Annual Research Report

2010

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Report by the Head of Research

May 2011

INTRODUCTION (Head of Research, Bill Page)

This Annual Report has been produced at an earlier time than previously so much of this introduction is reiterating what was reported in the last report written in September 2010.

Significant changes have taken place for PNG's oil palm industry. In April 2010 NBPOL announced the completion of the acquisition of 80% of the shares in CTP (PNG) Ltd. In May NBPOL formally took over management of the former CTP palm developments in Oro, Milne Bay and New Ireland Provinces. The former CTP (PNG) Ltd operations are now part of the NBPOL Group and are now collectively known as Kula Palm Oil Limited. NBPOL now manages about 83% of the country's palm oil plantations (Table 1), and, with the production from their associated smallholders, process about 84% of the country's FFB (Table 2).

Table 1.

Area Estimates Dec 2010 (ha)

Project Area	Plantation	Smallholder+	Total	
Hoskins (*NBPOL, Mosa*)	35,427	25,255	60,682	44.6%
Popondetta (*NBPOL, Kula Group*)	8,892	11,958	20,850	15.3%
Milne Bay (*NBPOL, Kula Group*)	11,306	1,900	13,206	9.7%
New Ireland (*NPOL, Kula Group*)	5,689	2,237	7,926	5.8%
Ramu (NBPOL, *RAIL*)	10,207	260	10,467	7.7%
Bialla (*Hargy Oil Palms*)	9,827	13,221	23,048	16.9%
TOTAL	81,348	54,831	136,179	
	59.7%	40.3%		

Table 2.

FFB Production in 2010 (tonnes)

Project Area	Plantation	Smallholder+	Total	
Hoskins	865,991	425,358	1,291,349	51.4%
Popondetta	228,659	143,043	371,702	14.8%
Milne Bay	235,998	12,426	248,424	9.9%
New Ireland	105,485	16,638	122,123	4.9%
Ramu	81,202	953	82,155	3.3%
Bialla	205,871	192,669	398,540	15.9%
TOTAL	1,723,206	791,087	2,514,293	
	68.5%	31.5%		

The industry's focus on sustainable production of palm oil strengthens. NBPOL, Hargy Oil Palms and Ramu Agri-industries Ltd are all currently RSPO certified. The process of RSPO certification of the former CTP (PNG) Ltd companies was postponed for 2-years to allow smallholder farmers to be brought to a standard that allows them to be certified along with the milling companies (CTP had not planned to include smallholders in their RSPO certification). In August 2010 NBPOL commissioned its second palm oil refinery in Liverpool UK to complement its existing refinery in Kumbango PNG. Both refineries process exclusively CSPO as segregated identity-preserved oil.

PNGOPRA is an Affiliate Member of the RSPO and has an important role to play in supporting PNG's plantations and smallholders in their commitment to sustainable development, particularly in the area of continuous improvement. PNGOPRA's research programme has been aligned with the RSPO Principles and Criteria and these are indicated for the various components of the research in this report.

PNGOPRA is an incorporated 'not-for-profit' research Association - a non-governmental organisation. The current Association membership comprises New Britain Palm Oil Limited (NBPOL), Kula Palm Oil Limited (part of the NBPOL Group comprising Higaturu Oil Palms, Milne Bay Estates, and Poliamba), Hargy Oil Palms Ltd, Ramu Agri-Industries Ltd (part of the NBPOL Group) and the Oil Palm Industry Corporation (OPIC). OPIC, through its Membership, represents the smallholder oil palm growers of PNG.

The Members of the PNGOPRA have full say in the direction and operation of the organisation and this ensures that PNGOPRA is responsive and accountable to the needs of its stakeholders. The organisation is truly demand driven. On the Board of Directors, NBPOL currently have one representative who represents all NBPOL interests and the other two organisations each have one representative. Each Member holds voting rights within the Board that reflect the Member's financial input to the organisation; this is calculated on the previous year's FFB production (the PNGOPRA Member's Levy is charged on a FFB basis). Voting rights for 2011 are presented in Table 3.

Table 3. PNGOPRA Members Voting Rights in 2011

MEMBER	FFB Produced in 2010	VOTES	
		Number	**%**
New Britain Palm Oil Limited	865,991	**9**	32.1
Smallholders (OPIC)	791,087	**8**	28.6
Kula Palm Oil Ltd (ex CTP (PNG) Ltd)	570,142	**6**	21.4
Hargy Oil Palms Pty Ltd	205,871	**3**	10.7
Ramu Agri-Industries Ltd	81,202	**1**	3.6
Managing Director	n/a	**1**	3.6
TOTAL	2,514,293	**28**	100

A sub-committee of the Board of Directors, the Scientific Advisory Committee (SAC), meets once a year. It reviews and recommends to the Board the research programme for the coming year. Thus the Members can directly incorporate their research and technical service needs into the work programme of PNGOPRA. The Members voting rights within the SAC meeting are the same as for the Board of Directors meeting.

OPIC is a statutory organisation responsible for the provision of agricultural extension for the smallholder oil palm growers. The link between PNGOPRA and smallholder extension is strong. As part of the PNG's National Agriculture Research System (NARS), both PNGOPRA and OPIC are included together as servicing PNG's smallholder oil palm growers.

PNGOPRA is financed by a levy paid by all oil palm growers and also by external grants. The total budgeted operating expenditure for PNGOPRA in 2011 is about K6.33 million. The Member's levy finances 86.8% of this expenditure and external grants 13.2%. The Member's levy is set at a rate of K2.00 per tonne of FFB for all growers. In 2011 PNGOPRA's expenditure is distributed as 39.3% agronomy research, 21.2% entomology research, 17.2% plant pathology research, and 22.2% management and centralised overheads.

The Managing Director, Ian Orrell, relocated to Port Moresby in late 2009 in order to begin addressing the wider sub-sector issues and initiate the setting up of a Palm Oil Council (POC). At the end of April 2011 he left PNGOPRA to finish setting up and then run the POC. Ian headed PNGOPRA for 18 years and his contribution to the organisation's success has been considerable. The post of Head of Research was taken up by Bill Page in May 2010 and he is now managing PNGOPRA.

RESEARCH 2010

PNGOPRA continues to carry out work for the stakeholders in the Association. This means that PNGOPRA has to be flexible enough to meet the research and technical services needs of all the players within the whole of the PNG oil palm sector, both the smallholders and the plantation companies. All players are represented on the Scientific Advisory Committee (SAC) that meets to review PNGOPRA's current work and decide on future research proposals and prioritise them. Thus the Association addresses only the most significant restraints to the sustainable production of palm oil.

With the increasing influence of the Round Table on Sustainable Palm Oil (RSPO) PNGOPRA, as an Affiliate Member, has taken on the Principals and Criteria set by RSPO and is actively involved in helping plantations and smallholders achieve certification and improve over time by research on improving plantation and smallholder practices, undertaking research on improved insecticides, environmental indicators, smallholder food security and understanding the constraints smallholders have. The main text of this Annual Report shows which main RSPO Principals and Criteria are being addressed for each research and technical services work. For convenience, a summary of the RSPO Principals and Criteria, as adopted by the PNG's National Implementation Working Group and approved by RSPO's Executive Board, is found at the end of the Annual Report in Appendix 1. A matrix of which RSPO Principles and Criteria are addressed by each PNGOPRA study is also provided in Appendix 2.

Agronomy Programme

The main task of PNGOPRA Agronomy Section is to determine the optimum nutrient requirements for oil palm from trials and at the same time understanding the processes within the soil which influence and regulate plant nutrient uptake and then communicate the information to the oil palm industry. In addition to optimising yield, activities are in place to determine the long term sustainability of the system.

The bulk of the work undertaken by the agronomy team has been fertiliser response work. At each of the plantations trials have been set up in collaboration with our funding partners (Plantation Companies and Smallholder Sector). The types of trials established are different between different areas and depend on where the gaps in knowledge are and soil type differences. A number of new trials started during the last 2-3 years at the various sites took into consideration possible effects of progenies on yield responses and therefore known progenies were planted for the trials. Trials in New Britain Palm Oil Ltd. (NBPOL) plantations in WNB were handed to OPRS to manage while PNGOPRA are concentrating on fertiliser/demonstration trials on smallholder blocks. The early results from the latter are showing large increases in yield due to Best Management Practices during the first year of the demonstrations before fertiliser affects are expected to appear.

There are also several experiments looking at a) the effects of different spacing arrangements on yield and b) yield monitoring and forecasting, however the monitoring trials were closed at the end of 2009. These non-fertiliser related trials are very important in providing management information to the industry.

Two important donor funded projects, N Loss and Mg/Cation, were closed and have been reported. There is now another donor funded project (ACIAR) looking at sustainability of oil palm production in PNG that started in May 2010. As part of this project, Rachel Pipai is now studying for a Masters Degree at University of Adelaide in Australia looking at nitrogen fixation by legume cover crops under the oil palm systems in PNG. Another project looking into food security in smallholder farming systems has been approved by AIGS (ARDSF project funded by AusAID) and is now being implemented. This is a joint project between PNGOPRA and OPIC.

There has also been an increased involvement in smallholder related activities. There are smallholder fertiliser-demonstration blocks in Hoskins, food security activities have started and are continuing in Oro, Hargy and Poliamba, collection of leaf tissues for analysis continue in Oro and have started in Hargy, and the setting up of fertiliser demonstration blocks in Milne Bay and Poliamba. The aim here is to increase FFB yields in the smallholder sector from 10-15 t/ha/year to >25 t/ha/year.

Across all sites, there is continuous involvement in training for the industry. There has been increased PNGOPRA involvement with OPIC on smallholder field days and radio broadcasts. Training has also been carried out in the plantations on N Loss studies regarding timing and placement of fertiliser applications.

Quarterly reports on yield achievement for selected trials were prepared for plantation managers throughout the year. These reports can assist plantation managers to review plantation block yields against trial yields and make appropriate management adjustments. There has been a large increase in the use of OPIC smallholder field days to extend the message of appropriate fertiliser management.

Entomology Programme

2010-2011 was characterised by a large increase in reported infestations, which was predicted as likely to occur in the previous (2009) report. OPIC Divisional Managers continued to provide samples of pest taxa and "sexava" eggs from smallholder blocks that were being harvested from areas agreed for sampling during the weekly pest management meetings. This material is now systematically dissected to enable us to improve our understanding of embryonic development and the development of field populations. The number of treatment teams varied throughout the year and infestation control lagged behind new reports, however there has been a considerable increase in teams in 2011 which has alleviated the problem. Close liaison is also maintained with Plantation Managers who also provide specimens for confirmation, but these samples are more erratic.

Staff numbers increased during 2010 with the appointment of two executive staff, and the re-deployment of one executive staff member to Kula Group at Higaturu Centre. A lab technician was also employed at Dami, and a recorder was employed and sent to New Ireland for pest related work. Strong collaboration with local and overseas research personnel continued. HoE visited Washington in February for the project, Basic Research to Enable Agricultural Development (BREAD), a Gates Foundation project, to investigate alternative methods for control of pests. There was no response received from The Department of Environment and Conservation (DEC) in Port Moresby for requests dealing with this project nor for Queen Alexandra Birdwing Butterfly project and NAQIA did not take the Notifiable Pest Status further for gazettal, although a draft has been sighted. The collaborative ACIAR Zophiuma project ended in August; however the staff member working on his MPhil. Degree will continue his studies until mid 2011.

Pest outbreaks

One hundred and thirty-eight (138) pest reports were received from plantations and smallholders, (73 from plantations and 65 from smallholders, including 3 from Solomon Islands) during the year. This was an increase from 2009, which had a total of 74 for all areas of PNG. This represented an overall increase of 64 reports, up 42%. During 2010, there was only one pest report received from mainland PNG, from Mamba Estate (Kula Group), where reports of a newly recorded weevil were investigated. The very heavy rains that fell during the latter part of 2009 and early 2010 are likely to be responsible for encouraging the build up of populations of sexava, although there were no obvious associated peaks. Wet periods benefit sexava population development while at the same time hindering the effective use of TTI for their control.

Insecticide trials
A recommendation for further work on the use of Dimehypo (Bisultap) has been made. The results show that this insecticide is suitable for the control of sexava, but at a higher dose that is currently used for methamidophos. For Dimehypo 18%, 40ml of the insecticide is required, as opposed to the 10ml of methamidophos.

Sexava survival and reproduction
Understanding the reproductive patterns and survival of individual sexava species is an essential part of our work with this pest. A programme probing into all aspects of the ecology of the insect is underway. With the appointment of a staff member with this responsibility, we are now able (insect stock permitting) to undertake detailed life history studies, which will enable us to make improvements in the management of these insects. Two small scale detailed rearing studies were undertaken: Trials 1 and 2: February-April and August –November 2010. The results are showing considerable differences between *S. defoliaria* and *S. decoratus.*

Destructive sampling of palms
Fifteen oil palms were destructively sampled during 2010 from Dami plantation (1987 planting). Records of any stages of sexava, stick insects or bagworms found on the fronds were removed, recorded and entered into the database as used in the previous collections. Acting on professional advice, all data collected during previous years' sampling work from plantations were re-entered onto newly designed record sheets, and they will be added to the database and analysed during 2011 with assistance from A.Yalu (OPRS).

Sexava egg parasitoids
Sexava egg parasitoids (*Leefmansia bicolor* Waterston and *Doirania leefmansi* Waterston) continued to be reared in the laboratory and released in both plantations and smallholder blocks during the year. There was an increase in release numbers for *L.bicolor* and a decrease in releases of *D.leefmansi* compared to the releases in 2009. Actual releases were 786,184 *L.bicolor* and 1,898,378 *D.leefmansi* at 117 sites.

Pollinating weevils
Pollinating weevils were monitored monthly from ten sites in WNB and New Ireland during 2010. The three sites on NI were only sampled for the first three months of the year because of staff availability. This situation was rectified at the end of the year, and monitoring of Maramakas, Lakurumau and Leinaru will commence again in 2011. On West New Britain, Lolokuru, Kumbango (until August), and Dami were regularly sampled, while Galewale, Kavui and Siki smallholder blocks sampled until the end of August.

Ghana origin weevils.
Two releases were made at RAIL after three previous unsuccessful attempts to fly material over there. It is hoped that the weevils will provide the genetic diversity to those weevils already present. Approval from the Board has been received to release the weevils at all plantations in PNG managed by NBPOL, Hargy Oil Palms and smallholder grower blocks. Weevil rearing will continue until these requirements are met.

Stick insects
Infestations of *E.calcarata* were regularly reported, however on no occasion during the year were they the primary cause of a reported infestation. In reports received from smallholder growers, *E.calcarata* was in almost as many locations as *S.defoliaria*.

Weevil pests
No species of *Rhabdoscelus* have yet been recorded as a pest of oil palm in PNG, however adults of *R..obscurus* weevil were found in appreciable numbers on freshly cut oil palm fronds and cut trunks in association with a smaller species (as yet not identified) from Mamba Estate, Higaturu Oil Palms, Northern Province (Kula Group). *Sparganobasis subcruciata* was recorded as a coconut pest (from Madang), but the records and damage observed in Mamba Estate, Northern Province are the first records from oil palm. Larvae were subsequently found at Giligili Plantation, Milne Bay Estates (from a palm felled due to Ganoderma). The weevil is strongly attracted to the decay smell given off from Ganoderma or rot in frond bases of palms, as a result of chemicals released either by the bacterium, *Thielaviopsis paradoxa* or the smell given off by a secondary yeast infection. The chemicals produced by *T. paradoxa* activity are most likely ethyl or methyl Acetates or Butyrates (esters), and from the yeasts, acetic acid or other carboxylic acids, produced by a breakdown of oil palm tissues.

Bagworm
There were two reports of rough bagworm (*M.corbetti*) from Solomon Islands (GPPOL) and recommended for TTI and hand picking during 2010. No reports of bagworm (*Mahasena* or *Manatha*) were received from the Kula Group plantations. Routine monitoring of the populations present at Ambogo continued throughout 2010.

Finschhafen disorder (causal agent Zophiuma butawengi*)*
Zophiuma lobulata has been found to be a synonym of *Zophiuma butawengi* and the latter name is now used except when quoting old reports/papers. The change of name is as a consequence of the PNGOPRA/ACIAR project on Finschhafen Disorder.

The ACIAR supported collaborative project with Charles Sturt University, Orange, Australia entitled, "*Integrated pest management for Finschhafen Disorder of Oil palm in Papua New* Guinea [CP/2006/063] was completed and a final report was prepared and submitted to ACIAR. Two peer-reviewed manuscripts were submitted during the year; however they will not be published until 2011. One paper "*Insect pests and insect-vectored diseases of palms-a review*", was published at the end of 2009 in The Australian Journal of Entomology (see references) by Gitau, Gurr, Dewhurst, Fletcher and Mitchell. *Z.pupillata* was studied, and a re-description produced entitled "*A review of the planthopper genus* Zophiuma *with first description of the male* Z.pupillata*"* was sent to the peer reviewed Australian Journal of Entomology and will be published in early 2011.

Deane Woruba, recipient of the ACIAR John Allwright Fellowship in 2008 commenced his Master of Philosophy studies in July 2009 at Charles Sturt University (CSU), Orange, New South Wales, Australia. He is investigating the potential for the use of entomopathogenic fungi in controlling *Zophiuma butawengi,* the causal organism for Finschhafen Disorder.

Weed pests
Mikania micrantha, Mile-a-minute vine (ACIAR project CP/2004/064). We continue to work in close collaboration with colleagues at NARI Kerevat, and infected material is sent to us at Dami for release in WNB. A paper is in preparation and will be submitted to the APS-IPPC conference in Hawaii in August 2011. *Sida rhombifolia,* Broomstick: releases of Chrysomelid beetles, (*Calligrapha pantherina*) from RAIL, were made during 2010, and a culture under shade was set up at Dami to enable cropping and release to be undertaken as required. *Eichornia crassipes*, Water hyacinth: water hyacinth is attacked by weevils of a different genus, *Neochetina bruchi (*Coleoptera: Curculionidae*)*-the Chevroned Water hyacinth beetle. Host material is collected from waterways in WNB and infested plants are returned on an *ad hoc* basis.

Queen Alexandra's Birdwing Butterfly (QABB)
Collaborative work with OPRS (Tissue culture laboratory) continued with emphasis on improving propagation techniques based on multiplication of *Pararistolochia* vine of known origin and of food

plant material. Results show that there is a strong possibility that there is a very narrow host plant preference at level of specific vine genotypes. Therefore research continues to concentrate on using known origin vine cuttings and developing methodologies that can be used simply under nursery conditions to propagate the vine for habitat enhancement. A review on QABB is currently near completion and next steps are being discussed.

Environmental Monitoring
PNGOPRA will be developing and trialling a system of stream monitoring using freshwater arthropods as bio-indicators. A detailed list of equipment requirements for this project has been prepared and has been sent for purchasing.

Training
The field days organised by OPIC were well attended during the year, and entomology staff participated in all except one meeting. Field days held in the Hoskins Project area were more readily accessible than those held by the Bialla Project where we were only able to attend a single field day. The majority of Bialla field days were cancelled by the Project Manager. An updated Entomology activities brochure was produced as a hand-out during meetings, training courses and to visitors.

Plant Pathology Programme
Work continued to concentrate on the epidemiology, population dynamics, physical and biological control of *Ganoderma boninense*, the fungus that causes Basal Stem Rot in oil palms. Basal stem rot is a difficult disease to control as infection cannot, at present, be identified until the symptoms appear.

Disease epidemiology
There are two objectives for this work (i) To determine the mechanism(s) of secondary spread of Ganoderma within plantations and to apply this data to refine control methods (ii) To generate epidemiological models from survey data that will allow growers to make predictions of crop loss and economic thresholds in future plantings. The research on epidemiology will continue until the blocks under study are replanted. After this the new plantings will be monitored to delineate any pattern of infection compared with the previous plantings.

Data for the epidemiology work has been collected from Milne Bay, New Ireland and West New Britain. At Milne Bay between 0.5 and 6.1palms/ha were recorded. A reduction in disease levels from 2009 was observed for all blocks except Blocks 7213 and 6503 where non-significant increases were seen. Block 7214 recorded the highest incidence in 2010 with 3.02%, down slightly from that recorded in 2009. Ganoderma surveys were completed in a number of smallholder (VOP) blocks in Milne Bay in 2010. Not all blocks were accessible due to poor upkeep and deteriorating road networks but all zones were visited and 30-100% of blocks in each zone were surveyed. Blocks not surveyed will be revisited in 2011 as roads are upgraded.

At New Ireland, Ganoderma infection levels were recorded for each estate at Poliamba in 2010. Noatsi Estate continues to record the highest levels of disease however in 2010 disease levels had decreased significantly from 5.7% in 2009 to 2.3%. This is significantly lower than most blocks in Milne Bay. Disease levels in all other Estates except Nalik East also decreased in 2010 from 2009.

In Popondetta, disease incidences in all Estates at Higuturu Oil Palms Ltd. were below 2% in 2010 with the highest recordings at Sumberipa which have mixed young (6-10 years) and old plantings (17-21 years). Disease levels at Sangara were similar to those at Sumberipa with 1.3%. As with Milne Bay, the numbers of suspects exceeds the number of bracket palms in all Estates except for Mamba. This may be a reflection of the more subtle expression of symptoms at Mamba which has a higher rainfall than the lowland areas in Oro Province. Most of the data for Sangara is derived from 1996 plantings in 2010 as a high percentage of blocks in this estate were not surveyed.

In West New Britain, annual disease rates increased for all E fields at Numundo in 2010. Field E4 recorded the highest increase in rate of 0.5%. Disease progress curves for the period 2000-2010 show the continuing linear trend in infection rates in the E Fields. Infection levels in Field E5 increased by 3.8% in 2010 and the disease incidence is now over 31%. Field E4 now has a cumulative infection level of 24.4%, above the theoretical threshold level for yield loss. Fields E1, E2 and E3 show disease incidences well below those of Fields E4 and E5 and it is not expected that these fields will have reached threshold levels at replant.

Monitoring the effects of disease on production in selected blocks
The theoretical threshold at which yield begins to decline in a mature oil palm crop is in the vicinity of 20% of crop loss. This threshold will be dependent on a number of factors including the age of the palms, planting density, nutritional status and prevailing weather conditions, however, a knowledge of the approximate level at which production begins to decline in different areas of PNG will provide a basis for future recommendations for replanting.

