there is a shortage of ships to transport beans from NIP to ENB.
- How will socio-economic issues that arise from increased income be addressed?

10.2.2 Research opportunities

- Test pulse and phosphonate trunk paints as a cheaper alternative to Ridomil.
- Find a safer and compliant replacement for dichlorvos.
- Shade management - use *Gliricidia* for alternative things like stakes; test high-value fruit or timber trees as alternatives to *Gliricidia.*
- Cocoa pod disposal - composting and biogas provide opportunities for linkages with other organisations.
- Disease survey of VSD - could be in collaboration with NAQIA.
- The discovery of CPB presented the opportunity to test the IPDM options developed in this project against CPB in the coming years. In November 2006 a workshop organised by CCI-PNG was held to discuss current and future management recommendations for CPB in PNG.

10.2.3 Other issues

The discovery of Cocoa Pod Borer (CPB) at NARI in Tavilo in April 2006, caused a significant disruption to this project. All staff from the CCI-Plant Pathology division were diverted to the monitoring and eradication of CPB causing a delay in several project activities, particularly those in ENBP and BOUGAINVILLE. Dr Konam was made Chairman and Technical Team Leader of the CPB eradication program. This caused massive disruptions to this project.

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11.2 List of publications produced by project

11.2.1 Books

Konam J, Namaliu Y, Daniel R and Guest D (2008) Integrated pest and disease management for sustainable cocoa production: a training manual for farmers and extension workers. ACIAR Monograph No. 131.

11.2.2 Journal publications

Guest D, Daniel R, Namaliu Y and Konam J (2009). Technology Adoption: Cocoa in the Cocoa block. *Journal of Plant Pathology. In Press*.

11.2.3 Conference papers:

Blomley CL, Liew ECY and Guest (2007). Fungal endophytes of cocoa (*Theobroma cacao*) in Australia and Papua New Guinea. The 17th Biennial Australasian Plant Pathology Society Conference, Adelaide, South Australia. September 24-27 2007.

Guest D (2006). Black pod: Diverse pathogens and the greatest global impact on cocoa yield. Joint meeting of the The American Phytopathological Society, The Canadian Phytopathological Society and the Mycological Society of America, Quebec City, Canada. July-August 2006.

Guest D (2006). Vascular-streak dieback: A new encounter disease caused by the obligate basidiomycete Oncobasidium theobromae. Joint meeting of the The American Phytopathological Society, The Canadian Phytopathological Society and the Mycological Society of America, Quebec City, Canada. July-August 2006.

Guest D, Daniel R, Namaliu Y and Konam J (2009). Technology Adoption: Cocoa in the Cocoa block. *Journal of Plant Pathology*. The 9th International Congress of Plant Pathology, Torino, Italy, August 24-29, 2008.

Konam J, Namaliu Y, Daniel R and Guest D (2006). Classroom in the cocoa block – a new approach to disease management and extension in PNG. Joint meeting of the The American Phytopathological Society, The Canadian Phytopathological Society and the Mycological Society of America, Quebec City, Canada. July-August 2006.

Namaliu Y, Vano JT, Guest DI and Konam JK (2005). Integrated management of cocoa diseases in Papua New Guinea. The 15th Biennial Australasian Plant Pathology Society Conference, Geelong, Victoria. 26th-29th September, 2005.

Saul-Maora J, Liew ECY and Guest DI (2007). Morphological, physiological and biological variation in *Phytophthora palmivora* on cocoa in Papua New Guinea. The 17th

Biennial Australasian Plant Pathology Society Conference, Adelaide, South Australia. September 24-27 2007.

Vano JT, Namaliu Y, Daniel R, Konam JK and Guest DI (2005). Enhancing smallholder cocoa production through improved pest and disease control. Integrated management of cocoa diseases in Papua New Guinea. The 17th Biennial Australasian Plant Pathology Society Conference, Adelaide, South Australia. September 24-27 2007.

12 Appendixes

12.1 Appendix 1. IPDM Farmers

Province	Location	Farmer Name
Madang	Kaul 2	Baras Nagu
Madang	Kaul 2	Henrey Willi
Madang	Kaul 2	Kekson Domin
Madang	Kaul 2	Lakamai
Madang	Kaul 2	Yukura Pamang
Madang	Kaul 2	Charkey munan
Madang	Kaul 2	Ghans Gando
Madang	Kaul 2	Kawun Awak
Madang	Kaul 2	Gerry
Madang	Kaul 2	Uron Masap
Madang	Kaul 2	Bagun Munog
Madang	Kaul 2	Charley Setu
Madang	Waden	Bunam Damon
Madang	Waden	Stanley Kawig
Madang	Waden	Rakau Damon
Madang	Waden	Silew Patal
Madang	Waden	Tobi Kawig
Madang	Waden	Paul Damon
Madang	Waden	William Kawig
Madang	Waden	Belington Joseph
Madang	Waden	Mastibud Kulmoi
Madang	Waden	Mulog Damar
Madang	Waden	Russel Kaku
Madang	Waden	Roy Damon
Madang	Waden	Baleo Damon
Madang	Waden	Isriel Sim
Madang	Waden	Guleg Linus
Madang	Galeg	Sebilon Kamong
Madang	Galeg	Paiaring Magul
Madang	Galeg	Wadeng Wadum
Madang	Galeg	Makak Milos
Madang	Galeg	Wilson Masbud
Madang	Galeg	Kumbulau Gamalmol
Madang	Galeg	Thomas Tamol
Madang	Galeg	Joe Banas
Madang	Galeg	Nicholas Bager
Madang	Galeg	Kalauk Kerai
Madang	Galeg	Banney Samuel
Madang	Galeg	Handris Ilau
Madang	Galeg	Marthin Samuel