Ganoderma BMP blocks
In 2008, selected blocks were designated Ganoderma Better Management Practice (BMP) blocks in an attempt to determine the effects of efficient and timely roguing on disease rates. Monthly surveys are conducted in BMP blocks and removals of all palms including suspect palms are carried out also on a monthly basis. Removals in the GMP blocks have been consistently lower than the infections over a 25 month period. Aside from the high numbers recorded in early 2008 due to surveys being omitted in the month of February, there appears to be a pattern emerging. Infections appear to rise and dip every 3 to 4 months indicating that symptom expression is staggered and not correlated with periods of high or low rainfall

Ganoderma biological control
Biological control research in PNG continued in 2008 and in the same year, a research proposal was submitted for funding to the ARDSF Agricultural Innovations Grant Scheme (AIGS) to further this research. This project commenced in 2009. For most of 2010, funds were not released from the AIGS administrators and hence, much of the work focused on testing formulations with locally available materials.

Several species of the fungus Trichoderma are used throughout the world for the control of diseases in a number of crops. Control is based on the ability of Trichoderma to antagonize other fungi in a number of different ways such as parasitism, production of inhibitory volatile compounds and production of compounds that dissolve the hypha of other fungi. Eleven Trichoderma isolates were challenged against each other on PDA plates. Linear growth of each isolate was measured and recorded after one week. Generally, there was little antagonism between the isolates although isolate BU was outgrown by the other test isolates BN, B and C. Isolate SP5A, W and BV were the fastest growing and out-competed most other isolates. Their performance in formulations is being tested.

Due to the high cost and difficulty of obtaining nitrates, alternatives sources of nitrogen for the liquid culture of Trichoderma were investigated. Readily available organic sources as well as inorganic N sources were tested *in vitro*. The highest biomass yield was obtained using yeast extract and the least growth was obtained with urea as the N source. In order to ascertain if the acidity or alkalinity of the solutions was a limiting factor in the use of these reagents, pH measurements were taken before and during culture. Glycine and urea had the highest pre- and post-culture pH and this had a detrimental effect on growth of *Trichoderma*. In the presence of nitrates, the pH of the media was reduced and remained low throughout the period of incubation. The total absence of nitrates caused poor mycelial growth and reduced spore production.

Several sets of field spraying trials were done in 2010. Trials were concentrated on sanitized logs and the bracket/palm interface. Trials indicated that some effect might be observed on growth of Ganoderma brackets in situ however due to a lack of controls, results were inconclusive. Numerous trials on sanitized bases and felled oil palm trunks in replanted areas were done in 2010 to test the effectiveness of different formulations of the fungus. Growth of Trichoderma in most of the formulated products was directly affected by weather. Spraying could not be carried out during rainfall events and growth could not be established if rain fell within 2 days of spraying. This presents some challenges for formulation selection.

Screening for Ganoderma Resistance (Incorporating ACIAR Ganoderma Project PC-2007/039)
Screening for Ganoderma resistance continued in 2010 with the establishment of a field trial at GPPOL in Solomon Islands. Laboratory and nursery assays also continued on seed provided by Dami OPRS. A local scientist was recruited and sent to PNG for training for 2 months from September to early November. Work on the laboratory was started in October and completed in December 2010 with only a few minor improvements remaining to be completed.

Three sets of nursery trials were established in 2010. All three trials tested selfs of Ganoderma infected palms as well as o x g hybrids. Preliminary results indicate that some progenies may be more susceptible to Ganoderma and these will be sampled and sent to the University of Queensland (UQ) for genetic testing. All trials are continuing. Field trials were established at Ngalimbiu Plantation, GPPOL, Solomon Islands, March and April 2010. Trial design is a randomized complete block design with 14 replicates (blocks) and a single progeny per block. Eighty one progenies provided by Dami OPRS are being tested. There are two identical trials laid out in adjacent blocks each with a different treatment at the time of felling. Data collection will commence in 2011.

In preliminary work, representative seedlings from each of 20 progenies were analysed by PCR analysis using microsattelite markers at the University of Queensland to assess the genetic diversity among parental lines and progenies from the various crosses used in a field trial in Solomon Is. The results of the genetic testing revealed that parental lines could be separated and some diversity in the microsattelite alleles was present. Further testing will be carried out in 2011.

Mitochondrial DNA of Ghana and PNG (ex Cameroon) weevils
A population of pollinating weevils was imported from Ghana by the Entomology Section as a means of increasing the genetic base of the PNG population. Interbreeding studies indicated that the populations were of the same species (despite small colour differences) and they could be released with confidence into the plantation. As a precautionary measure the mitochondrial DNA was assessed to see if there were any genetic differences between the populations. The Cox I mitochondrial gene was amplified from bulked and individual samples of weevils from Ghana, Milne Bay and Ramu. The results, along with interbreeding trials done at Dami, indicated that the weevils imported from Ghana could be released without detriment to the local population.

Bogia Coconut Syndrome(BCS)
One meeting was held in May 2010 and this was attended by the HoPP. Input and advice was also provided for further sampling of palms in districts in Madang Province. Collected samples were processed and sent to NAQIA for analysis overseas.

Socio-economic studies

Developing a Smallholder Engagement Strategy for OPIC
In 2010, PNGOPRA initiated discussions on assessing the effectiveness of smallholder extension services in the Hoskins project. As part of the overall strategy, a student project was supported by Curtin University of Technology, Australia in partnership with PNGOPRA. The fieldwork for this study was undertaken midyear 2010 and supported by the socioeconomics section. Field day surveys were designed to get feedback about the information posters and presentations in the field and develop new ideas and concepts for improving information services to the growers. At the same time, PNGOPRA has applied for a detailed research project, within the support framework of the Smallholder Agricultural Development Project (SADP), to determine the most effective and

appropriate extension methodologies to apply in SADP project areas. The project would be carried out in two phases: 1) a research phase to document the educational levels and strategies of the smallholder oil palm population in Bialla, Hoskins and Popondetta; and 2) the production of a smallholder engagement strategy for OPIC. The field day surveys will be continued in 2011 and, if funding from SADP becomes available, a detailed program would be undertaken to document the key characteristics and catalytic agents for changes in the delivery of extension to oil palm growers

Mobile Card Scheme, Bialla
Several visits were undertaken in 2010 after a review in late 2009 on the progress of the Mobile Card following concerns that the number of Mobile Cards in use in Bialla had declined. Some of the key action points from the review were acted upon in close collaboration with Hargy Oil Palm Ltd. (HOPL) and OPIC.

Customary Land Use Agreement (CLUA)
In 2010 discussions continued on the newly proposed CLUA template designed by OPRA with key stakeholders, including customary landowners and migrants involved in land dealings. As outlined in last year's annual report, current procedures for dealing with new oil palm plantings on Customary Rights Purchase (CRP) blocks and existing Clan Land Usage Agreements (CLUA) used by OPIC do not provide adequate land tenure security for the outsider 'purchasing' or leasing land; nor do they ensure that all members of the landowning clan agree to, or benefit from, these land transactions. Furthermore, the existing CLUA is not RSPO compliant. Therefore, there is a need to review current practices relating to the establishment of CRPs. The design of a new CLUA template is part of a collaborative ACIAR research project with Curtin University which started in 2008. OPIC and SADP would like to see the new CLUA used on SADP infill blocks. Importantly, the proposed CLUA template is compliant with RSPO requirements relating to land use rights (in particular proof of land ownership and defined legal boundaries of land), and central to the new CLUA template is the concept of Free, Prior and Informed Consent (FPIC) amongst all parties to the transaction in accordance with RSPO principles. This means that each party (customary landowning group and the person seeking to acquire a specified parcel of land parcel) must be fully informed about all aspects of the transaction prior to making a decision as to whether or not to proceed with the land transaction.

Household socioeconomic and demographic surveys
The household socio-economic and demographic surveys among LSS smallholder households started in the last quarter of 2009, continued in 2010. At Hoskins, Bialla and Popondetta, 100 LSS blocks were randomly selected for the survey. All households surveys for the Higaturu project have been completed and coding and data almost done. At Bialla the household surveys are nearly finished and data entry is almost complete. The Hoskins household socio-economic and demographic surveys will be completed by June 2011. The household survey data update the 2000 household survey data conducted at Hoskins, Bialla and Popondetta and will enable OPRA to assess changes in population, agronomic practices and socio-economic conditions on the block over time.

Smallholder Food Security Project
In 2010, the socioeconomics section, in collaboration with the agronomy section, jointly applied for and succeeded in securing a smallholder project titled "Improving food security and marketing opportunities for women in smallholder cash crop production". It is a 2 year project with funding from the Agricultural Innovation Grant Scheme (AIGS), an initiative of the Australian Government through the Agricultural Research and Development Support Facility (ARDSF). The project aims to improve food security and marketing opportunities among oil palm smallholders residing on the Land Settlement Schemes (LSS) in Papua New Guinea by: (i) investigating the optimal planting arrangements for oil palm to facilitate intercropping of food crops and fuel wood species for home consumption and sale at local markets while sustaining oil palm incomes (ii) develop policies to enhance food production on the land settlement schemes. The project will at the same time monitor changes in quantities produced and amounts sold and consumed when gardens are brought back on to the block. Spacing trials would help to ameliorate the land pressure for making gardens on marginal

and environmentally sensitive areas like the buffer zones. At the same time it would greatly improve women's access to land for food production, thereby contributing to food security and enhancing income opportunities. Whilst the spacing and intercropping trial may not be the panacea, it is one way to responding to the challenge arising from the declining access to land for food gardening, marketing and income generation.

Specific studies requested

Two specific studies were undertaken during 2010, at the request of stakeholders, to help understand smallholder constraints under particular conditions. First Study: Assessment of interest and perception of villagers to take up oil palm as alternative cash crop: Ramu Field Trip Report and the Second Study: Higaturu Smallholder Production Assessment Report

Technical services provision

The technical staff employed by PNGOPRA have a very wide knowledge base on oil palm growing and the constraints involved. The staff therefore provide technical services to the industry in Papua New Guinea through the provision of advisory material, recommendations, training and direct technical inputs such as the production of biological control agents.

1. AGRONOMY RESEARCH

HEAD OF SECTION: MUROM BANABAS

OVERVIEW

The main task of PNGOPRA Agronomy Section is to determine the optimum nutrient requirements for oil palm from trials and at the same time understanding the processes within the soil which influence and regulate plant nutrient uptake and then communicate the information to the oil palm industry. In addition to optimising yield, activities are in place to determine the long term sustainability of the system.

The bulk of the work undertaken by the Agronomy Team is fertiliser response work. At each of the plantations we have set up a large number of trials in collaboration with our funding partners (Plantation Companies and Smallholder Sector). The types of trials established are different between different areas and depend on where the gaps in knowledge are and soil type differences. A number of new trials started during the last 2-3 years at the various sites took into consideration possible effects of progenies on yield responses and therefore known progenies were planted for the trials. Trials in New Britain Palm Oil Ltd. (NBPOL) plantations in WNB were handed to OPRS to manage while PNGOPRA will concentrate on fertiliser/demonstration trials on smallholder blocks.

There are also several experiments looking at a) the effects of different spacing arrangements on yield and b) yield monitoring and forecasting, however the monitoring trials were closed at the end of 2009. These non fertiliser related trials are very important in providing management information to the industry.

Two important donor funded projects, N Loss and Mg/Cation, were closed and have been reported. There is now another donor funded project (ACIAR) looking at sustainability of oil palm production in PNG that started May. As part of this project, Rachel Pipai is now studying for a masters at University of Adelaide in Australia looking at nitrogen fixation by legume cover crops under the oil palm systems in PNG. Another important project looking into food security in smallholder farming systems has been approved by AIGS (ARDSF project funded by AusAID) and is now being implemented. This is a joint project between PNGOPRA and OPIC.

There has also been an increased involvement in smallholder related activities. There are smallholder fertiliser-demonstration blocks in Hoskins, food security activities have started and are continuing in Oro, Hargy and Poliamba, collection of leaf tissues for analysis continue in Oro and have started in Hargy, and the setting up of fertiliser demonstration blocks in Milne Bay and Poliamba. The aim here is to increase FFB yields in the smallholder sector from 10-15 t/ha/year to >25 t/ha/year.

Across all sites, there is continuous involvement in training for the industry. There has been increased PNGOPRA involvement with OPIC on smallholder field days and radio broadcasts. Training has also been carried out in the plantations on N Loss studies regarding timing and placement of fertiliser applications.

HARGY OIL PALMS LTD

(Winston Eremu and Steven Nake)

Trial 211: Systematic N Fertiliser Trial, Navo (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

Trial 211 is a systematic N fertiliser trial purposely established in 2001/02 at Navo estate in Hargy Oil Palm plantations to investigate effects of applying 9 different rates of N (0 – 2.0 kg N/palm) on oil palm growth and production. An 8 t/ha yield response resulted from the application of 3.7 kg/palm AN (1.25 kg N/palm). There was a drop in yield in the trial block in 2010 and was due to drop in bunche numbers (bunches/ha). The single bunch weight (kg/ha) remained steady. Bunch numbers per hectare (bunch/ha) decreased as palm matured in age. Regardless of the N fertiliser rates, an average yield of 33.5 t/ha was achieved at a rate of 2.22 AN/palm. N application had significant effect in leaflet N and dry matter production of the oil palm.

BACKGROUND

Factorial fertiliser trials with randomised spatial allocation of treatments have been generally showing poor responses to fertilisers in NBPOL trials since late 1980s. Yields and tissue nutrient concentrations in control plots have been generally higher than would be expected. It is suspected that fertiliser may be moving from plot to plot. Large plots, guard rows and trenches between plots were introduced to avoid poaching of nutrients between plots, but lack of response persisted. Systematic designs are seen as a way of avoiding this problem, by ensuring that high and low rates of application are not adjacent. The purpose of the trial is to provide a response curve to N fertiliser that will be used to determine optimum N input in the area.

Harvesting of ripe bunches and all other upkeep work is done by the plantation. Fertiliser applications and data collections are done by PNGOPRA. The background information for the trial is shown in Table 1.

Table1. Trial 211 background information.

Trial number	**211**	Company	Hargy Oil Palm Ltd
Estate	Navo	Block No.	Field 11, Rd 6-7, Ave 11 to 13
Planting Density	115 palms/ha	Soil Type	Volcanic
Pattern	Triangular	Drainage	Poor
Date planted	March 1998	Topography	Flat and swampy
Age after planting	11 years	Altitude	2 m asl
Treatments 1st applied	Nov 2001	Previous Land-use	Sago and forest
Progeny	unknown	Area under trial soil type (ha)	not known
Planting material	Dami D x P	Agronomist	Winston Eremu

MATERIALS AND METHODS

Experimental Design and Treatments

Trials 211 is a Systematic trial where 9 rates of N are applied in 8 replicated blocks. The rates applied increase from 0 to 2kg N/palm in 0.25kg N/palm increments (equivalent to 0 to 5.92kg AN/palm at 0.74kg AN/palm increments). The trial is designed such that in each adjacent replicate block the N rates increase or decrease systematically (Figure 1). Each plot has 4 measured rows of palms with 13 palms each (52 palms/plot). Fertiliser treatments are shown in Table 2.

Replicate 1									Replicate 2								
N8	N7	N6	N5	N4	N3	N2	N1	N0	N0	N1	N2	N3	N4	N5	N6	N7	N8

Figure 1. Example of two replicates for the Systematic N trial design (N rate increments are at 0.25kg N/palm)

Table 2. Fertiliser treatments and basal applied in Trial 211

	LEVELS (kg palm^{-1})								
N Fertiliser Code	N0	N1	N2	N3	N4	N5	N6	N7	N8
Ammonium Nitrate	0	0.74	1.48	2.22	2.96	3.70	4.44	5.18	5.92
N rate (equivalent)	0	0.25	0.50	0.75	1.0	1.25	1.50	1.75	2.0

Ammonium nitrate (AN) is used in this trial and applied in two split doses during the year. Any other fertilisers used by the plantations are applied as basal. In 2010 basal fertilisers applied were: MOP 2.0 kg, KIE 1.5 kg, TSP 0.5 kg and Borate 0.150 kg/palm.

Data Collection

Yield recording - ripe bunches with loose fruits are weighed every 14 days (fortnightly). Leaf samples are collected from frond 17. The samples are processed and dried over night at 75°C. The dried samples are ground at Dami and exported to AAR for chemical analysis. Leaf measurements (total frond length, width and thickness (WxT) of the petiole, length and width of the leaflets, count on the total number of leaflets on one side of the frond) are done on frond 17. The data collected is used for calculating the radiation interception and dry matter production. Leaf measurements are done on the same frond number (17) that is also used for leaflet collection for analysis and on the same selected palms. Both leaf sampling and leaf measurements are normally done once a year. Frond marking and frond production counts to determine the frond production per year is done twice a year (every 6 months). Height measurements are done once a year to calculate height increment each palm per year. Leaf sampling and the vegetative measurements are done on selected palms in a row. The data is checked for any recording errors on or about the same day, after the collection of each set of data in the trial. The raw data collected is sent to Dami once every two weeks to be entered into the data base, including the leaf and rachis sampling results received from AAR.

Trial maintenance and upkeep

The trial block is maintained regularly by Navo estate. This covers pruning, weed control (either herbicide spraying or slashing), wheelbarrow path clearance, cover crop maintenance and other routine plantation practices. Fertilisers (MOP, Kie, TSP and Borate) not used as treatments but normally applied by the plantations are also applied by the plantations.

Field, data quality and data entry checks

The trial yield recording checks are done once or twice a month by randomly reweighing four to five bunches after the recorders had weighed through to be sure that the weights recorded already by a recorder are actually correct and scale is not defective or misread. Trial inspection and standard checks are done once or twice a month on harvest path clearance, frond stacking, ground cover; visibility of ripe bunches, weighing of loose fruits, pruning, pests and diseases. This information is passed on to the plantation management with quarterly reports to assist in improving the block management standards. The accuracy check of marking frond one (1) and cutting frond seventeen (17) is done during tissue sampling, vegetative measurements and frond count to be sure the activity is not based on any other fronds. Scales are checked against a known weight once a week. Other tools are inspected and ensure there are no defects before using them. Database entry checks are done prior to commencement of data analysis and report writing for each year to ensure that no wrong entries of dates, unusual figures and etc are included.

RESULTS

Yield response to fertiliser treatment in 2010

The effects of 9 different rates of N fertiliser on yield and other components in 2010 and 2008-2010 are presented in Table 3. In 2010, the effects of N fertiliser rates on yield, number of bunches per hectare and single bunch weights were all significant ($p<0.001$). Generally, the yields increased with increasing rates of AN fertiliser with a yield response of 2.7 to 8.8 t/ha. The responses were also similar for the last three years' (2008-2010) running average.

Table 3. Effects of applying different N rates over yield (YLD), bunch number per hectare (BN) and single bunch weight (SBW) in 2010 and for the last three years (2008-2010).

		2010			2008-2010		
N rate (kg/palm)	**Equivalent AN rate (kg/palm)**	**YLD (t/ha)**	**BN (bunches/ha)**	**SBW (kg/bunch)**	**YLD (t/ha)**	**BN (bunches/ha)**	**SBW (kg/bunch)**
0	0.0	28.0	1411	19.8	31.5	1644	19.2
0.25	0.74	30.7	1477	20.7	34.8	1732	20.1
0.5	1.48	32.8	1559	21.1	36.1	1770	20.4
0.75	2.22	33.5	1562	21.5	37.2	1794	20.8
1.0	2.96	35.0	1648	21.2	38.5	1855	20.8
1.25	3.70	36.5	1658	22.0	39.7	1858	21.4
1.5	4.44	35.2	1618	21.8	39.0	1857	21.0
1.75	5.18	36.7	1680	21.9	40.7	1912	21.3
2.0	5.92	36.8	1701	21.6	39.6	1892	21.0
Mean		**33.9**	**1590**	**21.3**	**37.5**	**1813**	**20.7**
Significant diff		**P<0.001**	**P<0.001**	**P<0.001**	**P<0.001**	**P<0.001**	**P<0.001**
$LSD_{0.05}$		**2.31**	**107.8**	**0.68**	**1.91**	**85.0**	**0.43**
CV%		**6.8**	**6.8**	**3.2**	**5.1**	**4.7**	**2.7**

Yield response over time

By applying N, a gradual and noticeable increase of 10 t/ha in FFB yield occurred between 2003 and 2009 but dropped to about 4 t/ha in 2010. (Figure 2).

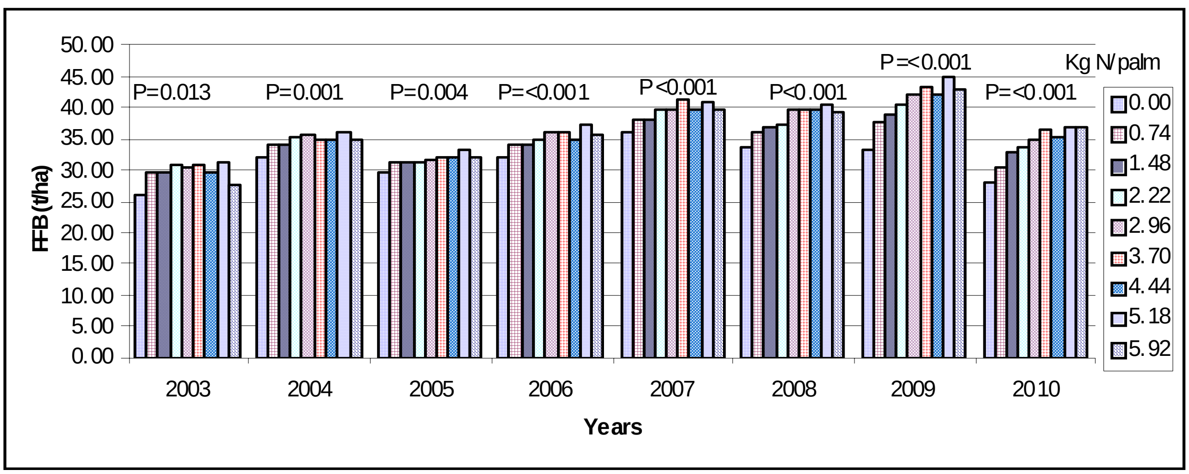


Figure 2. Yield response to all the rates of N (kg/palm) over time, (fertiliser N was first applied in late 2002)

Tissue nutrient concentration for 2010

Results of effects of N fertiliser rates on leaf nutrient contents for 2010 are presented in Table 4. Leaflet N and P increased with rates of N fertiliser at p<0.001, whilst there was no significant effect of N rate on leaflet K, and rachis N, P and K.

Table 4. Leaf and rachis nutrient content for trial 211 in 2010

N rate (kg/palm)	Equivalent AN rate (kg/palm)	Leaf (% dm) N	P	K	Mg	B (ppm)	Rachis (% dm) N	P	K
0.00	0.00	2.20	0.133	0.74	0.214	17.9	0.280	0.063	2.03
0.25	0.74	2.21	0.128	0.72	0.209	19.3	0.290	0.057	2.03
0.50	1.48	2.31	0.130	0.74	0.189	17.4	0.294	0.055	2.08
0.75	2.22	2.34	0.133	0.76	0.182	16.2	0.325	0.058	2.09
1.00	2.96	2.40	0.136	0.74	0.186	17.3	0.325	0.058	2.05
1.25	3.70	2.40	0.135	0.76	0.171	16.2	0.311	0.052	2.00
1.50	4.44	2.38	0.135	0.73	0.186	17.7	0.306	0.058	1.93
1.75	5.18	2.41	0.136	0.74	0.174	16.6	0.335	0.063	2.00
2.00	5.92	2.40	0.136	0.76	0.176	17.1	0.310	0.051	1.98
Mean		**2.34**	**0.133**	**0.74**	**0.188**	**17.3**	**0.308**	**0.057**	**2.02**
Significant difference		**P<0.001**	**P<0.001**	**NS**	**P<0.001**	**NS**	**NS**	**NS**	**NS**
$LSD_{0.05}$		**0.08**	**0.003**	**-**	**0.02**	**-**	**-**	**-**	**-**
CV%		**3.3**	**2.3**	**5.2**	**10.0**	**10.4**	**11.7**	**14.8**	**9.5**

Tissue N concentration over time - 2004 to 2010

The mean leaflet N contents fell with time from 2.70 % in 2004 to 2.34 % DM in 2010 (Table 5). The low N rates (0.00 and 0.25 kg N/palm) have fallen below critical levels in 2010.

Table 5. Leaflet N (% dm) over time.

N rate (kg/plm)	*Equivalent AN rate (kg/plm)*	*Leaflet N (%DM) 2004*	*2005*	*2006*	*2007*	*2008*	*2009*	*2010*
0.00	*0.00*	2.66	2.60	2.44	2.40	2.36	2.25	2.20
0.25	*0.74*	2.67	2.63	2.46	2.48	2.38	2.29	2.21
0.50	*1.48*	2.72	2.65	2.51	2.51	2.46	2.37	2.31
0.75	*2.22*	2.72	2.67	2.50	2.53	2.49	2.42	2.34
1.00	*2.96*	2.71	2.68	2.52	2.57	2.54	2.45	2.40
1.25	*3.70*	2.71	2.66	2.51	2.56	2.56	2.50	2.40
1.50	*4.44*	2.67	2.69	2.54	2.60	2.57	2.46	2.38
1.75	*5.18*	2.69	2.68	2.50	2.57	2.57	2.52	2.41
2.00	*5.92*	2.72	2.65	2.52	2.56	2.46	2.54	2.40
Mean		***2.70***	***2.66***	***2.50***	***2.53***	***2.49***	***2.42***	***2.34***
Sign- difference: P		***NS***	***P=0.02***	***<0.001***	***<0.001***	***<0.001***	***<0.001***	***<0.001***
$LSD_{0.05}$		***-***	***0.05***	***0.08***	***0.04***	***0.09***	***0.08***	***0.08***
CV%		***2.1***	***1.9***	***2.2***	***1.5***	***3.6***	***3.3***	***3.3***

Fertiliser N effects on oil palm vegetative growth

The effect N fertiliser rates on the physiological growth parameters are presented in Table 6.

About 25 new fronds were produced in 2010 (one every 15 days), indication of good growing conditions during the year. Total green fronds counted per palm averaged at 34 fronds.

N fertiliser application had significant effect on PCS and BDM, TDM and VDM whileall the other physiological growth parameters were not affected in 2010.

Table 6. Effects of N treatments on vegetative growth parameters in 2010

N rate Kg/palm	**Equiv-AN rate kg/palm**	**Radiation Interception PCS**	**GF**	**FP**	**FA**	**LAI**	**Dry matter production (t/ha/yr) FDM**	**BDM**	**TDM**	**VDM**
0.00	0	35.2	33.4	25.5	12.3	4.7	11.2	23.7	38.8	15.1
0.25	0.74	38.7	34.1	25.9	12.5	4.9	12.3	25.9	42.5	16.6
0.50	1.48	39.9	33.9	25.5	13.2	5.2	12.5	27.7	46.6	16.9
0.75	2.22	41.8	35.8	24.2	13.6	5.6	12.3	28.2	45.0	16.8
1.00	2.96	43.0	34.6	25.3	13.3	5.3	13.3	29.3	47.3	18.0
1.25	3.7	43.7	34.4	24.0	13.5	5.3	12.9	30.8	48.5	17.8
1.50	4.44	44.3	34.8	26.0	13.6	5.5	14.1	29.6	48.6	19.0
1.75	5.18	43.4	34.9	25.4	13.2	5.3	13.5	31.2	49.7	18.5
2.00	5.92	42.6	35.4	25.9	13.2	5.4	13.5	31.2	49.7	18.5
Mean		**41.4**	**34.6**	**25.3**	**13.2**	**5.2**	**12.9**	**28.6**	**46.1**	**17.5**
Significance		**P<0.001**	**NS**	**NS**	**P=0.003**	**NS**	**P=0.002**	**P<0.001**	**P<0.001**	**P<0.001**
$LSD_{0.05}$		**2.8**	**-**	**-**	**0.7**	**-**	**1.3**	**2.1**	**3.2**	**1.6**
CV %		**6.7**	**7.2**	**8**	**5.4**	**10.1**	**10.3**	**7.3**	**6.9**	**9.0**

PCS = Petiole cross-section of the rachis (cm^2); GF = number of green fronds (fronds per palm); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond dry matter production (t/ha/yr); BDM = Bunch dry matter production (t/ha/yr); TDM = Total dry matter production (t/ha/yr); VDM = Vegetable dry matter production (t/ha/yr)

DISCUSSION

Nitrogen (N) is an important nutrient for both oil palm yield and growth. N fertiliser has significant response, above 28t/ha in yield, despite a drop of 6-7t/ha from 2009 results due to drop in bunch numbers. A yield of over 33 t/ha was realized at N rates at more than 0.7kg N/palm (equivalent of more than 2.0 kg AN/palm). The optimum yield response of 8 t/ha achieved at N rate of 1.25 kg/palm (equivalent of 3.70kg/palm AN). The average data from the last three years (2008 to 2010) were slightly higher however the actual FFB yields are now starting to fall. Leaf N levels in each treatment have been gradually falling over the years. The results in 2010 indicated the N leaflet levels in the three lowest N treatments plots (0.00, 0.25, & 0.50 kg N/palm) were deficient, (critical level 2.30%). This was also obvious in with the visible symptoms in the field. The N fertiliser had improved the growth of the palm in the vegetative dry matter production of the oil palm.

CONCLUSION

There were significant responses in yield, despite the drop, tissue nutrient N, P and Mg in leaf and dry matter production (t/ha/yr) in physiological growth parameters. Leaflet N contents and yield in the low N rate plots have been falling with time.

Trial 212 Systematic N Fertiliser Trial, Hargy (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

Trial 212 is a systematic Nitrogen (N) fertiliser trial established in 20002 at Hargy estate in Hargy Oil Palm plantations to investigate effects of applying 9 different rates of N (0 – 2.0 kg N/palm) on oil palm growth and production. A 7t/ha yield response resulted from the application of 4.44kg/palm AN (1.50 kg N/palm), a decline of about 5t/ha from 2009. Bunch numbers per hectare (bunch/ha) decreased resulting in drop in yield. Regardless of the N fertiliser rates, average yield for the trial block was achieved at more than 27t/ha – at a rate of 2.22kgs AN/palm. Similarly, leaf N levels and the vegetative growth of the oil palm increased significantly with N application.

BACKGROUND

Factorial fertiliser trials with randomised spatial allocation of treatments have been generally showing poor responses to fertilisers in NBPOL trials since late 1980s. Yields and tissue nutrient concentrations in control plots have been generally higher than would be expected. It is suspected that fertiliser may be moving from plot to plot. Large plots, guard rows and trenches between plots were introduced to avoid poaching of nutrients between plots, but lack of response persisted. Systematic designs are seen as a way of avoiding this problem, by ensuring that high and low rates of application are not adjacent. The purpose of the trial is to provide a response curve to N fertiliser that will be used to determine optimum N input in the area. Harvesting of ripe bunches and all other upkeep work is done by the plantation. Fertiliser applications and data collections are done by PNGOPRA. The background information for the trial is shown in Table 1.

Table 1. Trial 212 background information.

Trial number	**212**	Company	Hargy Oil Palms Ltd.
Estate	Hargy	Block No.	Area 8, blocks 10 and 11
Planting Density	140 palms/ha	Soil Type	Volcanic
Pattern	Triangular	Drainage	Free draining
Date planted	Feb 1996	Topography	Moderate slope
Age after planting	13 years	Altitude	155 m asl
Treatments 1st applied	2002	Previous Land use	Oil palm
Progeny	unknown	Area under trial soil type (ha)	Not known
Planting material	Dami D x P	Agronomist	Winston Eremu

MATERIALS AND METHODS

Experimental Design and Treatments

Trial 212 is a Nitrogen (N) Systematic trial where 9 rates of N are applied in 8 replicated blocks. The rates applied increase from 0 to 2kg N/palm in 0.25kg N/palm increments (equivalent to 0 to 5.92kg AN/palm at 0.74kg AN/palm increments). The trial is designed such that in each adjacent replicate block the N rates increase or decrease systematically (Figure 1). It is purposely set out that way so that any nutrient shift from high to low N rate under ground can be detected. Unlike 211, Trial 212 has 2 measured rows of 15 core palms each (30 palms/plot) and one guard row palm at both ends (3-4 guard row palms in a plot). Fertiliser treatments are shown in Table 2.

Replicate 1									Replicate 2								
N8	N7	N6	N5	N4	N3	N2	N1	N0	N0	N1	N2	N3	N4	N5	N6	N7	N8

Figure 1. Example of two replicates for the Systematic N trial design (N rate increments are at 0.25kg N/palm)

Table 2. Fertiliser treatments applied in Trial 212

	LEVELS (kg palm^{-1})								
Treatment Code	N0	N1	N2	N3	N4	N5	N6	N7	N8
N rate	0	0.25	0.50	0.75	1.0	1.25	1.50	1.75	2.0
Ammonium Nitrate	0	0.74	1.48	2.22	2.96	3.70	4.44	5.18	5.92

Ammonium nitrate (AN) is the N source used in this trial and applied in two split doses in the middle and towards the end of the year. Any other fertilisers used by the plantations, but not included as treatments are applied as basal. In 2009 basal fertilisers applied were: MOP (2 kg), KIE (3.0 kg), TSP (0.5 kg) and Borate (0.150 kg/palm).

Data Collection

Yield recording – harvested ripe bunches with loose fruits are weighed every 14 days (fortnightly).
Leaf samples are collected from frond 17 from selected 16 palms out of the 52 measured palms in all the plots once a year. The samples are processed and oven dried. The dried samples are ground at Dami and exported to AAR for chemical analysis. Vegetative measurements, on total frond length, width and thickness of the frond bud, length and width of the leaflets, total number of leaflets on each frond are measured at the same time with leaf sampling, using the same frond 17 where leaflets for chemical analysis are taken from. The data collected is used for calculating the radiation interception and dry matter production. First frond marking and frond production count to determine the frond production per year is also done twice a year (six monthly).The heights of the same 16 palms are measured once a year. This is to work out the growth rate for each palm per year. The data is checked for any recording errors on or about the same day, after the collection of each set of data in the trial. The raw data is sent to Dami once every two weeks to be entered into the database, including the leaf and rachis sampling results received from AAR.

Field, data quality and data entry checks

The trial yield recording checks are done once or twice a month by randomly reweighing four to five bunches after the recorders had weighed through to be sure that the weights recorded already by a recorder are actually correct and scale is not defective or misread. Trial inspection and standard checks are done once or twice a month on harvest path clearance, frond stacking, ground cover; visibility of ripe bunches, weighing of loose fruits, pruning, pests and diseases. This information is passed on to the plantation management with quarterly reports to assist in improving the block management standards. The accuracy check of marking frond one (1) and cutting frond seventeen (17) is done during tissue sampling, vegetative measurements and frond count to be sure the activity is not based on any other fronds. Scales are checked against a known weight once a week. Other tools are inspected and ensure there are no defects before using them. Data base entry checks are done prior to commencement of data analysis and report writing for each year to ensure that no wrong entries of dates, unusual figures and etc are included.

RESULTS

Yield and its components response to fertiliser treatment in 2010

The results of yield and yield component responses to N fertiliser rates are presented in Table 3.
The N fertiliser rates had a significant effect on yield (t/ha), single bunch weight (kg/bunch) and the number of bunches (bunch/ha) in 2010. There was a significant effect in yield and yield component average in the last three years (2008-2010). The highest yield difference was 7 t/ha obtained from the application of 1.5kg N/palm (equivalent to 4.44kg AN/palm), a 5 t/ha drop in yield in 2010 due to decrease in number of bunches (bunch/ha).

Table 3. Trial 212: 2010 Yield (t/ha), bunches/ha) and SBW (kg/bunch) by N rate.

		2010			2008-2010		
N rate (Kg/palm)	**Equivalent AN rate (Kg/palm)**	**YLD (t/ha)**	**BHA (bunches/ha)**	**SBW (Kg/Bunch)**	**YLD (t/ha)**	**BHA (bunches/ha)**	**SBW (Kg/Bunch)**
0	0.0	22.9	1067	21.5	22.4	1108	20.3
0.25	0.74	23.7	1051	22.6	22.8	1073	21.3
0.5	1.48	26.1	1120	23.2	26.7	1207	22.1
0.75	2.22	27.1	1115	24.4	27.2	1193	22.9
1.0	2.96	26.9	1104	24.6	28.7	1186	23.6
1.25	3.70	28.8	1208	23.9	29.1	1278	22.9
1.5	4.44	30.0	1230	24.4	30.6	1317	23.3
1.75	5.18	30.2	1252	24.2	30.3	1298	23.3
2.0	5.92	29.4	1263	23.3	30.3	1344	22.5
Mean		**27.2**	**1157**	**23.6**	**27.5**	**1223**	**22.4**
Significant diff		**P<0.001**	**P=0.002**	**P<0.001**	**P<0.001**	**P=0.001**	**P<0.001**
LSD0.05		**2.6**	**126.4**	**1.4**	**2.2**	**115.0**	**1.2**
CV%		**9.6**	**10.8**	**5.8**	**8.1**	**9.4**	**5.3**

Yield response over time

The trial was initiated in 2002 and significant yield responses commenced in 2004 and the gap between nil N fertilised and N fertilised plots widened with time, a difference of 11 t/ha was recorded in 2009 but has dropped to 7t/ha in 2010 (Figure 2).

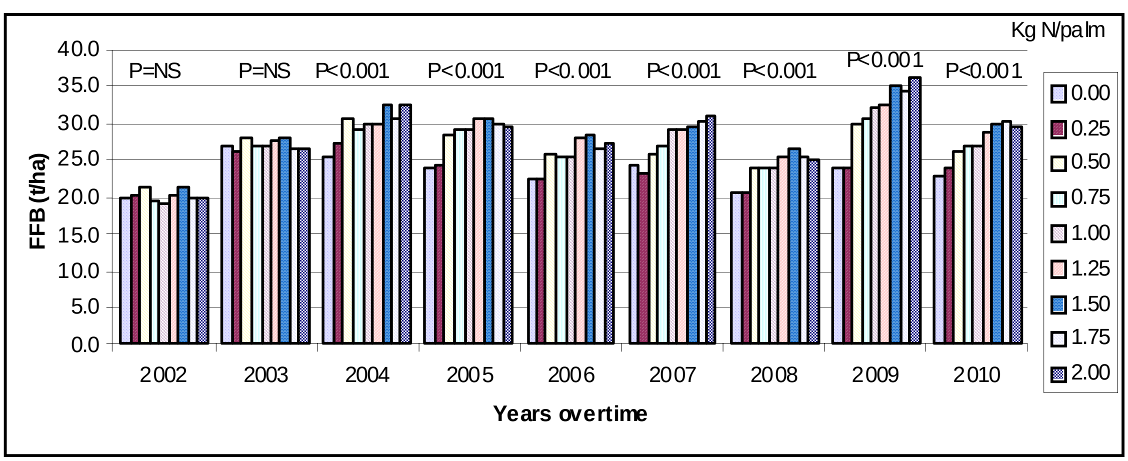


Figure 2. Trial 212: Yield response to all the rates of N (Kg/palm) over time (fertiliser N was first applied 2002).

Tissue nutrient concentration

The effects of N fertiliser rates on the leaflet and rachis nutrient contents are presented in Table 4. Nitrogen fertiliser significantly ($p<0.001$) increased leaflet N and Mg contents in 2010. Leaflet P and K contents did not respond to the N treatment. The N concentrations were generally low and below the optimum range (2.45 – 2.50 %). Similarly, the leaflet P contents were also below the adequate level of 0.145. The rachis K content was adequate. The N treatment did not have any significant effects on the nutrient concentration in the rachis.

Table 4. Tissue nutrient concentration's in leaflets and rachis in 2010.

N rate (Kg/palm	Equivalent AN rate (Kg/palm)	Leaflet nutrient concentration (% DM)					Rachis nutrient concentration (% DM)		
		N	**P**	**K**	**Mg**	**B**	**N**	**P**	**K**
0.00	0.00	2.26	0.131	0.68	0.210	15.8	0.26	0.044	1.67
0.25	0.74	2.28	0.132	0.69	0.208	14.8	0.26	0.040	1.56
0.50	1.48	2.27	0.133	0.66	0.199	15.4	0.27	0.040	1.61
0.75	2.22	2.34	0.133	0.66	0.184	14.9	0.26	0.037	1.45
1.00	2.96	2.36	0.134	0.66	0.180	14.7	0.27	0.039	1.62
1.25	3.70	2.40	0.136	0.64	0.175	14.6	0.29	0.042	1.50
1.50	4.44	2.44	0.137	0.68	0.166	14.3	0.30	0.047	1.72
1.75	5.18	2.46	0.138	0.67	0.171	15.8	0.29	0.044	1.60
2.00	5.92	2.43	0.136	0.72	0.154	13.5	0.30	0.047	1.72
GM		**2.36**	**0.134**	**0.68**	**0.183**	**14.9**	**0.28**	**0.042**	**1.61**
p values		**P<0.001**	**P=0.009**	**NS**	**P<0.001**	**NS**	**NS**	**NS**	**NS**
LSD0.05%		**0.06**	**0.004**	**0.05**	**0.02**	**1.3**	**0.04**	**0.007**	**0.22**
CV%		**2.7**	**2.9**	**7.0**	**9.6**	**8.7**	**13.7**	**17.0**	**13.6**

Tissue N concentration over time 2004 to 2010

Leaflet N concentrations increased with N fertiliser rates however the contents fell with time for each of the respective rates (Table 5).

Table 5. Leaflet N (% DM) from 2004 to 2010

N rate (kg/palm)	***Equivalent AN rate (kg/palm)***	***Leaflet N (% DM)***						
		2004	***2005***	***2006***	***2007***	***2008***	***2009***	***2010***
0	*0*	2.35	2.30	2.25	2.21	2.20	2.18	2.26
0.25	*0.74*	2.38	2.35	2.29	2.24	2.20	2.15	2.28
0.5	*1.48*	2.45	2.44	2.36	2.33	2.29	2.24	2.27
0.75	*2.22*	2.43	2.45	2.36	2.35	2.30	2.28	2.34
1.0	*2.96*	2.42	2.47	2.41	2.39	2.34	2.33	2.36
1.25	*3.70*	2.45	2.51	2.41	2.36	2.34	2.35	2.40
1.5	*4.44*	2.46	2.51	2.43	2.40	2.36	2.38	2.44
1.75	*5.18*	2.45	2.50	2.44	2.45	2.40	2.40	2.46
2.0	*5.92*	2.48	2.54	2.43	2.42	2.39	2.41	2.43
Grand mean		**2.43**	**2.45**	**2.37**	**2.35**	**2.31**	**2.30**	**2.36**
Significant difference:		***P<0.001***	***P<0.001***	***P<0.001***	***P<0.001***	***P<0.001***	***P<0.001***	***P<0.001***
$LSD_{0.05}$		***0.05***	***0.05***	***0.04***	***0.05***	***0.06***	***0.04***	***0.06***
CV%		***2.3***	***2.1***	***1.8***	***2.0***	***2.4***	***1.9***	***2.7***

Fertiliser N effects on oil palm vegetative growth

The results of effects of N fertiliser rates on the physiological growth parameters are presented in Table 6. N fertiliser rates had positive significant effects on all the vegetative growth parameters except on the number of green fronds on the palms, which depend on the harvesting and pruning standards.

Table 6. Effects of N treatments on vegetative growth parameters in 2010.

N rate kg/palm	Equiv. AN rate kg/palm	PCS	Radiation Interception				Dry Matter Production (t/ha)			
			GF	FP	FA	LAI	FDM	BDM	TDM	VDM
0	0	42.4	32.0	21	12.8	5.8	13.3	12.4	28.4	16.0
0.25	0.74	43.1	33.0	21	12.9	5.9	13.6	13.0	29.5	16.5
0.50	1.48	46.7	33.0	21	13.7	6.3	14.6	14.3	32.1	17.8
0.75	2.22	49.2	33.0	22	14.1	6.5	15.8	14.9	34.2	19.3
1.0	2.96	48.5	34.0	22	13.8	6.5	15.7	14.7	33.8	19.1
1.25	3.70	51.3	33.0	22	13.9	6.4	16.8	15.8	36.1	20.4
1.5	4.44	51.7	34.0	22	13.7	6.9	16.9	16.2	36.8	20.6
1.75	5.18	50.9	34.0	22	13.9	6.5	16.4	16.5	36.6	20.1
2.0	5.92	52.0	34.0	22	13.7	6.5	17.1	15.9	36.7	20.8
	Mean	48.4	33.0	22	13.9	6.4	15.6	14.9	33.8	18.9
Significance			**NS**		**<0.001**	**<0.001**	**<0.001**	**<0.001**	**P<0.001**	**<0.001**
LSD 0.05%		**<0.0012.6**	**-**	**<0.0010.6**	**0.7**	**0.5**	**1.0**	**1.5**	**2.2**	**1.1**
CV%		**5.4**	**3.8**	**2.8**	**5.2**	**5.8**	**6.2**	**9.8**	**6.6**	**6.0**

PCS = Petiole cross-section of the rachis (cm^2); GF = number of green fronds (fronds per palm); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production (t/ha/yr); BDM = Bunch Dry Matter production (t/ha/yr); TDM = Total Dry Matter production (t/ha/yr); VDM = Vegetative Dry Matter production (t/ha/yr).