Province	Village	Farmer
ENBP	Bitagalip	Ben Okole
ENBP	Bitagalip	Sebastian Tolom
ENBP	Bitagalip	Getrude Kapa
ENBP	Bitagalip	Maria Namiti
ENBP	Bitagalip	John Limlimbur
ENBP	Bitagalip	Ricahard Malemar
ENBP	Bitagalip	Anastasia Ngenge
ENBP	Bitagalip	Anton Marakan
ENBP	Bitagalip	Steven Richard
ENBP	Bitagalip	Bernard Balur
ENBP	Bitagalip	Moreen Togola
ENBP	Bitagalip	Alphonse Kuau
ENBP	Tokiala	Larry Kubak
ENBP	Tokiala	Tolick Wartoto
ENBP	Tokiala	William Gunarang
ENBP	Tokiala	Odiliah Virua
ENBP	Tokiala	Anet Rolly
ENBP	Tokiala	Peter Berick
ENBP	Tokiala	Emannuel Marnapal/Kiau Low
ENBP	Tokiala	Kenny Francis
ENBP	Tokiala	Stanis Painuk
ENBP	Tokiala	John Vua
ENBP	Tokiala	Norman
ENBP	Tokiala	Malana Tibu
ENBP	Kareeba	H .Mapina
ENBP	Kareeba	D.Tuvi
ENBP	Kareeba	P.Totua
ENBP	Kareeba	P.Wakol
ENBP	Kareeba	A.Luaina
ENBP	Kareeba	O.Tangia
ENBP	Kareeba	J.Reddy
ENBP	Kareeba	K.Palavo
ENBP	Kareeba	B. Talil
ENBP	Kareeba	H.Dukduk
ENBP	Kareeba	Patrick.T
ENBP	Kareeba	N.Rongdiat

Province	Village	Farmer
Bougainville	Buka	Evelyne Otto
Bougainville	Buka	Lucy Jimmy
Bougainville	Buka	Erica Hannet
Bougainville	Buka	Freddy N'nlau
Bougainville	Buka	Clement N'nlau
Bougainville	Buka	Francis Soatsin
Bougainville	Buka	Charles Mitil
Bougainville	Buka	Joanita N'nlau
Bougainville	Buka	Harry Pukpuk
Bougainville	Buka	Michael Tamahin
Bougainville	Buka	Aiden Gimots
Bougainville	Buka	Demien Tenevi
Bougainville	Tinputz	Michael Toveret
Bougainville	Tinputz	Pauline Anauin
Bougainville	Tinputz	Tobongi Francis
Bougainville	Tinputz	Buen William
Bougainville	Tinputz	David Sovi
Bougainville	Tinputz	Joe Toumo
Bougainville	Tinputz	Domingo Tobasy
Bougainville	Tinputz	Felix Taues
Bougainville	Tinputz	Gayne Yobu
Bougainville	Tinputz	Philip Warubo
Bougainville	Tinputz	James Nisu
Bougainville	Tinputz	Alex Masata
Bougainville	Tinputz	Grace Habba
Bougainville	Arawa	Charles BISIKO
Bougainville	Arawa	James SANDY
Bougainville	Arawa	Frank BINAWATA
Bougainville	Arawa	Bruce MOUVO
Bougainville	Arawa	Chris DAMANA
Bougainville	Arawa	Thomas KOITAU
Bougainville	Arawa	Herman TIONI
Bougainville	Arawa	Jerry TUNJIO
Bougainville	Arawa	Talman ANIS
Bougainville	Arawa	Arthur SAMUEL
Bougainville	Arawa	Elmah SAMUEL
Bougainville	Arawa	Richard TSIA
Bougainville	Arawa	Steven BOADA

12.2 Appendix 2: Farmer surveys

Data presented is the average of all farmers surveyed in Kaul 2, Waden and Galeg in Madang, Malasang, Tinputz and Arawa in Bougainville, and in Bitagalip and Kareeba in ENBP. Final surveys were conducted in Bougainville in June 2009 and data is not included here. Total number of surveys in PNG (Madang, ENB and ARB; does not include ARB for 2008): 2005: 96; 2008: 58.

Yes/no answers given as percentages are the percentage of respondents that answered yes to the question. 'n' refers to the number of respondents for each question.

NB - the graphs were removed from this document to reduce the size for emailing