DISCUSSION

Nitrogen (N) is an important nutrient for both oil palm yield and growth. By applying N fertiliser, yields had significantly increased and remain above 23 t/ha, even though an average drop of 3-4t/ha in yield realized in 2010. Yields of 30 t/ha were achieved at N rate1.5kg N/palm (equivalent of 4.44 kg AN/palm). Similar effects were seen in 2008-2010 average yield data. Yield from the nil fertilised plots produced was on average 23.3 t/ha for the last 7-8years. The highest yield in the nil fertilised plots was 27.1t/ha recorded in 2003. The leaf N levels in these plots are lower than 2.30% (deficient) for the last six years, as was expected in nil N fertilised plots. Leaf N levels at each of the treatment levels has been gradually falling. The results in 2010 also indicate that in the first four (4) low N treatments plots (0.00, 0.25, 0.50 & 0.75 kg N/palm) leaflet N contents were deficient (critical level 2.30%) and this was evident with visible symptoms in the field. The N fertiliser also improved the radiation interception and dry matter production parameters of palms.

CONCLUSION

N fertilisers had significant effect over yield, single bunch weight and bunch numbers. Yield declined There was a general decline in yield (t/ha) and bunch numbers. Leaflet N contents and physiological growth parameters and the effects have been consistent for the last 7 years. The leaflet N contents in the leaflets have been falling with time.

Trial 214: P (TSP) Fertiliser Placement, Hargy (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

The P treatments had significant effect on P levels in leaflets and rachis in April tissue analysis results but not any significant effects on the yields, other tissue nutrient levels and vegetative growth of the palms since the treatments started in 2008. Regardless of the treatments, the average yield for all plots increased from 19.6 t/ha in 2008 to 26.6 t/ha in 2010.The bunch numbers per hectare (bunch/ha) and single bunch weights also increased in 2010. N levels in the leaflets (2.52 %) and the P levels in both leaflets (0.145 %) and rachis (0.048 %) had increased to optimum levels.

BACKGROUND

Trial 214 was originally set up as a Magnesium trial in 2007, however was changed to a P (TSP) placement trial in 2008. The two most important influences on P nutrition on volcanic soils are (i) high allophane content of these soils, and (ii) soil acidification caused by the use of N based fertilisers. Allophane will bind to phosphate making it unavailable for plant uptake, thus it is important to minimise the direct contact of phosphate with the mineral soil (which is where the allophone material is). Volcanic ash soils have moderate to very low CEC with variable charge and contain allophone and iron oxides which fix phosphates (by forming complexes such as aluminium and iron phosphates). The topsoil at the site contained 6 – 8 % allophone (high) and the subsoil around 12 % (very high). In addition, soils around the weeded circle are being acidified and hence P in phosphate is becoming less available for uptake. Applying P on the frond pile where the soil is high in organic matter, low in mineral soil and where there are an abundance of palm feeder roots should enable more rapid uptake of P as phosphate. Therefore the aim of the trial is to identify the best option for the placement of TSP in light of volcanic soils containing high levels of allophane. The initial work on pre-treatment data and soil samples were collected in 2007. The application of treatment fertilisers was done in October 2008. Harvesting of ripe bunches and all other upkeep work is done by the plantation. Fertiliser applications and data collections are done by PNGOPRA. The background information for the trial is shown in Table 1.

Table 1. Trial 214 back ground information

Trial number	**214**	Company	Hargy Oil Palms Ltd
Estate	Hargy	Block No.	Area 4, block 2
Planting Density	129 palms/ha	Soil Type	Volcanic
Pattern	Triangular	Drainage	Well drained
Date planted	1994	Topography	Rising and hilly
Age after planting	15 years	Altitude	? m asl
Recording Started	2006	Previous Land use	Oil palm
Progeny	Unknown	Area under trial soil type (ha)	Not known
Planting material	Dami D x P	Agronomist in charge	Winston Eremu

Pre- treatment Data

Pre-treatment yield (Table 2) and tissue nutrient (Table 3) data (for use as co-variate in following years) were all done in 2007. Plot layout and first round of P fertiliser application (as treatment) was done in October 2008. Soil sampling was also done on selected sites and samples were sent to NZ for chemical analysis and allophane content determination (result not available).

Table 2. Trial 214- Pre-treatment Yield and PCS in 2007

Treatment code	**P rates / placement (Kg/placement)**	**2007**	
		Yield (t/ha)	**PCS (cm^2)**
1	0.0 - Control	27.5	41.9
2	1.0 – Weed Circle	29.4	41.1
3	1.0 – Frond Pile	27.8	40.9
4	2.0 – Weeded Circle	27.4	44.1
5	2.0 – Frond Pile	29.9	42.9
Mean		**28.4**	**42.2**
Significance		**NS**	**NS**
$LSD_{0.05}$		**-**	**-**
CV%		**13.5**	**6.1**

Table 3. Trial 214- Pre-treatment tissue nutrient concentration for leaflets and rachis in 2007

Treat Code	P rates / placement (Kg/palm)	2007							
		Leaf (%dm)					Rachis (%dm)		
		N	P	K	Mg	B	N	P	K
1	0.0 – Control	2.29	0.134	0.61	0.175	13.8	0.22	0.039	1.10
2	1.0 – Weeded Circle	2.39	0.137	0.63	0.167	15.5	0.22	0.036	1.03
3	1.0 – Frond Pile	2.35	0.136	0.65	0.180	15.7	0.23	0.038	1.07
4	2.0 – Weeded Circle	2.38	0.136	0.64	0.173	14.9	0.23	0.040	1.11
5	2.0 – Frond Pile	2.32	0.135	0.63	0.175	15.0	0.22	0.038	1.05
Mean		**2.35**	**0.136**	**0.63**	**0.175**	**14.9**	**0.22**	**0.038**	**1.07**
Significant difference		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV%		**3.2**	**2.7**	**4.5**	**11.9**	**12.0**	**5.5**	**12.2**	**8.1**

MATERIALS AND METHODS

Fertilisers are applied twice a year. There are 5 levels of TSP fertiliser applied in different locations around the palms in each plot. The first level is no application (0), the 2nd one is 1.0kg in the weeded circles (WC), 3rd one is 1.0kg in the frond pile (FP), 4th level is 2.0 kg in the weeded circle (WC) and 5th level is 2.0 kg applied in the frond pile (FP) (Table 4)

Table 4. Fertiliser treatments applied in Trial 214

Fertiliser	TSP				
Levels	1	2	3	4	5
Rates/Placement	0.0Kg -Nil	1.0Kg - WC	1.0Kg - FP	2.0Kg-WC	2.0Kg - FP

The basals applied in 2010 were N (AC) - 4kg/palm/year, MOP (K) - 2Kg/palm/year, Kie (Mg) 1kg/palm/year and Borate (B) 150g/palm/year.

Data Collection

Yield recording - ripe bunches with loose fruits are weighed 2 times a month or 26 times in a year on 14 day intervals. Leaf samples are collected from frond 17, from the 16 core palms in all the plots twice a year. The samples are processed and dried over night at 75°. The dried samples are ground at Dami and exported to AAR for chemical analysis for major elements along with few minor ones (N,P,K, Mg, B in leaflets and N, P, K on rachis). Vegetative measurements, on total frond length, width and thickness of the frond bud, length and width of the leaflets, total number of leaflets on each frond are measured at the same time as the leaf sampling using the same frond 17 from the 16 core palms in each plot in all the plots once a year. The data is collected and used for calculating the radiation interception and dry matter production. First frond marking and frond production count to determine the frond production per year is done twice a year (six monthly). The height of the 16 core palms in all the plots in the trial are measured once a year. This is to work out the growth rate for each palm per year.

The data is checked for any recording errors on or about the same day after the collection of each set of data in the trial. The raw data collected is sent to Dami once every two weeks to be entered into the database, including the leaf and rachis sampling results received from AAR

Field and data quality and data entry checks

The trial yield recording checks are done once or twice a month by randomly reweighing four to five bunches or even more after the recorders had weighed through to be sure that the weights recorded already by a recorder are actually correct and scale is not defective or misread. Trial inspection and standard checks are done once or twice a month on harvest path clearance, frond stacking, ground cover, visibility of ripe bunches, weighing of loose fruits, pruning, pests and diseases. This information is passed on to the plantation management with quarterly reports to assist in improving the block management standards. The accuracy check for marking frond one (1) and cutting frond seventeen (17) is done during tissue sampling, vegetative measurements and frond count to be sure the activity is not based on any other fronds. Scales are checked against a known weight once a week. Other tools are inspected to ensure there are no defects before using them. Data base entry checks are done prior to commencement of data analysis and report writing for each year to ensure that no wrong entries of dates, unusual figures and etc are included.

RESULTS

The yields with other components (Bunch number and SBW) have not shown any significant response to the treatments since the application of the first treatment. The average yield for all plots in 2010 was 26.4 t/ha (Table 5), an increase of 2.2 t/ha from 2009. Bunch number increased slightly from an average of 1173 in 2009 to 1218 bunches/ha in 2010. The average single bunch weight was 20.6 kg in 2009 and increased slightly to 21.9 kg in 2010. The 2008-2010 data also showed no response to the treatments (Table 6).

Table 5. Yield (t/ha),Bunch numbers (bunch/ha) and SBW (Kg/bunch) by P (TSP) rates.

			2010		
Treatment levels	P Rates Kg/ palm/year	Placement	Yield (t/ha)	BHA (bunch/ha)	SBW (kg/bunch)
1	0.0	Control	25.5	1227	20.6
2	1.0	1 - WC	26.9	1202	22.5
3	1.0	2 - FP	27.2	1219	22.4
4	2.0	1 - WC	25.0	1117	22.4
5	2.0	2 - FP	28.5	1323	21.6
Mean			26.6	1218	21.9
Significance			NS	NS	NS
CV%			10.9	12.3	6.3

(*WC- Weeded circle, FP – Frond pile*)

Table 6. Yield (t/ha), Bunch numbers (bunch/ha) and SBW (Kg/bunch) by TSP rates (2008- 2010).

			2008-2010		
Treatment levels	P Rates Kg/ palm/year	Placement	Yield(t/ha)	BHA (bunch/ha)	SBW (kg/bunch)
1	0.0	Control	22.4	1165	19.1
2	1.0	1 - WC	24.9	1209	20.6
3	1.0	2 - FP	23.2	1146	20.1
4	2.0	1 - WC	22.8	1114	20.5
5	2.0	2 - FP	24.1	1230	19.5
Mean			23.5	1173	20.0
Significance			NS	NS	NS
CV%			10.1	9.8	5.2

Yield response over time

Yield responses were not significant with time, however mean yield increased for all P treatment levels (Table 7)

Table 7. FFB yield trend from 2008 to 2010.

Treatment levels	P Rates Kg/ palm/year	Placement	2008 Yield (t/ha)	2009 Yield (t/ha)	2010 Yield (t/ha)
1	0.0	Control	18.5	23.5	25.2
2	1.0	1 - WC	22.1	25.6	26.9
3	1.0	2 - FP	18.5	23.9	27.2
4	2.0	1 - WC	20.0	23.3	25.0
5	2.0	2 - FP	19.1	24.7	28.4
Mean			19.6	24.2	26.6
Significance			ns	Ns	ns
CV%			16.8	19.9	10.1

Leaf tissue nutrient concentrations

The effects of P placement treatments on leaf tissue nutrient contents are presented in Tables 8 and 9. Leaflet and Rachis P contents were significantly increased in April 2010 ($p<0.001$) and in November 2010 as well, though not statistically significant. There appears to be no difference in P contents between 1 and 2 kg TSP and between the two zones.

The mean nutrient contents are at adequate levels. It is also interesting to note here that in November 2010, rachis K concentrations were low in the P fertilised plots.

Table 8. Tissue nutrient concentrations for leaflet N, P, K, Mg, B and rachis N, P, K - April 2010 (1st)

		2010 April							
Treat-	**P rates / placement**	**Leaf (%dm)**					**Rachis (%dm)**		
Levels	**(Kg/palm)**	**N**	**P**	**K**	**Mg**	**B**	**N**	**P**	**K**
1	0.0 – Nil (Control)	2.48	0.139	0.62	0.193	16.5	0.26	0.036	1.37
2	1.0 – Weeded Circle	2.50	0.146	0.61	0.186	16.2	0.26	0.046	1.28
3	1.0 – Frond Pile	2.48	0.143	0.63	0.190	15.8	0.29	0.052	1.28
4	2.0 – Weeded Circle	2.49	0.146	0.63	0.185	15.4	0.28	0.051	1.35
5	2.0 – Frond Pile	2.47	0.147	0.64	0.203	14.9	0.27	0.056	1.24
Mean		**2.49**	**0.144**	**0.62**	**0.192**	**15.8**	**0.27**	**0.048**	**1.30**
Significance		**NS**	**P<0.001**	**NS**	**NS**	**NS**	**NS**	**P<0.001**	**NS**
LSD0.05%		**-**	**0.004**	**-**	**-**	**-**	**-**	**0.03**	**-**
CV%		**2.3**	**2.3**	**4.5**	**9.2**	**7.3**	**5.5**	**7.3**	**9.5**

Table 9. Tissue nutrient concentrations for leaflet N, P, K, Mg, B and rachis N, P, K – November 2010 (2nd)

		2010-November							
Treat-	**P rates / placement**	**Leaf (%dm)**					**Rachis (%dm)**		
Levels	**(Kg/palm)**	**N**	**P**	**K**	**Mg**	**B**	**N**	**P**	**K**
1	0.0 – Nil (Control)	2.51	0.142	0.70	0.168	20.4	0.27	0.038	1.51
2	1.0 – Weeded Circle	2.52	0.144	0.68	0.167	22.2	0.27	0.045	1.24
3	1.0 – Frond Pile	2.52	0.146	0.71	0.177	20.5	0.28	0.052	1.33
4	2.0 – Weeded Circle	2.54	0.145	0.68	0.168	21.6	0.31	0.052	1.33
5	2.0 – Frond Pile	2.50	0.149	0.68	0.183	19.3	0.26	0.051	1.24
Mean		**2.52**	**0.145**	**0.69**	**0.173**	**20.9**	**0.28**	**0.048**	**1.33**
Significance		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV%		**2.4**	**2.9**	**5.4**	**9.5**	**14.5**	**10.5**	**22.0**	**11.1**

Fertiliser N effects on oil palm vegetative growth

Similar to the other parameters, there was no significant response on the vegetative growth of the palm to the P rates and fertiliser application zones (Table 10).

Frond production and frond number

On average 22 new fronds were produced in 2010 (one every 26 days) an increase of 8 fronds from 2009. Total green fronds counted per palm averaged 33 fronds which is low and indicating possible over pruning.

Frond and canopy size

The two assessments of canopy coverage, Frond area (based on leaflet length and width) and LAI (Leaf Area Index) as based on Frond area, frond number and palms per ha, were within expected values for 14 year old palms (average frond area $13m^2$ and LAI of 5.8).

Vegetative dry matter production

Regardless of the treatments, there was an increase in Dry matter production (FDM, BDM, TDM and VDM) in 2010. This is due to increase in palm age. Petiole cross section (PCS), which is a primary determinant of vegetative dry matter production, also increased in the same year.

Table 10. Effects of N treatments on vegetative growth parameters in 2010.

TSP(P)Levels	P rate / placement (kg/palm)	PCS	Radiation Interception				Dry Matter Production (t/ha)			
			GF	FP	FA	LAI	FDM	BDM	TDM	VDM
1	0.0 - Nil	42.0	33	21	13.8	5.8	12.5	13.4	28.8	15.3
2	1.0 - WC	43.4	33	22	13.6	5.7	13.1	14.0	30.3	16.1
3	1.0 - FP	42.2	33	23	13.5	5.8	13.3	14.2	30.6	16.4
4	2.0 - WC	44.6	34	22	13.9	6.0	13.6	13.3	29.9	16.5
5	2.0 - FP	43.7	33	22	13.8	5.8	13.4	14.9	31.5	16.2
	Mean	43.2	33	22	13.7	5.8	13.2	14.0	30.2	9.5
Significance:		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV%		**6.7**	**4.8**	**4.4**	**4.3**	**6.5**	**8.8**	**10.2**	**6.1**	**7.9**

PCS = Petiole cross-section of the rachis (cm^2); GF = number of green fronds (fronds per palm); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production (t/ha/yr); BDM = Bunch Dry Matter production (t/ha/yr); TDM = Total Dry Matter production (t/ha/yr); VDM = Vegetative Dry Matter production (t/ha/yr)

DISCUSSION

The treatments commenced in October 2008 and have not shown any significant response on yield, P was significant in leaflet/rachis tissue levels in April 2010 analysis results. There were no significant responses from the other nutrient concentration and the overall vegetative growth of the palms. Despite that, the yields have increased by 7 t/ha since 2008. This increase was caused by an increase in bunch numbers and single bunch weigh (kg/bunch) in 2009 and 2010. Application of N as basal since the inception of the trial has improved the N levels in the leaflets which had increased to optimum or adequate range. The rachis N levels are reasonably high (adequate) due to eventual translocation of N to the leaflets from the rachis, which had boosted the N concentration in the leaflets in 2010. P level in both the leaflets and the rachis was significant in April tissue analysis results and should provide a better response from the treatments in the future.

CONCLUSION

There was no response of TSP and placement on yield, its components and vegetative growth parameters except on leaflet and rachis P concentrations.

Trial 216: N x P x K trial at Barema, HOPL (RSPO 4.2, 4.3, 4.6, 8.1)

BACKGROUND

This trial was set out in March 2009 where unknown progenies of 2 year olds were growing in the field. 24 plots were marked out and the 16 would be core palms were removed in each plot and replaced with four known commercial progeny palms (Dami material: 0710226N; 0791065N; 0791195C and 0709668C). Planted randomly for each plot with TSP (100g/plm) applied to the bottom the planting hole. Guard row can be any progeny. Commence trial fertiliser application will be in March 2013 (year 4 after planting)

Table 1. Basic information on trial 216

Trial number	**216**	Company	Hargy Oil Palms Ltd
Estate	Barema	Block No.	Filed 14
Planting Density	135 palms/ha	Soil Type	Gravel old Barema river
Pattern	Triangular	Drainage	Freely draining
Date planted	2009	Topography	Flat
Age after planting	2 years	Altitude	20 m asl
Recording Started	Not yet	Previous Land-use	Forest
Progeny	Known*	Area under trial soil type (ha)	Not known
Planting material	Dami D x P	Agronomist in charge	Winston Eremu

4 different identified Dami DxP progenies planted randomly in each plot.

Trial design (Central Composite Design)
Fertiliser response curves will be developed for each of the nutrients supplied in the trial (response curves for N, P and K to (i) yield and (ii) economic return).

- Nutrients: N, P and K
- Start treatments at year 4 (mature); up to year 4 apply immature rates as a basal to all plots
- Treatments rates (to start in 2013, year 4 after planting):
  N as AC: Optimum rate 4; Lowest rate 1 and Highest rate 7 kg/palm
  K as MOP: Optimum rate 2.5; Lowest rate 0 and Highest rate 5 kg/palm
  P as TSP: Optimum rate 1; Lowest rate 0 and Highest rate 2 kg/palm

(i) Design criteria

Lf and Uf (rates of fertiliser as kg/palm)

	Lf (lower level fertiliser)	**Uf (upper level fertiliser)**
N (as AC)	1	7
K (as MOP)	0	5
P (as TSP)	0	2
	A (Optimum rate)	**B**
N (as AC)	4	1.84
K (as MOP)	2.5	1.53
P (as TSP)	1	0.61

Calculation of transformed level to actual level

Transformed level (X)	**Actual level (Z)**
-1.633	A – (1.633 x B)
-1	A - B
0	A
1	A + B
1.633	A + (1.633 x B)

Where: A = (Lf + Uf)/2 B = (Uf – Lf)/(2 x alpha) alpha = 1.633

Fertiliser rates as treatments:

	-1.633	**-1**	**0**	**1**	**1.633**
N (as AC)	1.0	2.2	4.0	5.8	7.0
K (as MOP)	0	1.0	2.5	4.0	5.0
P (as TSP)	0	0.4	1.0	1.6	2.0

(ii) Treatments

		LEVEL			RATE (kg/palm)		
Treatment		**N**	**K**	**P**	**AC**	**MOP**	**TSP**
1	factorial	-1	-1	1	2.2	1	1.6
2	factorial	1	-1	-1	5.8	1	0.4
3	factorial	-1	1	-1	2.2	4	0.4
4	factorial	1	1	1	5.8	4	1.6
5	factorial	-1	-1	-1	2.2	1	0.4
6	factorial	1	-1	1	5.8	1	1.6
7	factorial	-1	1	1	2.2	4	1.6
8	factorial	1	1	-1	5.8	4	0.4
9	starpoint	-1.633	0	0	1	2.5	1
10	starpoint	1.633	0	0	7	2.5	1
11	starpoint	0	-1.633	0	4	0	1
12	starpoint	0	1.633	0	4	5	1
13	starpoint	0	0	-1.633	4	2.5	0
14	starpoint	0	0	1.633	4	2.5	2
15	center	0	0	0	4	2.5	1
16	center	0	0	0	4	2.5	1
17	center	0	0	0	4	2.5	1
18	center	0	0	0	4	2.5	1
19	center	0	0	0	4	2.5	1
20	center	0	0	0	4	2.5	1
21	center	0	0	0	4	2.5	1
22	center	0	0	0	4	2.5	1
23	center	0	0	0	4	2.5	1
24	center	0	0	0	4	2.5	1

(iii) Block layout (including randomisation of treatments)

Block 1		Block 2		Block 3	
Treatment	**Plot no.**	**Treatment**	**Plot no.**	**Treatment**	**Plot no.**
4	1	22	9	12	17
15	2	7	10	9	18
18	3	20	11	23	19
1	4	5	12	14	20
3	5	21	13	10	21
17	6	6	14	13	22
2	7	8	15	24	23
16	8	19	16	11	24

Work done

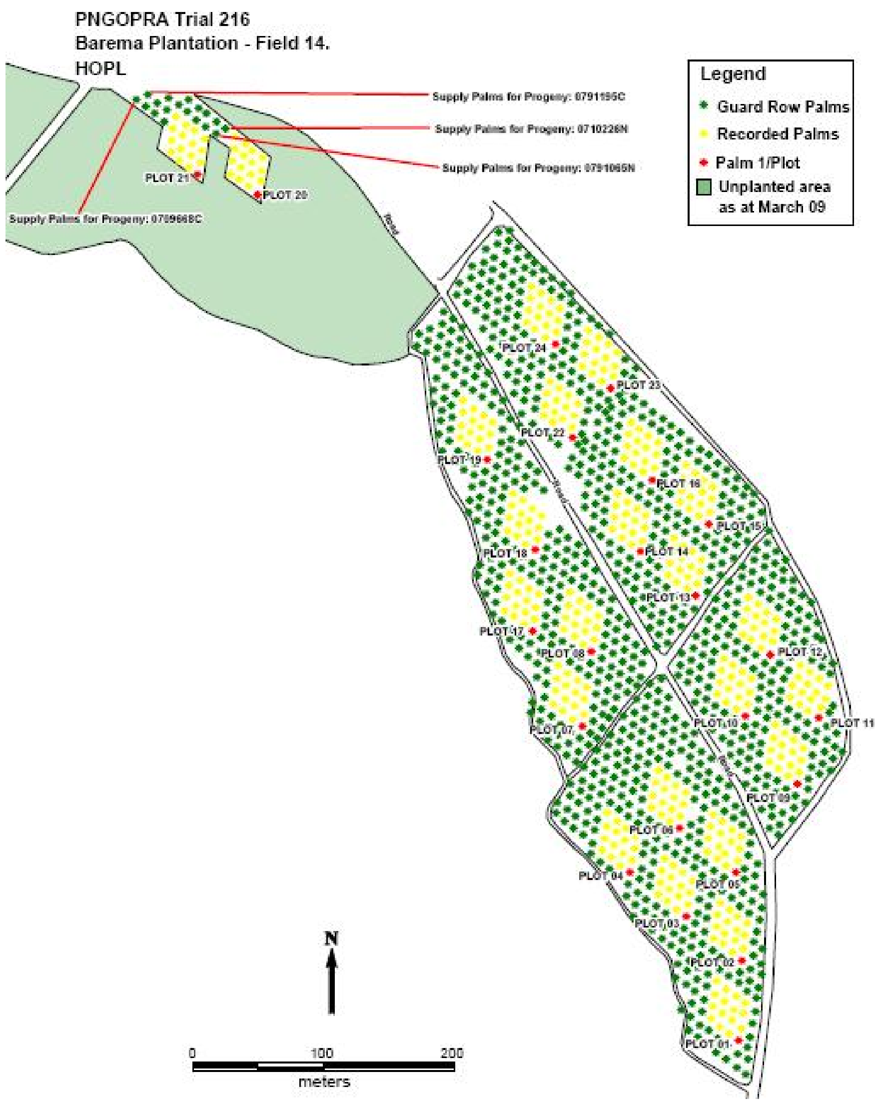
In 2009:

- 16 central palms planted with four identified progenies
- Guard rows, perimeters also planted
- GPS reference each 'supply' palm
- GPS reference every palm 1 in each plot for future plot/palm location
- Replaced dead core palms with the same spare progenies as supply palms planted near by after five months of initial planting.
- 1 x three monthly periodic checks to ensure that cover crops and weed are not over grown in the trial
- Palm census once a year.
- Ensure trial upkeep up to plantation standard

In 2010:

- Continue to liaise with plantation on upkeep and other trial maintenance work
- Palm census done at the end of the year
- Periodic checks to ensure that cover crops and weed are not over grown in the trial
- Monthly field visits and trial standard checks

Trial 216 map



Trial 217 (proposed): N x P x K trial, Navo (HOPL) (RSPO 4.2, 4.3, 4.6, 8.1)

The trial design will be the same as trial 216 at Barema and intended for setup at Navo. Four known progenies will be identified/selected (from the commercial Dami material) and planted randomly in each plot including the guard row palms from the same progeny. TSP (100g/plm) will be placed at the bottom of the hole. There will be 50 plots planted, after width and thickness (W x T) is done, the final 24 plots will be selected for proper treatments.

This trial is to develop robust fertiliser recommendations using nutrient response curves by applying N x P x K at three rates each. The same four progeny planted in each plot will remove progeny effect from the fertiliser response, using central Composite Design requiring 24 plots (see Verdooren in Oil Palm, Management for Large and Sustainable Yields, Fairhurst and Hardter, 2003). Each plot has 16 monitored palms with 20 guard palms.

The setup of the trial is currently on hold awaiting replant at the Navo estate in 2011/2012.

NEW BRITAIN PALM OIL LTD, WEST NEW BRITAIN

(Steven Nake)

Trial 139: Palm Spacing Trial, Kumbango (RSPO 4.2, 4.3, 8.1)

EXECUTIVE SUMMARY

A trial with varying avenue widths of 8.2, 9.5 and 10.6 m at a constant palm density of 128 palms/ha was planted in 1999. Yield monitoring commenced in 2003. There were no differences in yield between the 3 different spacings (avenue widths) in 2010. An average block yield of 25.0 t/ha was obtained in 2010, which represented a yield drop from 2009 of about 4.2 t/ha. Similarly, the vegetative growth of the palms, radiation interception and dry matter production did not respond to the spacing treatments.

BACKGROUND

The purposes of this trial is to investigate the opportunities for different field planting arrangements and how to make use of increased inter-row spacing to facilitate mechanised in-field collection of fresh fruit bunches (FFB). If there is no large yield penalty between the different spacing configurations then in a small holder context it may be possible to use the wider avenue widths for planting with either cash crops (e.g. vanilla) or a variety of food crops. Mechanical removal of FFB from the field after harvest is now a common practice in some plantations. This is intended to reduce harvesting labour cost and speed up the operation of getting freshly harvested fruit to the mill. Little is known about the impact of machine traffic on compaction and associated physical properties of volcanic soils. Background information for the trial is shown in Table 1.

Table 1. Background information on trial 139.

Trial number	**139**	Company	NBPOL
Estate	Kumbango	Block No.	Division 1, Field B
Planting Density	128 palms/ha	Soil Type	Volcanic
Pattern	Triangular (see treatments).	Drainage	Good
Date planted	1999	Topography	Flat
Age after planting	9	Altitude	? m asl
Recording Started	Jan 2003	Previous Landuse	Oil Palm
Planting material	Dami D x P	Area under trial soil type (ha)	Not known
Progeny	unknown	Agronomist in charge	Steven Nake

Basal fertilisers applied in 2010: AN 2.0 kg/palm, TSP 0.5kg/palm, MOP 2kg/palm and Boron 0.15kg/palm.

MATERIALS AND METHODS

The field layout comprises three replicates for each of the three spacing arrangements (treatments), giving a total of nine plots, each 10.6 ha in area. The planting density remains constant at 128 palms per hectare. The three spacing treatments are shown in Table 2. Leaf sampling, frond marking and vegetative measurements are being done in every 5th palm per recorded row per plot.

Table 2. Spacing treatments in Trial 139.

Treatment	Spacing (m)	Density (palms/ha)	Avenue width (m)	Inter-row width (m)
1	9.5 x 9.5 x 9.5 (standard)	128	8.2	8.2
2	9.0 x 9.0 x 9.0	128	9.5	7.8
3	8.6 x 8.6 x 8.6	128	10.6	7.5

Data Collection

There are 12 rows of palms in one treatment or plot. Each single recorded row for each plot/treatment is guarded by two guard rows on both sides. Loose fruits are also collected and weighed with their respective bunches. Bunches from the guard row palms are not weighed. The data is recorded onto the yield record sheets in the field and later on entered onto the computer database using Microsoft Access and are later converted into yield expressed in tonnes per hectare, total number of bunches harvested per hectare and the single bunch weight. Yield recording is done every fortnight (14 day round) on all palms in the plots/treatment.

Tissue samples, leaflet and rachis, were taken from Frond 17 following standard procedures and analysed by AAR in Malaysia for nutrient concentration. Vegetative measurements were taken at the same time as tissue sampling to calculate vegetative growth parameters. Frond production counts and total frond number were assessed twice annually (6 monthly). Height measurements are also done every year to determine the height incremental growth. Leaf samples, vegetative measurements and frond production counts were done on every 5th palm in the 12 rows.

Trial maintenance and upkeep

The three trial blocks (3 reps) are maintained regularly by Kumbango Division 2 plantation. This covers pruning, weed control (either herbicide spraying or slashing), wheelbarrow path clearance, cover crop maintenance and other routine plantation practices. Fertilisers (MOP, Kie, TSP and Borate) not used as treatments but normally applied by the plantations are also applied by the plantations.

RESULTS

Spacing treatment effect on yield in 2010

Similar to 2009, the spacing treatment in 2010 had no significant effect on the yield, bunch number and the single bunch weight (Table 3). The Wide and Intermediate avenue spacing were slightly lower in yield, bunch number and single bunch weight compared to the Standard spacing (but not significantly different).

Table 3. Impact on yield, bunch number and single bunch weight from three row spacing treatments in 2010

Avenue width	**Yield t/ha**	**Bunch number per hectare**	**Single bunch weight**
Standard	25.5 (30.0)	1114 (1301)	23.9 (23.0)
Intermediate	25.1 (29.0)	1075 (1276)	23.4 (22.7)
Wide	24.5 (28.5)	1067 (1269)	22.9 (22.5)
Significant difference	**NS**	**NS**	**NS**
LSD	-	-	-
CV%	**4.8**	**4.9**	**1.4**

(…) *2009 data.*

The effect of the different avenue widths on yield (2003-2010)

Irrespective of the different avenue widths, the FFB yields increased from 16.0 t/ha in 2003 to 32 t/ha in 2007, decreased in 2008 to below 25 t/ha and increased again the following year (2009) to over 28 t/ha in 2009. In 2010, the trial experienced another drop in FFB yields by 3 t/ha. The yield loss in 2010 was caused by a fall in the number of bunches the same year (Figures 1 and 2). Despite the fall in the number of bunches (and yield), the single bunch weight increased consistently to 23 kg/bunch in 2010; an increase by 0.3 kg (Figures 1 and 2).

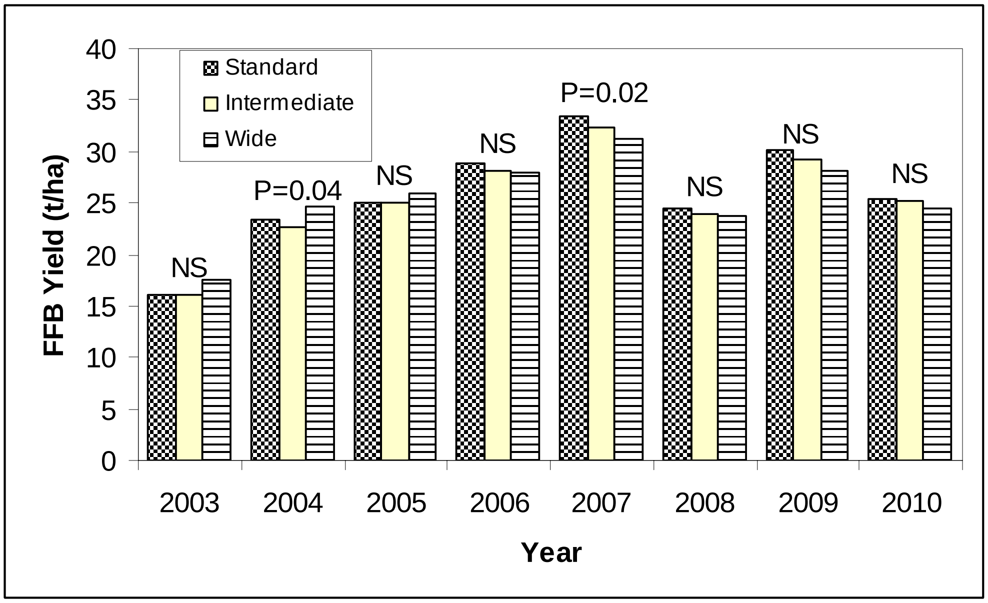


Figure 1. The impact of avenue width on yield (keeping planting density the same), 2003-2010.

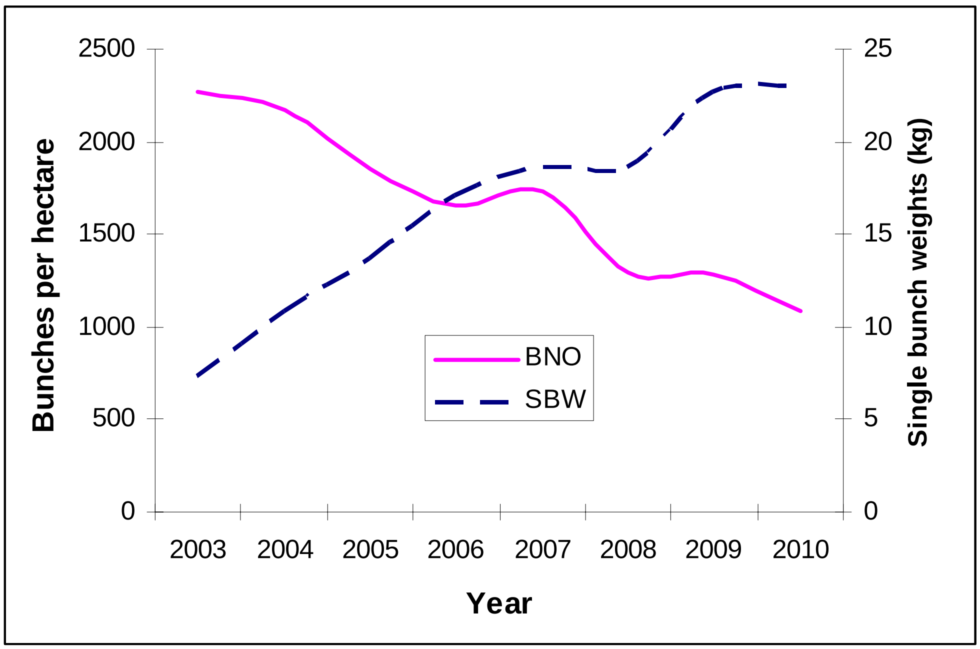


Figure 2. Mean bunch number per hectare (BHA) and SBW (kg/bunch) over the trial duration.

Spacing treatment effect on tissue nutrient levels

Unlike the 2009 results, there were significant differences in both leaflet and rachis P levels and not the other nutrients (N, K, Mg, B) (Table 4). Leaflet P was higher in palms in the standard avenue width than the palms in the intermediate and wide avenue widths, whereas in the rachis, the P level in palms in the wide avenue width was higher than the palms in the intermediate and standard avenue widths. Leaflet N increased from an average of 2.42 % dm in 2009 to 2.50 % dm in 2010. In contrast, rachis N declined from last year (0.40 to 0.30 % dm). Leaflet N, P, K and B were adequate, while leaflet Mg level was slightly below the adequate level. Leaflet B levels were low (<0.15 ppm). Rachis K is well over the adequate level, while N and P levels are slightly below adequacy.

Table 4. Leaflet and rachis nutrient status for three different Avenue widths in 2010

Avenue Width	Leaflet nutrient concentration (% dm)					Rachis nutrient concentration (% dm)		
	N	**P**	**K**	**Mg**	**B (ppm)**	**N**	**P**	**K**
Standard	2.51	**0.150**	0.68	0.19	13.5	0.29	**0.07**	1.36
Intermediate	2.46	**0.146**	0.67	0.19	13.1	0.30	**0.07**	1.53
Wide	2.53	**0.148**	0.69	0.18	13.3	0.31	**0.08**	1.49
Significance:	NS	**P=0.003**	NS	NS	NS	NS	**P=0.013**	NS
CV %	1.8	1.5	3.7	7.2	7.6	6.0	3.8	5.6

Spacing treatment effects on vegetative growth parameters

The spacing treatments had no significant effect on all the vegetative growth parameters in 2010 (Table 5).

Frond production and frond number

The number of new fronds produced dropped from 25 in 2009 to 24 in 2010 (one every 15 days) – this is normal for this age palm. Total green fronds counted per palm averaged 39 fronds which is an adequate number. The number of green fronds is expected to decline as palms mature.

Frond and canopy size

Frond area (based on frond length, leaflet number, leaflet length and width) and LAI (Leaf Area Index calculated from Frond area, frond number and palms per ha) are two assessments for canopy coverage. Frond area in 2010 remained around 13 m^2 while the LAI dropped slightly to 6.6.

Vegetative dry matter production

Petiole cross section (PCS) is a primary determinant of vegetative dry matter production. PCS continued to increase in 2010 to an average of 49 cm^2. The other measures of foliar vegetative dry matter production (FDM (frond dry matter production), TDM (total dry matter production) and VDM (vegetative dry matter production) have increased from 2009 and the increments were not related to the spacing treatments (Table 5).

Table 5. Effects of the different Avenue widths on vegetative growth in 2010

	HI	PCS	Radiation interception				Dry matter production (t/ha)			
	(cm)	(cm^2)	FA	GF	FP	LAI	FDM	BDM	TDM	VDM
Means	97.5	48.9	13.3	39.1	24.1	6.6	16.0	14.6	34.1	19.4
Significance	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
lsd	-	-	-	-	-	-	-	-	-	-
CV%	32	2.1	3.7	1.6	1.3	3.6	2.0	4.0	1.0	1.5

HI = Height increment; PCS = Petiole cross-section of the rachis (cm^2); HI = Height Increment (m); GF = number of green fronds (fronds per palm);FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production (t/ha/yr); BDM = Bunch Dry Matter production (t/ha/yr); TDM = Total Dry Matter production (t/ha/yr); VDM = Vegetative Dry Matter production (t/ha/yr); BI = Bunch Index

DISCUSSION

The yield and tissue nutrient concentrations (except leaflet and rachis P) have not shown any significant response to the different spacing treatments for the last 3 years (2008 – 2010) and could be related to the non significant response also obtained from frond/leaf parameters which in turn affects the palm growth and dry matter production. From field observation, the canopy cover was more or less the same between the different spacing treatments (avenue width) since the palm canopy closed up several years ago, hence the insignificant difference in the amount of radiation interception by the palms at the different spacing treatments. Radiation interception is important for the process of photosynthesis which produces carbohydrate ($C_6H_{12}O_6$), which is used by the palms for vegetative growth and production of flowers and subsequent yields (bunches). Thus, the obvious reason why yields have not differed between treatments is because the amount of light intercepted from the sun was more or less the same due to similar FA, LAI and the number of green fronds on the palms.

CONCLUSION
All parameters (yield, tissue nutrient concentration and vegetative) did not respond to the spacing treatments in 2010, except very little response in the levels of P in both the leaflets and rachis. The only possible reason for this (i.e. no significant response) is that the palms have reached maturity and the canopy have fully closed regardless of the spacing (with different avenue widths) treatments. The FFB yields in the trial block declined from an average of 29.1 t/ha in 2009 to 25.0 t/ha in 2010 (4 t/ha difference). In comparison, the levels of N, P and K levels in the leaf tissues increased in 2010. Leaf parameters that influence the radiation interception in 2010 either declined or did not change whereas the dry matter production, height increment and PCS increased from 2009.

NBPOL, KULA GROUP, MILNE BAY ESTATES
(Murom Banabas and Wawada Kanama)

Trial 502 and 511 Nitrogen, Phosphorus, Potassium and EFB trials at Milne Bay Estates (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY
Two trials, 502 and 511, with the same treatments, were established in 1994/95 at Waigani Estate in Milne Bay. The soil type on which the trials are located are different – 502 is relatively flat and soils are alluvial in origin with a high clay content (50 to 60% clay); whilst 511 has a terraced appearance, soils contain buckshot, are also alluvial in origin but have less clay (around 30%) and a higher sand content (50 to 60%). Both trials were set up to test responses to N, P, K fertilisers in a factorial combination, with and without EFB. EFB was included to test whether it can be used to replace or supplement inorganic fertiliser. Treatments consisted of four rates of SOA (0, 2.0, 4.0 and 6.0 kg/palm), 4 rates of MOP (0, 2.5, 5.0 and 7.5 kg/palm), two rates of TSP (0 and 2.0 kg/palm) and two rates of EFB (0 and 0.3 t/palm). Yield recording and tissue analysis continued in Trial 502 and in 14 plots in Trial 511 while the fields await replant.

In Trial 502, the following responses were observed in 2010:

- There were significant yield responses to SOA, TSP, MOP and EFB.
- Only TSP and MOP affected P and K contents in the leaf tissues

In Trial 511, the following were responses observed in 2010:

- After three years of experiment in Trial 511, although small, there has been a significant response in yield and tissue nutrient concentrations in both low and high yielding plots.
- Average yield in low yielding plots changed significantly from 12.2 t/ha in 2007 to 25.7t/ha in 2009 and 18 t/ha in 2010.
- In the high fertilised plots, yield fell from 19.0 t/ha in 2007 to 12.5 t/ha in 2010, a drop in yield of 6.5 t/ha.
- Leaf N, P and K significantly increased in low fertilised plots after fertilisers were added.
- Monitoring will continue in Trial 511 until replant

BACKGROUND
Trial 502 and 511 were set up in 1994 to investigate the response to N, P and K fertilisers plus or minus EFB (Table 1).

Table 1. Trial 502 and 511 background information

Trial number	**502**		
Estate	Waigani	Company	CTP Milne Bay Estates
Planting Density	127 palms/ha	Block No.	Field 6503, 6504
Pattern	Triangular	Soil Type	recent alluvial origin
Date planted	1986	Drainage	Poor
Age after planting	22 years	Topography	Flat
Recording Started	1995	Altitude	103 m asl
Progeny	Unknown	Previous Landuse	Cocoa/coconut plantings
Planting material	Dami D x P	Area under trial soil type (ha)	1067
Trial number	**511**		
Estate	Waigani	Block No.	Field 8501, 8502
Planting Density	127 palms/ha	Soil Type	Alluvial, interfluvial deposits
Pattern	Triangular	Drainage	Moderate
Date planted	1988	Topography	Hilly
Age after planting	20 years	Altitude	157 m asl
Recording Started	1994	Previous Landuse	Coconut plantation
Progeny	Unknown	Area under trial soil type (ha)	3165
Planting material	Dami D x P	Supervisor in charge	Wawada Kanama

**Data should be synchronous with OMP.*

MATERIALS AND METHODS

Trials 502 and 511 are factorial fertiliser trials with 4 levels of ammonium sulphate (SOA), 4 levels of potassium chloride (MOP), 2 levels of triple superphosphate (TSP) and 2 levels of EFB (Table 2). Each treatment has a single plot (4 x 4 x 2 x 2 = 64 plots); the trial site has four replicate blocks within which the main effects of N and K are represented. Each plot contains 16 core palms, which are surrounded by a guard row and a trench. Trial fertilisers were first applied in late 1994 and EFB was first applied in 1995. EFB is applied by hand as mulch between palm circles once per year. Other fertilisers are applied in 3 doses per year. General ANOVA was used to analyse the effects of different treatments on yield and tissue nutrient concentrations in both trials.

Table 2. Amount of fertiliser and EFB used in Trials 502 and 511.

	Amounts (kg/palm/year)			
	Level 0	Level 1	Level 2	Level 3
SOA	0.0	2.0	4.0	6.0
MOP	0.0	2.5	5.0	7.5
TSP	0.0	2.0	-	-
EFB	0.0	300	-	-

The treatments in both trials ceased in 2007. In Trial 502 yield recording is still being done while leaf samples are taken for tissue nutrient analysis. Trial site 511 was planned for replanting in late 2008 (now planned for 2011 or may be further delayed). It was proposed that while the trials are awaiting replant, it is worthwhile to consider whether there can be other benefits gained from the trials. In late 2007 it was decided to change fertiliser application to plots which had received the same fertiliser regime for over 14 years. The aim of the experiment was to determine what would happen when:

- low input plots receive high doses of fertiliser (i.e. how long does it take for poor palms to recover and start producing high yields)
- high input plots receive reduced doses of fertiliser (i.e. how long does it take for healthy palms to start running down).

Fourteen currently monitored plots out of the 64 plots were selected. The 14 plots represent the highest yielding treatments (plots 12, 18, 26, 44, 51 and 56) and the lowest yielding treatments (plots 2, 4, 24, 32, 35, 43, 55, 61). Thus in 2008 and through 2009 and 2010, a new plan was followed (Table 3).

Table 3. New fertiliser treatments in Trial 511

		Current fertiliser applied (kg/palm)			Proposed fertiliser 2008 (kg/palm)		
Plot	**YLD 04 to 06**	**SOA**	**MOP**	**TSP**	**SOA**	**MOP**	**TSP**
32	7.0	0	0	0	6	7.5	2
61	11.3	0	0	2	6	7.5	2
4	9.1	0	2.5	0	6	0	2
43	10.7	0	2.5	2	6	7.5	2
35	7.2	0	5	0	6	0	2
2	13.7	0	5	2	6	7.5	2
55	9.2	0	7.5	0	6	0	2
24	9.7	0	7.5	2	6	7.5	2
12	21.5	6	7.5	0	0	0	0
44	27.6	6	7.5	2	6	0	0
18	18.7	6	5	0	0	0	0
56	26.2	6	5	2	6	0	0
51	21.8	6	2.5	0	0	0	0
26	30.9	6	2.5	2	6	0	0

The lowest yielding plots were fertilised with highest fertiliser rates (6.0 kg SOA/palm) and 0 and 7.5 kg MOP (EFB excluded) and were monitored to see how long it would take for the palms to respond in (i) tissue nutrient content, (ii) female flowers and (iii) possibly yield (if enough time before felling). Also, the highest yielding treatment plots (excluding EFB) were stopped from being fertilised with SOA, MOP and TSP to see how long it would take for the palms to (i) rundown the K and P reserves and (ii) suffer in N deficiency. Some plots in the high yielding treatment plots continued to receive 6.0 kg SOA to see the effect of N on how fast K and P become deficient. Harvesting is done at normal 10 day harvest rounds, and trial maintenance inspections are carried out at the end of every month to ensure that the trial is maintained at good field standard.

DATA COLLECTION AND ANALYSIS

Leaf tissue samples (leaflets and rachis) are collected from frond 17 annually, oven dried, grinded and sent to AAR in Malaysia for analysis. Yield and its components, tissue nutrient concentrations and vegetative parameters are analysed using General Analysis of Variance.

RESULTS AND DISCUSSION (PART 1. TRIAL 502)

The effects of fertiliser treatments on FFB yield its components are presented in Tables 4 and 5. SOA, MOP and EFB significantly increased FFB yield and SBW in 2010 and 2008-2010. TSP affected BN and FFB yield in 2010 but not in 2008-2010. MOP and EFB had a significant interaction on SBW and FFB yield in 2010 and 2008-2010. MOP increased SBW (not presented) and FFB yields, however the weights were further increased in the presence of EFB (Table 6). The significant effects on FFB yield reported annually since 1998 continued in 2010. Yield response to TSP is seen in 2010. Mean FFB yield has increased from 20 t/ha in 2009 to 24 t/ha in 2010.

Table 4. Effect (p values) of treatments on FFB yield and its components for 2010 and 2008 to 2010

	2010			2008 to 2010		
Source	**Yield**	**BN**	**SBW**	**Yield**	**BN**	**SBW**
SOA	**0.019**	0.787	**<0.001**	**0.015**	0.454	**<0.001**
TSP	**0.006**	**0.004**	0.654	0.179	0.155	0.830
MOP	**<0.001**	0.052	**<0.001**	**0.006**	0.222	**<0.001**
EFB	**<0.001**	**0.020**	**<0.001**	**<0.001**	0.171	**<0.001**
SOA.TSP	0.797	0.730	0.879	0.157	0.225	0.773
SOA.MOP	0.102	0.357	**0**.207	0.634	0.865	0.062
TSP.MOP	0.073	**0.031**	0.934	0.107	0.334	**0.011**
SOA.EFB	**0.035**	0.406	**0.044**	0.282	0.338	0.415
TSP.EFB	0.405	0.744	0.325	0.836	0.955	0.598
MOP.EFB	**<0.001**	0.090	**<0.001**	**<0.001**	0.053	**<0.001**

3 years averaged data. P values less than 0.05 are presented in bold.

Table 5. Main effects of treatments on FFB yield (t/ha) and its components for 2010 and 2008 to 2010

	2010			2008 to 2010		
	Yield (t/ha)	**BN (bunches/ha)**	**SBW (kg)**	**Yield (t/ha)**	**BN (bunches/ha)**	**SBW (kg)**
SOA 0	**22.7**	850	**26.6**	**20.6**	796	**25.9**
SOA 1	**23.3**	819	**28.3**	**21.1**	747	**28.2**
SOA 2	**25.5**	844	**30.2**	**23.4**	783	**29.9**
SOA 3	**25.6**	856	**29.6**	**23.0**	780	**29.2**
$lsd_{0.05}$	2.21		1.21	1.93		0.99
TSP 0	**23.1**	**800**	28.8	21.6	760	28.2
TSP 1	**25.4**	**884**	28.6	22.5	793	28.3
$lsd_{0.05}$	1.56	56.2				
MOP 0	**21.5**	790	**26.9**	**20.1**	749	**26.5**
MOP 1	**24.6**	855	**28.7**	**22.5**	788	**28.4**
MOP 2	**24.4**	824	**29.6**	**22.0**	759	**29.0**
MOP 3	**26.6**	900	**29.7**	**23.6**	810	**29.2**
$lsd_{0.05}$	2.21		1.21	1.93		0.99
EFB 0	**22.5**	**809**	**27.7**	**20.8**	761	**27.1**
EFB 1	**26.0**	**876**	**29.8**	**23.3**	792	**29.4**
$lsd_{0.05}$	1.56	56.2	0.85	1.36		0.70
GM	24.3	842	28.7	22.0	776	28.3
SE	3.07	110.5	1.68	2.68	89.3	1.38
C.V.%	12.6	13.1	5.8	12.2	11.5	4.9

3 years averaged data. P values less than 0.05 are presented in bold.

Table 6. Effect of MOP and EFB on FFB yield (t/ha) in 2008 to 2010 (three year average data).

MOP by EFB 2008 to 2010		
	EFB 0	EFB 1
MOP 0	16.4	23.7
MOP 1	21.3	23.6
MOP 2	21.1	22.9
MOP 3	24.2	23.0
P<0.001 Sed = 1.34, d.f =33		

Leaf tissue nutrient concentrations

The effects of fertilisers on leaf tissue nutrient contents are presented in Tables 7 and 8. Fertiliser applications ceased in 2007, however their affects on leaf tissue nutrient concentrations are still noticed in 2010. SOA did not have any affect on the nutrient content except on rachis P content. The leaflet N content increased with SOA rates but was not statistically significant. TSP continued to increase leaflet and rachis P concentrations. MOP significantly affected leaflet K, Mg, Ca and B, and rachis Ash and K concentrations. EFB also continued to affect leaflet Ash, K and Ca, and rachis Ash and K contents. The residual contents of TSP, MOP and EFB continued to affect the leaf tissue nutrient contents 2-3 years after fertilising was stopped.

There were significant interactions between MOP and EFB on the cation concentrations in the tissues. The results indicated that:

- MOP increased leaflet and rachis K concentrations however the increases were further enhanced in the presence of EFB, a similar effect was report for ffb yields in 2008-2010.
- MOP decreased the leaflet Mg and Ca contents however the contents were decreased further in the presence of EFB.

Table 7. Trial 502, effects (p values) of treatments on frond 17 nutrient concentrations in 2010**.**

	Leaflet nutrient contents (% DM)									Rachis nutrient contents (% DM)			
Source	**Ash**	**N**	**P**	**K**	**Mg**	**Ca**	**Cl**	**B (ppm)**		**Ash**	**N**	**P**	**K**
SOA	0.063	0.054	0.077	0.726	0.448	0.706	0.688	0.739		0.533	0.060	**<0.001**	0.291
TSP	0.211	0.070	**<0.001**	0.185	0.974	**0.013**	0.380	0.051		0.973	0.229	**<0.001**	0.266
MOP	0.182	0.762	0.289	**0.019**	**0.012**	0.309	0.850	**0.006**		**<0.001**	0.321	0.110	**<0.001**
EFB	0.143	0.076	0.282	**0.031**	0.088	**0.029**	0.230	0.075		**0.015**	0.109	0.447	**<0.001**
SOA.TSP	0.413	0.089	0.807	0.803	0.957	0.684	0.321	0.420		0.150	0.861	0.393	0.073
SOA.MOP	0.500	0.057	0.479	0.500	0.075	0.332	0.135	0.037		0.564	0.721	0.192	0.325
TSP.MOP	0.069	0.117	0.426	0.978	0.979	0.785	0.229	0.866		0.739	0.700	0.198	0.525
SOA.EFB	0.533	**0.011**	0.181	0.786	0.599	0.789	0.370	0.368		0.559	0.115	0.537	0.257
TSP.EFB	0.897	0.165	0.342	0.447	0.386	0.314	0.298	0.326		0.774	0.338	0.934	0.906
MOP.EFB	0.763	0.151	0.840	0.500	0.174	0.831	0.488	0.234		0.028	0.964	0.142	**<0.001**

p values less than 0.05 are indicated in bold.

Table 8. Trial 502, main effects of treatments on frond 17 nutrient concentrations in 2010, in units of dry matter %.

	Leaflet nutrient concentrations (% DM)									Rachis nutrient concentrations (%DM)			
	Ash	**N**	**P**	**K**	**Mg**	**Ca**	**Cl**	**B (ppm)**		**Ash**	**N**	**P**	**K**
SOA 0	13.4	2.29	0.142	0.58	0.39	0.87	0.53	17		5.1	0.32	**0.218**	1.33
SOA 1	13.8	2.28	0.142	0.55	0.40	0.88	0.54	17		4.9	0.33	**0.180**	1.24
SOA 2	13.7	2.31	0.140	0.57	0.39	0.86	0.54	17		4.9	0.33	**0.145**	1.32
SOA 3	14.4	2.34	0.144	0.56	0.36	0.85	0.53	17		4.8	0.35	**0.149**	1.20
$LSD_{0.05}$												*0.0228*	
TSP 0	13.7	2.29	**0.140**	0.58	0.38	**0.84**	0.53	17		4.9	0.33	**0.138**	1.30
TSP 1	14.0	2.32	**0.145**	0.55	0.38	**0.88**	0.54	18		4.9	0.34	**0.208**	1.24
$LSD_{0.05}$			*0.019*			*0.032*						*0.016*	
MOP 0	14.3	2.30	0.142	**0.51**	**0.44**	0.88	0.53	**19**		**4.4**	0.32	0.164	**0.90**
MOP 1	13.7	2.30	0.142	**0.56**	**0.37**	0.87	0.53	**17**		**4.9**	0.34	0.176	**1.28**
MOP 2	13.9	2.29	0.140	**0.59**	**0.37**	0.85	0.54	**17**		**5.2**	0.34	0.164	**1.40**
MOP 3	13.5	2.32	0.143	**0.60**	**0.36**	0.85	0.54	**16**		**5.3**	0.33	0.189	**1.51**
$LSD_{0.05}$				*0.058*	*0.055*			*1.387*		*0.317*			*0.158*
EFB 0	14.0	2.29	0.141	0.54	0.40	0.88	0.54	18		**4.8**	0.34	0.170	**1.14**
EFB 1	13.7	2.32	0.143	0.59	0.37	0.84	0.53	17		**5.1**	0.33	0.176	**1.41**
$LSD_{0.05}$										*0.224*			*0.112*
GM	13.8	2.30	0.142	0.56	0.38	0.86	0.53	17		4.9	0.33	0.173	1.27
SE	0.976	0.061	0.004	0.081	0.077	0.063	0.045	1.929		0.441	0.0295	0.032	0.220
C.V.%	7.0	2.6	2.7	14.4	19.9	7.4	8.4	11.2		8.9	8.8	18.3	17.3

P values less than 0.05 are indicated in bold.

CONCLUSION

SOA, TSP, MOP and EFB affected yield in 2010. Higher yields were obtained in the presence of SOA and MOP for 2008-2010. Effects of MOP on cation contents in the leaf tissues were enhanced with the addition of EFB.

RESULTS AND DISCUSSIONS (PART 2 – TRIAL 511)
The terms in Table 9 are defined for data interpretation.

Table 9. Trial 511 defined terms for data interpretation

Treatment	Fertiliser applied (kg/palm/year)						To determine;
	1994-2007			2008-2010			
	SOA	TSP	MOP	SOA	TSP	MOP	
T1	0.0	2.0	2.5, 5.0, 7.5	6.0	2.0	7.5	Response to N (SOA)
T2	0.0	0.0	2.5, 5.0, 7.5	6.0	2.0	0.0	K depletion
T3	6.0	0.0	5.0, 7.5	0.0	0.0	0.0	N and K depletion
T4	6.0	2.0	2.5, 5.0, 7.5	6.0	0.0	0.0	P and K depletion
T5	0.0	0.0	0.0	6.0	2.0	7.5	Response to N, P&K

The results from the 14 selected plots were analysed and were used to answer the following questions:

Question 1. What happens if N and K applications are stopped?
After fertiliser treatments were stopped in 2007, FFB yield in T3 plots continued to fall to 14.7 t/ha in 2008 by 5 t/ha from 2007 and to 12.5 t/ha in 2010 (Figure 1). On the other hand in T5 plots, after N, P and K fertilisers were applied in 2008, FFB yield responded immediately to 12 t/ha in 2008 and to 26 t/ha in 2009 however fell to 18.6 t/ha in 2010.

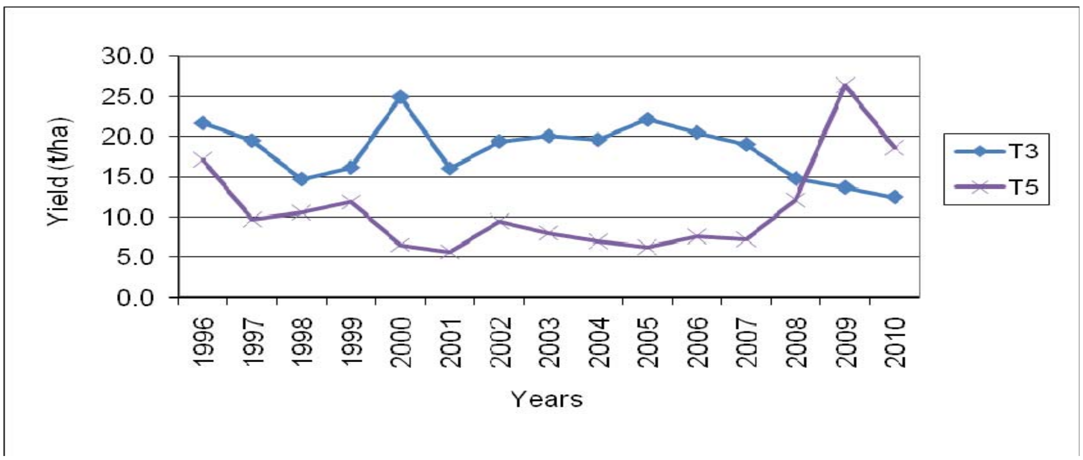


Figure 1. Yield trend in T3 and T5 plots from 1996 to 2009. Fertiliser treatments changed in 2008.

With the leaflet nutrient contents, after N and K fertilisers were stopped in 2008 in T3 plots, the leaflet N contents continued to remain above 2.3 % except for August 2008, which suggests N contents in the soil and the palms are still sufficient to sustain growth. However, in T5 plots, leaflet N contents increased immediately to 2.45% in 2008 and remained high throughout the sampling months. Similar trend was seen with leaflet P, leaflet K and rachis K contents in T5 plots (Figures 2, 3, 4 and 5).

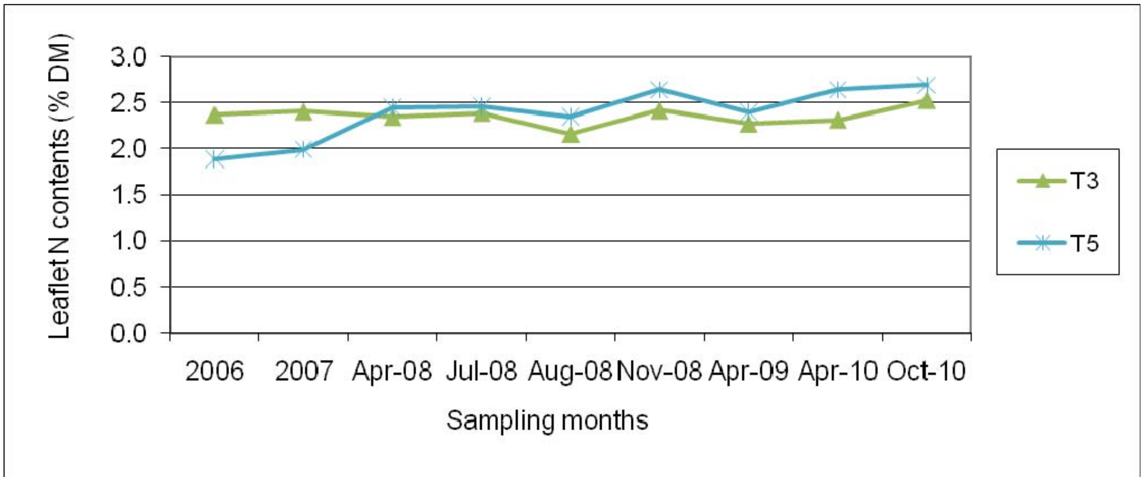


Figure 2. Leaflet N concentrations (% DM) in T3 and T5 plots.

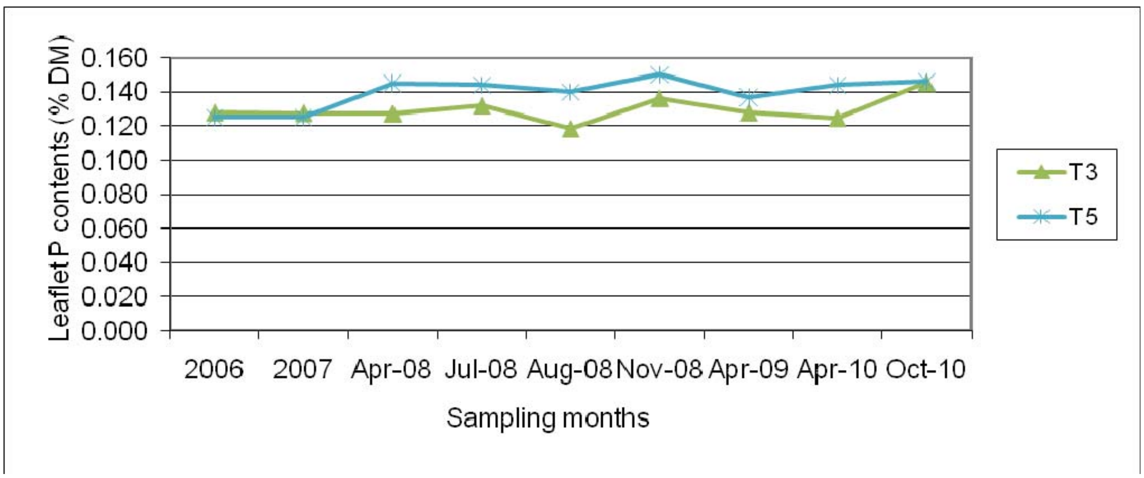


Figure 3. Leaflet P concentrations in T3 and T5 plots

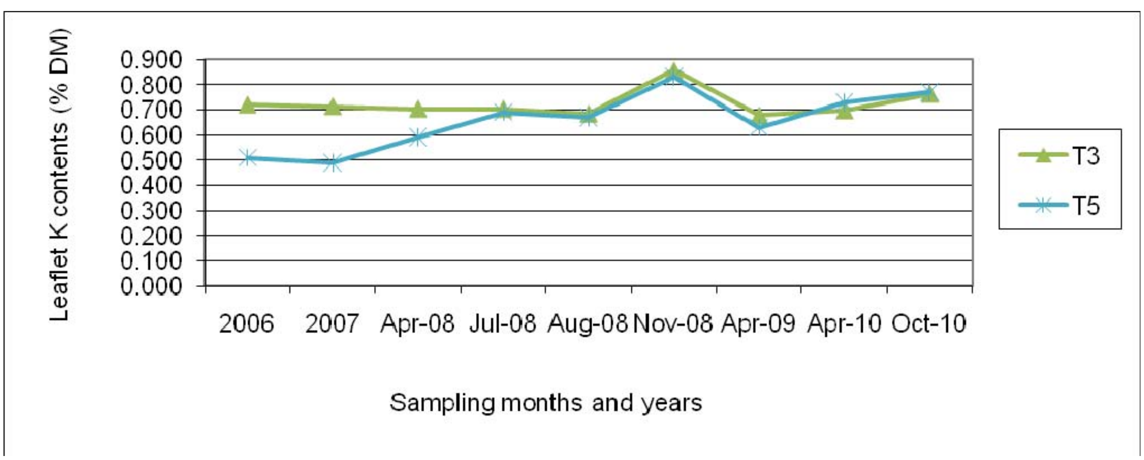


Figure 4. Leaflet K concentrations in T3 and T5 plots.

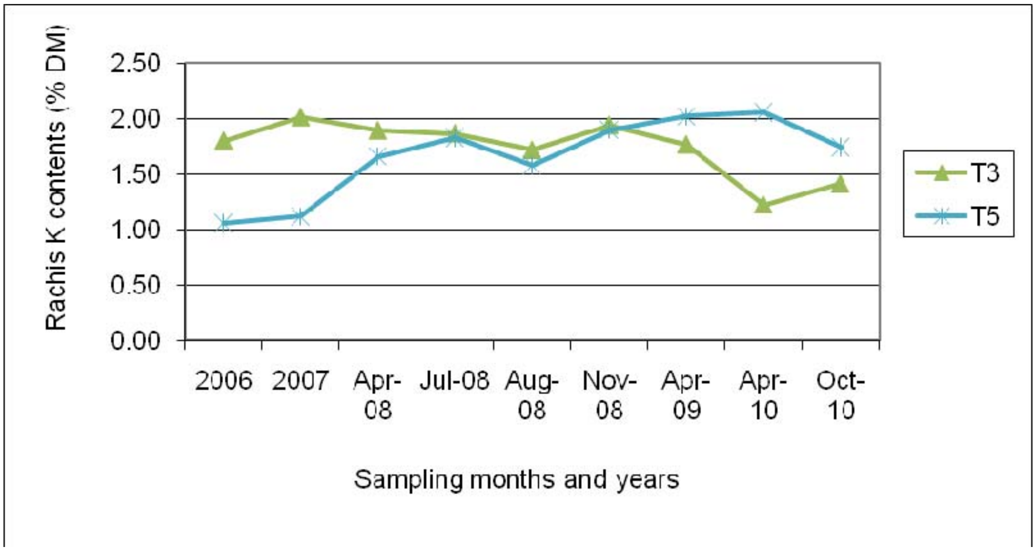


Figure 5. Rachis K concentrations in T3 and T5 plots.

Question 2. What happens if P and K fertilisers are stopped however N fertiliser is maintained?
FFB yield in T4 plots decreased in 2008 however increased to just above 25 t/ha in 2009 and continued to increase in 2010 (Figure 6). The fall in 2008 can not be fully explained by nil P and K fertiliser application in 2008 because there was a general fall in crop across all trials and plantations during 2008. In T3 plots where N was also stopped, yield continued to fall in 2010.

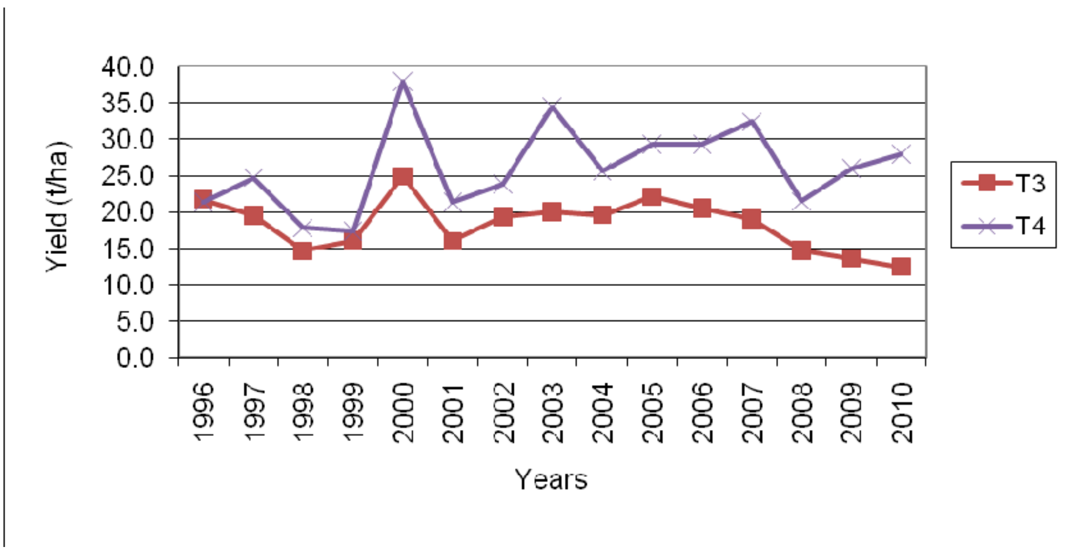


Figure 6. Yield trend in T3 and T4 plots from 1996 to 2010. Fertiliser treatments changed in 2008

In T2 plots, K was always applied but after N and P were added and K stopped, leaflet K contents improved from 0.60 % DM in 2007 to 0.80% in 2008 and 2009 (Figure 7). Addition of N and P fertilisers appeared to have improved the uptake and utilisation of K reserves in the soil and rachis. In T4 plots, there is no indication of K falling after being stopped in 2007 implying sufficient reserves in the soil and or in the palm to meet the palm requirements.

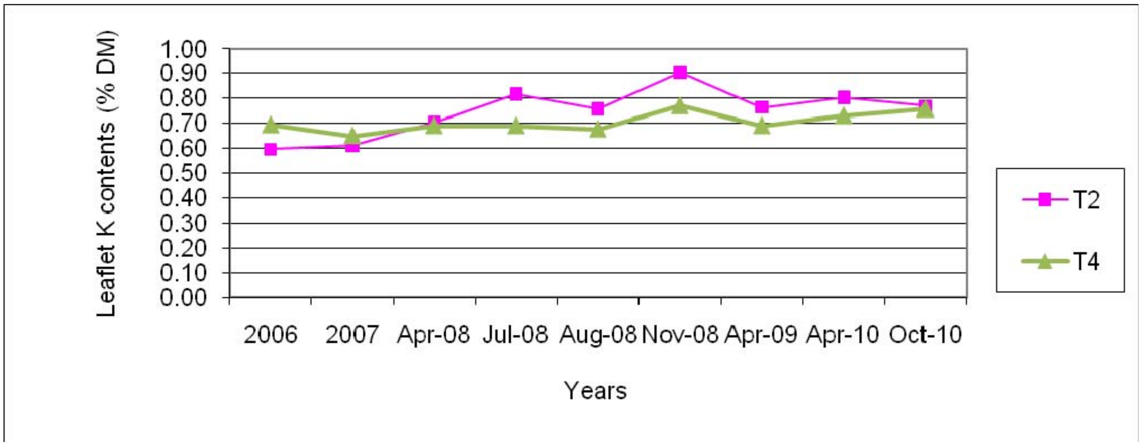


Figure 7. Leaflet K concentrations in T2 and T4 plots.

K addition was stopped in T2 and T4 plots, and remained above 1,5 % DM but are now falling (Figure 8).

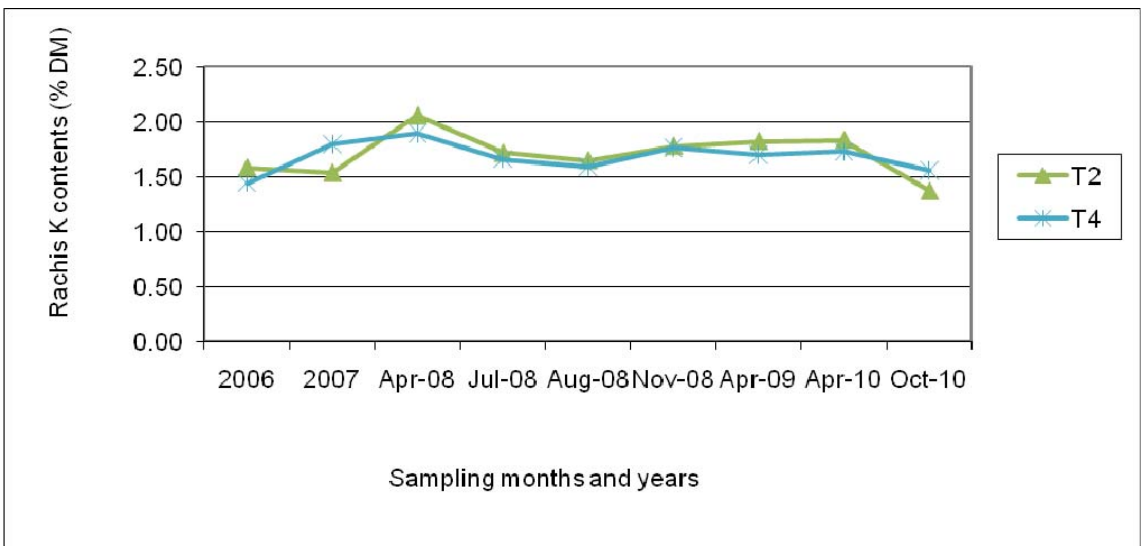


Figure 8. Rachis K concentrations in T2 and T4 plots.

Addition of N and P in T2 plots in 2008 improved leaflet P concentrations (Figure 9). The fall in P contents in April 09 happened in both T2 and T4 and therefore cannot be due to P depletion. However the gap between T2 and T4 is widened in Oct 10 sampling suggesting depletion of P in T4 plots.

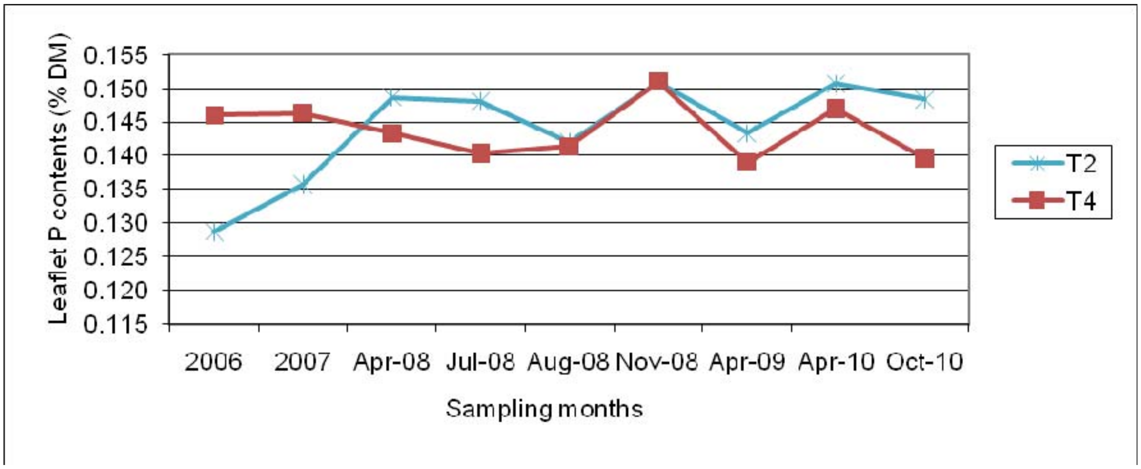


Figure 9. Leaflet P concentrations in T2 and T4 plots

CONCLUSION

The response to addition of fertilisers, especially N fertilisers, had an immediate effect on yield (within a year) and on leaf nutrient content. Addition of N fertilisers to N deficient palms improved the utilisation of K in the palms immediately. Yield and leaf tissue nutrient content responses to the stopping of fertiliser applications are beginning to appear in 2010.

Trial 504. Nitrogen by Potassium trial, Sagarai (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

Trial 504 was established at Sagarai Estate in Milne Bay Estates to test oil palm responses to N and K fertilisers. Soils in this area are of recent alluvial origin, consisting of deep clay loam soils with a reasonably good drainage status. Treatments consisted of four rates each of 0, 2.0, 4.0 and 6.0 kg/palm of SOA and 0, 2.5, 5.0 and 7.5 kg/palm of MOP. FFB yield, frond 17 nutrient concentration and vegetative growth parameters responded well to the fertiliser treatments, especially to SOA as the N source. N drives production in this estate. Over the last few years the response to K fertiliser has been increasing. Highest yields were obtained at high levels of SOA in the presence of MOP..

BACKGROUND

The background information for the trial is shown in Table 1.

Table 1. Trial 504 background information.

Trial number	**504**	Company	CTP Milne Bay Estates
Estate	Sagarai	Block No.	Field 0610, 0611 and 0612
Planting Density	127 palms/ha	Soil Type	Clays (alluvium)
Pattern	Triangular	Drainage	Moderate
Date planted	1991	Topography	Flat
Age after planting	20 years	Altitude	94 m asl
Recording Started	1995	Previous Land use	Ex-Forest/Rubber plantation
Planting material	Dami D x P	Area under trial soil type (ha)	1324
Progeny	unknown	Supervisor in charge	Wawada Kanama

METHODS

Experimental Design and Treatments

64 plots, each with a core of 16 measured palms, made up the trial site. In each plot the core palms are surrounded by a guard row and a trench.

The 64 plots are divided into sixteen treatments (four levels of N by four levels of K), and replicated four times (Table 2). Fertiliser was first applied in 1994. Fertilisers are applied in 3 doses per year. TSP at 0.5 kg/palm was applied as a basal in 2010.

Table 2. Types of treatment fertiliser and rates used in Trial 504.

	Amount (kg/palm/year)			
	Level 0	**Level 1**	**Level 2**	**Level 3**
SOA*	0	2.0	4.0	6.0
MOP*	0	2.5	5.0	7.5

* SOA (Sulphate of Ammonia) contains 21% N and MOP (Muriate of Potash) contains 51% K.

Data Collection

Yield recording (weighing of bunches) is done on a ten day round basis. Vegetative measurements included: palm height; frond measurements (total frond length, leaflet width, leaflet length, total number of leaflets); and rachis cross-section width and thickness. Total number of fronds and new frond counts were undertaken twice annually. Leaflet and rachis sampling for tissue nutrient concentration was carried out on frond 17 using standard procedures. Samples were analysed by AAR. Trial data was analysed using standard two way analysis of variance.

RESULTS and DISCUSSION

Yield and other components response to fertiliser treatments

Treatment effects on FFB yield and other components are shown in Tables 3 and 4. The overall effect of the treatments, over the course of the trial, is illustrated in Figure 1.

In 2010 and 2008-2010, SOA had a significant effect ($p<0.001$) on FFB yield and this was due to significant increases in BN and SBW. MOP had a positive effect on yield ($p=0.002$) due to an increase in the number of bunches in 2008-2010.

The effect of the treatments, especially SOA in increasing yield has been consistent over the last nine years. The yield difference between the maximum level and zero level of SOA application widened in 2005, 2006 and continued into 2007 compared to the previous years. The effect of K fertiliser on yield, although significant from 2004 to 2007, is less marked compared to N fertiliser and insignificant in 2010. The combination of both fertilisers resulted in the highest yields highlighting the importance of N and K nutrition on this soil type.

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Table 3. Effect (p values) of treatments on FFB yield and its components for 2008 and 2008 to 2010

	2010			2008 to 2010		
Source	**Yield**	**BN**	**SBW**	**Yield**	**BN**	**SBW**
SOA	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
MOP	0.106	0.229	0.478	**0.002**	**0.012**	0.132
SOA.MOP	0.556	0.803	0.278	0.552	0.619	0.065

3 years averaged data. P values less than 0.05 are presented in bold.

Table 4. Main effects of treatments on FFB yield (t/ha) and its components for 2010 and 2008 to 2010

	2010				2008-2010		
	Yield (t/ha)	BN (b/ha)	SBW (kg)		Yield (t/ha)	BN (b/ha)	SBW (kg)
SOA0	**21.0**	**830**	**25.2**		**18.7**	**781**	**23.8**
SOA1	**23.8**	**890**	**26.8**		**21.8**	**850**	**25.7**
SOA2	**28.3**	**996**	**28.4**		**24.6**	**898**	**27.5**
SOA3	**28.6**	**1011**	**28.3**		**25.2**	**926**	**27.2**
$LSD_{0.05}$	2.66	88	1.10		1.58	50.1	0.83
MOP0	23.4	878	26.7		**20.8**	**817**	25.6
MOP1	26.4	963	27.2		**22.6**	**859**	26.1
MOP2	26.0	937	27.6		**24.0**	**900**	26.6
MOP3	28.6	951	27.2		**22.9**	**879**	26.0
$LSD_{0.05}$					*1.58*	50.1	
GM	25.4	932	27.2		22.6	864	26.1
SE	3.74	123.7	1.55		2.22	70.5	1.17
CV %	14.7	13.3	5.7		9.9	8.2	4.5

Three years averaged data. P values less than 0.05 are presented in bold.

Combinations of both SOA and MOP produced the highest yields (Table 5). The highest FFB yields were obtained and 4 and 6 kg SOA in the presence of MOP.

Table 5. Effect of SOA and MOP on FFB yield (t/ha) in 2008 and 2006 to 2008 (three year average data). The treatment interactions are not significant.

SOA by MOP – 2010

	MOP0	MOP1	MOP2	MOP3
SOA0	21.4	20.9	19.8	21.9
SOA1	21.6	23.6	26.1	24.1
SOA2	25.4	**28.9**	**30.1**	**28.8**
SOA3	25.3	**32.2**	**27.9**	**29.1**

SOA by MOP – 2008 to 2010

	MOP0	MOP1	MOP2	MOP3
SOA0	17.7	17.5	20.1	19.5
SOA1	20.0	21.5	24.2	21.5
SOA2	21.8	24.8	**26.8**	**25.1**
SOA3	23.7	**26.4**	**25.0**	**25.6**

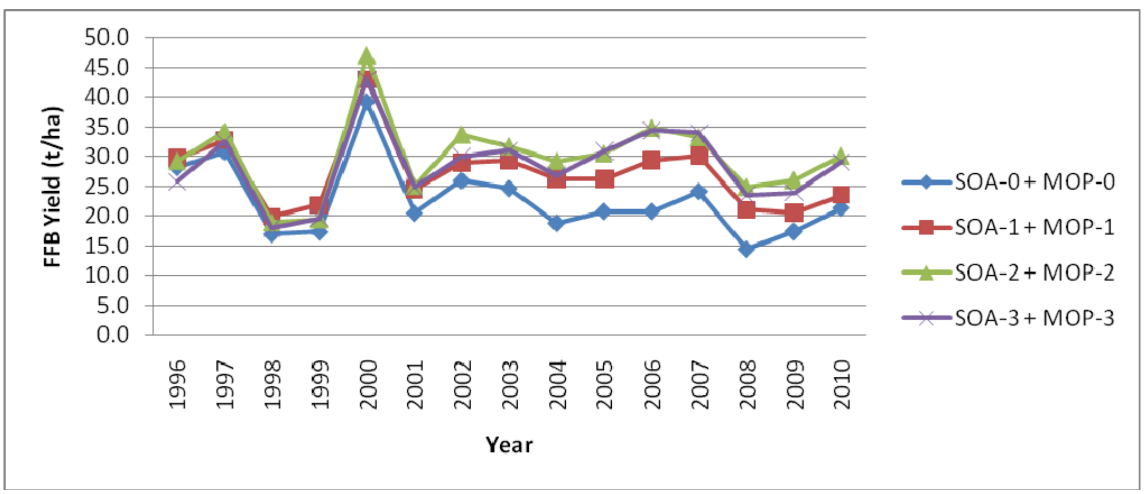

Figure 1. Effects of various combinations of SOA and MOP on yield from 1996 to 2010.

Fertiliser effects on Frond 17 nutrient concentrations

SOA and MOP had a significant impact on tissue nutrient concentration (Tables 6 and 7). SOA application increased the level of N in the leaflets and in the rachis whilst lowered rachis P and K concentrations. MOP increased leaflet K, Ca and Cl, and rachis Ash, P and K concentrations but lowered leaflet Mg contents.

In brief:

- In the leaflets N was low with the zero N treatment and adequate at higher rates
- P levels in leaflets were adequate
- K levels were low in the leaflet for the zero K treatment and adequate at higher rates
- B levels (12 ppm) were low
- N fertiliser mobilized P and K out of the rachis
- K in the rachis was very low for the zero MOP treatment

With very low values of K in the rachis for the zero MOP treatment, palms in these plots will experience increasing deficiency in K, as already exhibited in the leaflets with this treatment, and yields in this treatment are likely to fall in the near future.

Table 6. Effect (p values) of treatments of frond 17 nutrient concentration.

Source	**Leaflet nutrient concentrations**							**Rachis nutrient concentrations**			
	Ash	**N**	**P**	**K**	**Mg**	**Cl**	**B (ppm)**	**Ash**	**N**	**P**	**K**
SOA	**<0.001**	**0.661**	0.816	0.040	0.807	0.269	**0.111**	**0.035**	**<0.001**	**<0.001**	**<0.001**
MOP	0.566	0.826	0.486	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.153	**<0.001**	**<0.001**
SOA.MOP	0.772	0.587	0.003	0.889	0.248	0.757	0.262	0.864	0.770	0.290	0.870

P values < 0.05 are shown in bold.

Table 7. Main effects of treatments on frond 17 nutrient concentration.

		Leaflet nutrient concentrations							**Rachis nutrient concentrations**			
	Ash	**N**	**P**	**K**	**Mg**	**Ca**	**Cl**	**B (ppm)**	**Ash**	**N**	**P**	**K**
SOA0	**10.8**	**2.34**	0.146	0.63	0.39	0.80	0.50	12	4.6	**0.28**	**0.266**	**1.29**
SOA1	**10.9**	**2.35**	0.146	0.62	0.39	0.82	0.52	13	4.4	**0.28**	**0.220**	**1.25**
SOA2	**11.5**	**2.37**	0.145	0.58	0.38	0.81	0.49	12	4.2	**0.30**	**0.168**	**1.12**
SOA3	**11.7**	**2.38**	0.145	0.58	0.39	0.81	0.51	12	4.3	**0.33**	**0.144**	**1.09**
$LSD_{0.05}$	0.445			0.041						0.016	0.0154	0.103
MOP0	11.4	2.35	0.147	**0.53**	**0.43**	**0.78**	**0.45**	13	**3.1**	0.31	**0.172**	**0.55**
MOP1	11.2	2.37	0.144	**0.59**	**0.39**	**0.81**	**0.50**	12	**4.4**	0.29	**0.199**	**1.20**
MOP2	11.1	2.37	0.145	**0.64**	**0.37**	**0.83**	**0.53**	12	**4.8**	0.30	**0.213**	**1.43**
MOP3	11.2	2.35	0.145	**0.64**	**0.36**	**0.82**	**0.53**	12	**5.2**	0.30	**0.214**	**1.58**
$LSD_{0.05}$				0.041	0.022	0.028	0.028	0.637	0.269		0.0154	0.103
GM	11.2	2.36	0.145	0.60	0.39	0.81	0.50	12	4.4	0.30	0.200	1.19
SE	0.626	0.089	0.0043	0.058	0.031	0.040	0.040	0.896	0.379	0.023	0.0217	0.144
CV %	5.6	3.8	2.9	9.6	8.0	4.9	7.9	7.3	8.6	7.6	10.9	12.2

P values < 0.05 are shown in bold. All units expressed in % dry matter.

Though statistically not significant, the response of rachis K to addition of SOA and MOP is presented in Table 8. The lowest rachis K content was at SOA3 (6.0 kg/palm/year) implying high N have led to depletion of K reserves in the palms and or remobilizing K reserves in the rachis.

Table 8. Effect of SOA and MOP on rachis K concentrations in 2010

	MOP0	MOP1	MOP2	MOP3
SOA0	0.73	1.31	1.48	1.64
SOA1	0.60	1.21	1.53	1.66
SOA2	0.45	1.16	1.32	1.53
SOA3	0.41	1.10	1.38	1.48

Fertiliser effects on vegetative growth parameters

Effects of SOA and MOP on vegetative parameters are presented in Tables 9 and 10. SOA had a positive and significant effect on FP, FA, LAI, dry matter production and BI. MOP had no effect on the vegetative parameters measured except on FDM. The mean bunch index was 0,40 in 2010 compared to 0.33 in 2009

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Table 9. Effect (p values) of treatments on vegetative growth parameters in trial 504

			Radiation interception			Dry matter production				
Source	FL	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
SOA	0.191	0.064	**0.023**	**0.002**	**0.004**	**0.002**	**<0.001**	**<0.001**	**<0.001**	**<0.001**
MOP	0.350	0.516	0.110	0.110	0.319	**0.025**	0.125	0.066	0.127	0.818
SOA.MOP	0.141	0.885	0.602	0.602	0.529	**0.050**	0.558	0.783	0.954	0.686

Significant effects ($p<0.05$) are shown in bold.

FL = Frond length (cm); PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM)

Table 10. Main effects of treatments on vegetative growth parameters in trial 504

			Radiation interception			Dry matter production (t/ha/year)				
	FL	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
SOA0	640	56.7	21.0	**13.7**	**5.44**	**15.9**	**11.3**	**30.3**	**19.0**	**0.37**
SOA1	645	57.9	21.0	**13.9**	**5.57**	**16.3**	**12.6**	**32.2**	**19.5**	**0.39**
SOA2	647	60.1	21.5	**14.3**	**5.83**	**17.3**	**15.1**	**36.0**	**20.9**	**0.42**
SOA3	651	63.1	21.8	**14.1**	**5.75**	**18.4**	**15.5**	**37.6**	**22.1**	**0.41**
$LSD_{0.05}$			0.614	0.341	0.226	1.336	1.382	2.541	1.554	0.022
MOP0	640	57.3	21.0	**13.7**	5.58	16.1	**11.3**	31.9	19.3	0.40
MOP1	647	59.7	21.3	**14.0**	5.60	17.0	**12.6**	34.6	20.4	0.41
MOP2	648	59.9	21.7	**14.2**	5.77	17.4	**15.1**	34.9	21.0	0.40
MOP3	647	60.9	21.3	**14.1**	5.65	17.4	**15.5**	34.8	20.9	0.40
$LSD_{0.05}$				0.341			1.382			
GM	645	59.5	21.3	14.0	5.65	17.0	13.4	34.0	20.4	0.40
SE	14.0	6.94	0.863	0.480	0.317	1.878	1.943	3.573	2.185	0.031
CV %	2.2	11.7	4.0	3.4	5.6	11.1	14.2	10.5	10.7	7.7

Significant effects ($p<0.05$) are shown in bold.

FL = Frond length (cm); PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM)

CONCLUSION

N fertiliser, applied as SOA, was the main driver of production in this trial. N treatments resulted in higher concentrations of N in the leaflets rachis and leaflets, increased frond dry matter production and subsequent high yields. The high yield of palms in the N treatments was brought about by more and heavier bunches. K fertiliser, applied as MOP, is becoming more important over time as K levels are dropping in the zero MOP plots. Palms in these plots have low rachis and leaflet K levels. Highest yield was obtained by a combination of the higher rates of SOA (4 to 6 kg SOA/palm or 0.8 to 1.2 kg N/palm) together with middle rate of MOP (5.0 kg MOP/palm or 2.55 kg K/palm).

Trial 516: New NxK trial at Maiwara Estate (RSPO 4.2, 4.3, 4.6, 8.1)

INTRODUCTION

Two new trials were established in 2007 at Maiwara. Trial 516 is an NxK factorial trial; and Trial 517 is a replicated K placement trial. The trial site was selected in 2005 and pre-treatment yield data was collected for eighteen months until the first fertiliser treatments were applied in May 2007. Site details are presented in Table 1.

Table 1. Trial 516 back ground information

Trial number	**516**	Company	Milne Bay Estates
Estate	Hagita, Maiwara	Block No.	AJ 1290
Planting Density	143 p/ha	Soil Type	Alluvial
Pattern	Triangular	Drainage	Site is often waterlogged
Date planted	2001	Topography	Flat
Age after planting	10	Altitude	Not known
Recording started	2005	Previous Land-use	Forest
Planting material	Dami D x P	Area under trial soil type (ha)	Not known
Progeny	Mix	Supervisor in charge	Wawada Kanama

Basal fertiliser applied in 2010: 0.5 kg TSP

METHODS

Plots were marked out in 2005 and pre-treatment data were collected throughout 2006 and 2007. First treatments were applied in May 2007 and hence 2008 was the first full year with treatments imposed. Plots consisted of 16 recorded palms surrounded by a single guard row (total 36 palms per plot). The trial site was split in two and two trials were established in May 2007 (516 and 517).

Trial 516 – NxK: Has the aim to identify the optimum economic return for N and K fertiliser application on alluvial soils at MBE. The trial consists of 13 plots with 5 treatment rates of both N and K (N range: SOA from 0 to 9 kg/palm and MOP from 0 to 7 kg/palm). A uniform precision rotatable central composite trial design was established, this design is standard for generating fertiliser response surfaces. For a 2-factor (k = 2) central composite design, the treatments consist of (a) 2^k (= 4 treatments) factorial, (b) 2k (= 4) star or axial points and (c) 5 centre points. Linear multiple regression was used to analyze the yearly influence of fertiliser N and K on yield. In the regression equation, yield is the dependent variable, and the N and K fertilisers the independent variables. The equation used was:

$$\text{Yield} = a \pm bN \pm cN^2 \pm dK \pm eK^2 \pm fN.K \qquad \text{(equation 1)}$$

where a, b, c, d, e, f and g are the parameters to be calculated. The last term, f, represents the linear by linear interaction between N and K fertilisers. Tissue samples (Frond 17) were also collected and the results are presented.

RESULTS

The two analyses undertaken for 2010 were not available at the time of going to press as they are being checked by a statistician. These results will be issued as soon as possible

DISCUSSION

There were no fertiliser effects (N or K) on yield in 2008. However, even though barely significant, there were some differences observable at that stage in the tissue data. We expect that the tissue data differences will increase in future years to be followed by yield differences.

Trials 517: New K placement trial at Maiwara Estate (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

In the first full year of treatment application there were no differences in application method for MOP in yield or in tissue K content.

INTRODUCTION

Two new trials were established in 2007 at Maiwara. Trial 516 is a NxK factorial trial; and Trial 517 is a replicated K placement trial. The trial site was selected in 2005 and pre-treatment yield data was collected for eighteen months until the first fertiliser treatments were applied in May 2007. Site details are presented in Table 1.

Table 1. Trial 517 background information

Trial number	**517**	Company	Milne Bay Estates
Estate	Hagita, Maiwara	Block No.	AJ 1290
Planting Density	143 p/ha	Soil Type	Alluvial
Pattern	Triangular	Drainage	Site is often waterlogged
Date planted	2001	Topography	Flat
Age after planting	10	Altitude	Not known
Recording started	2005	Previous Land-use	Forest
Planting material	Dami D x P	Area under trial soil type (ha)	Not known
Progeny	Mix	Supervisor in charge	Wawada Kanama

Basal fertiliser applied in 2010: 0.5kg/palm TSP

METHODS

Plots were marked out in 2005 and pre-treatment data were collected throughout 2006 and 2007. First treatments were applied in May 2007 and hence 2008 is the first full year with treatments imposed. Plots consisted of 16 recorded palms surrounded by a single guard row (total 36 palms per plot). The trial site was split in two and two trials were established in May 2007 (516 and 517).

Trial 517 – K placement: has the aim to identify the optimum placement of MOP (K fertiliser) on the deep clay soils at Milne Bay. It is known from other trials (specifically 502) that K is an essential nutrient, however there are some indications that even with high amounts applied that uptake is not optimum, this could be due to ineffective placement. Currently MOP is applied to the edge of the weeded circle and in this trial we are investigating alternatives such as application on the frond tips and frond pile where uptake could be more efficient. There is also talk about using mechanical spreaders for spreading MOP and this was included as a treatment (simulated mechanical spreading by throwing the fertiliser throughout the plot). The trial consists of 16 plots with one rate of K (MOP at 7.5 kg/palm) and four placements, replicated four times. Placements are: (i) weeded circle, (ii) frond tips and frond pile, (iii) edge of weeded circle, and (iv) broadcast. Three additional plots were available and two of these did not receive any K fertiliser and the third plot received a higher rate of 12kg/palm. These three plots are not part of the analysis but can provide additional information especially when interpreting tissue K levels. One way Anova is used for trial analysis.

RESULTS AND DISCUSSION

Analysed yield data for 2010 and 2008-2010 are presented in Table 2. Yield data for the nil fertilised and the highest MOP rate plots are also presented in the same table. The trial is still at its early stage and therefore there are no yield and or yield component responses to the different fertiliser placement treatments. Mean FFB yield was 30.6 t/ha in 2010.

Table 2. Main effects of fertiliser placement treatments on FFB yield (t/ha) and its components for 2010 and 2008 to 2010 (three years averaged data). P values less than 0.05 are presented in bold.

	2010			2008-2010		
	Yield (t/ha)	**BN (bunches/ha)**	**SBW (kg)**	**Yield (t/ha)**	**BN (bunches/ha)**	**SBW (kg)**
Nil fertiliser	30.0	1571	17.4	27.2	1565	19.1
Highest MOP rate	30.0	1607	20.8	28.2	1601	18.3
Edge of weeded circle	29.0	1404	20.7	28.1	1532	18.6
Weeded circle	30.4	1522	20.1	28.2	1570	18.1
Broadcast	31.7	1631	19.5	29.5	1655	17.9
Frond tips and piles	31.3	1544	20.3	20.3	1625	17.9
P values	*0.540*	*0.267*	*0.669*	*0.553*	*0.374*	*0.780*
GM	30.6	1525	20.1	28.7	1595	18.1
SE	2.76	153.0	1.35	1.51	103.4	0.97
C.V.%	9.0	10.0	6.7	5.3	6.5	5.3

P values less than 0.05 are presented in bold.

Analysed leaf tissue nutrient content data are presented in Table 3. Again, just as with the yield data, there are still no responses to the different fertiliser placement The mean rachis K concentration in nil fertiliser plot was 0.89 % DM and was much lower than the treated plots which had a mean of 1.28 % DM. The highest MOP fertilised plot has rachis K concentration of 1.46 % DM. The difference suggests there is response to MOP fertiliser addition, however there is no statistically significant difference between the placements.

Table 3. Trial 517, main effects of treatments on frond 17 nutrient concentrations in 2009, in units of dry matter %. P values less than 0.05 are indicated in bold

	Leaflet nutrient concentrations								Rachis nutrient concentrations			
Treatments	**Ash**	**N**	**P**	**K**	**Mg**	**Ca**	**Cl**	**B (ppm)**	**Ash**	**N**	**P**	**K**
Nil fertiliser	11.2	2.36	0.142	0.51	0.87	0.38	0.43	12	4.1	0.29	0.100	0.89
Highest MOP rate	11.6	2.30	0.140	0.57	0.95	0.35	0.54	13	5.5	0.29	0.082	1.46
Edge of weeded circle	10.6	2.39	0.143	0.60	0.34	0.87	0.51	12	5.2	0.28	0.094	1.37
Weeded circle	11.1	2.35	0.139	0.60	0.35	0.83	0.50	12	5.1	0.28	0.066	1.12
Broadcast	11.4	2.39	0.131	0.57	0.34	0.88	0.52	13	4.9	0.26	0.081	1.31
Frond tips and piles	10.6	2.39	0.137	0.61	0.34	0.84	0.50	13	5.9	0.31	0.099	1.30
P values	0.709	0.071	0.141	0.828	0.907	0.492	0.956	0.795	0.481	0.461	0.516	0.530
GM	10.9	2.35	0.140	0.60	0.34	0.86	0.51	13	5.3	0.28	0.080	1.28
SE	1.126	0.064	0.003	0.059	0.020	0.047	0.041	1.257	0.972	0.0433	0.025	0.239
C.V.%	10.3	2.71	2.2	9.8	5.9	5.5	8.0	10.0	18.5	15.4	31,6	18.7

P values less than 0.05 are indicated in bold

SUMMARY

It is too early to see responses to the treatments.

Trial 513: Spacing and Thinning Trial, Padipadi (RSPO 4.2, 4.3, 8.1)

SUMMARY

The trial was designed to test the effects of spacing configuration, thinning and planting density on FFB yield. At field planting, there were six density treatments (128, 135, 143, 192, 203 and 215 palms/ha). Thinning took place at 5 years of age (in February 2008), the treatments planted at 192, 203 and 215 palms/ha were thinned to 128, 135 and 143 palms/ha respectively. These are now the replicate of the three original lower densities but with different spacing configurations. Density treatment had a significant effect on yield and number of bunches produced in the combined pre-thinning and post-thinning phase. The highest yielding treatment (April 2006 to December 2008) was

the treatment planted at 215 and thinned to 143 palms/ha. Whether this treatment with a relatively high density (143 palms/ha) can maintain its yield advantage compared to the 128 and 135 planting densities remains to be seen.

INTRODUCTION

The purpose of the trial was to determine the effects of spacing configuration, thinning and density on palm yield. The theory is that during the immature phase, the yield of palms planted at a high planting density will be higher compared to the lower planting density until canopy closure has been achieved (at approximately 5 years of age). Following thinning of the high density plots the wider avenues will allow more sunlight to penetrate the remaining palm rows and yield should be able to be maintained at a similar levels compared to the lower planting densities. The end result is a higher total yield over the immature phase with the higher planting densities without a subsequent loss in yield after canopy closure has been achieved. In a smallholder situation, it would also be possible to grow food or cash crops for extra income in the wider inter-rows. Back ground information of the trial is presented in Table 1.

Table 1. Trial 513 back ground information

Trial number	**513**	Company	Milne Bay Estates
Estate	Padipadi	Block No.	1051
Planting Density	See Table 3	Soil Type	Alluvial
Pattern	Triangular	Drainage	Good
Date planted	2003	Topography	Flat
Age after planting	8	Altitude	Not known
Recording started	April 2006	Previous Land-use	Savanna grassland
Planting material	Dami D x P	Area under trial soil type (ha)	Not known
Progeny	Known	Supervisor in charge	Wawada Kanama

METHODS

Design and treatments

The design is the same as Trial 331 at Higaturu. There are 6 treatments initially of different planting densities with equilateral triangular spacing (Table 2). In treatments 4, 5 and 6 every third row was removed 5 years after planting and treatments 1, 2 and 3 remain as planted (thinning took place in February, 2008). The final densities of treatments 4, 5 and 6 will be the same as treatments 1, 2 and 3 but they will have closely spaced pairs of rows with wider avenues between the pairs. There are 3 replicates of the 6 spacing treatments, giving a total of 18 plots. Each plot has 4 rows of recorded palms and these plots are enclosed by guard palms. Fertiliser application will follow normal plantation practice for an immature fertiliser program up to year 6.

Table 2. Treatment allocations in Trial 513. 'Thinning' involved the removal of every third row, 5 years after planting, in treatments 4, 5 and 6 (in February 2008).

Treatment No	**Initial density (palms/ha)**	**Triangular spacing (m)**	**Initial number of rows/plot***	**Density after thinning (palms/ha)**	**Inter-row width after thinning (m)**
1	128	9.50	7	128	8.23
2	135	9.25	7	135	8.01
3	143	9.00	7	143	7.79
4	192	7.75	8	128	13.4 (6.71)
5	203	7.55	9	135	13.08 (6.54)
6	215	7.33	9	143	12.7 (6.35)

( ) avenue width before thinning
* includes guard rows

Data Collection
Recordings and measurements are taken on 4 rows of palms in each plot. The number of bunches and bunch weights recording commenced in April 2006. Pre-thinning yield was determined from weight recording all bunches in four rows in each plot; the total yield was calculated for each harvest and then expressed per ha per year. Post thinning (February 2008) recorded palms in four palms rows in each plot were numbered and bunch number and SBW are now recorded against numbered palms. Leaf sampling is carried out once annually according to standard procedures and analysed for nutrient concentrations using standard analytical procedures.

Statistical Analysis
Analysis of variance (One-way ANOVA) of the main effects of density treatments was carried out for yield and its component variables.

RESULTS and DISCUSSION
Density treatments had a significant effect on yield during the pre-thinning years - 2006 and 2007. There was no difference in yield in the treatments post-thinning in 2008, 2009 and 2010 (Table 3).

2006 Yield: treatments 4, 5 and 6 had a significantly higher yield (P=0.006) compared to treatments 1, 2 and 3
2007 Yield: treatment 6 had a significantly higher yield compared to treatments 4 and 5, which in turn had a significantly higher yield compared to treatments 1, 2 and 3 (P<0.001)
2008 Yield: there was no significant difference in yield between the treatments post thinning (P=0.11)
2009 Yield: there was no significant difference in yield between the treatments post thinning
2010 Yield: there was no significant difference in yield between the treatments post thinning

The yields in Treatments 1, 2 and 3 were greater than treatments 4, 5 and 6 but were not statistically significant after thinning (Table 3). However before thinning, the high density plots were yielding more than the low density treatments (1, 2 and 3) (Figure 1).

Table 3. Trial 513 Main effects of density treatments on FFB yield (t/ha) and its components for 2010 and 2008 to 2010 (two years averaged data). P values less than 0.05 are presented in bold.

	2010			**2008-2010**		
Density Treatment	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**
128	34.5	2741	12.7	27.6	**2777**	10.2
135	33.9	2747	12.5	28.3	**2929**	10.0
143	33.8	2865	11.9	29.5	**3079**	9.9
128 (192)	30.1	2407	12.7	25.8	**2595**	10.3
135 (203)	30.7	2589	12.0	25.3	**2699**	9.7
143 (215)	31.3	2591	12.3	26.1	**2760**	9.8
$lsd_{0.05}$					227	
p values	0.155	0.083	0.275	0.176	0.009	0.704
Grand Mean	32.4	2657	12.4	27.1	2807	10.0
SE	2.292	168.8	0.482	2.047	124.8	0.506
CV %	7.1	6.4	3.9	7.6	6.5	5.1

P values less than 0.05 are presented in bold.
(..) previous density

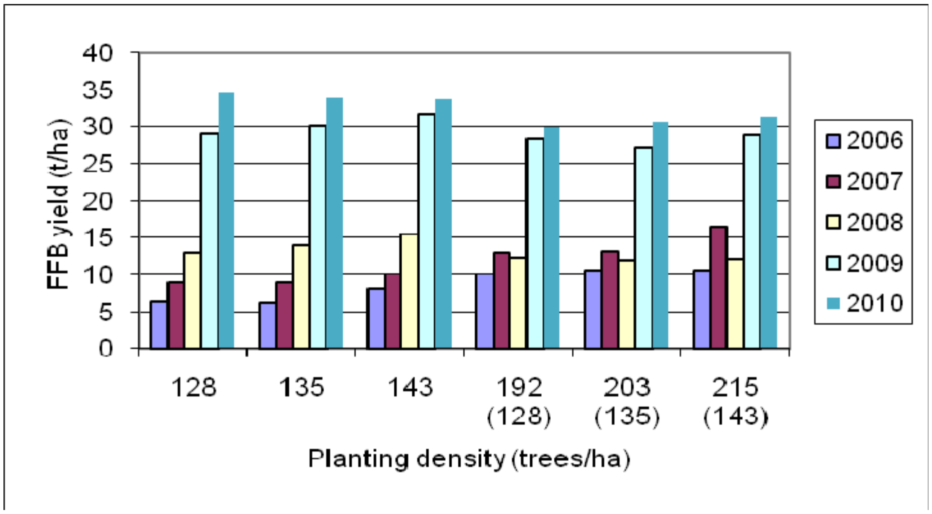

Figure 1. Trial 513: FFB yield for the pre-thinning years (2006 and 2007) and the post-thinning year (2008 - 2010).
Note 1. the planting density in brackets refers to post-thinning
Note 2. in 2006 harvest commenced in April (yield only for April to December)
Note 3. post-thinning in 2008 harvest commenced in April (yield only for April to December)

Leaf tissues nutrient contents are reasonably above critical levels except for rachis K content which is at 0.84 % DM. K could be limiting in this environment due to no proper fertiliser applications.

Table 3. Trial 513, frond 17 nutrient concentrations in 2010, in units of dry matter %.

	Leaflets nutrient concentrations (% DM)								Rachis nutrient concentrations (% DM)			
Plots	**Ash**	**N**	**P**	**K**	**Mg**	**Ca**	**B (ppm)**	**Cl**	**Ash**	**N**	**P**	**K**
1	16.93	2.7	0.152	0.57	0.42	1.00	23.6	0.5	3.71	0.26	0.073	0.75
6	13.75	2.87	0.163	0.67	0.48	0.83	20.1	0.59	4.64	0.31	0.085	0.83
14	14.24	2.94	0.151	0.67	0.39	0.89	23.2	0.47	4.33	0.28	0.093	0.95
Mean	15.0	2.84	0.155	0.64	0.43	0.91	22.3	0.52	4.2	0.28	0.084	0.84

P values less than 0.05 are indicated in bold

CONCLUSION
There was no effect of density treatments in the post-thinning phases.

NBPOL, KULA GROUP, HIGATURU OIL PALM, NORTHERN PROVINCE

(Susan Tomda and Murom Banabas)

GENERAL SUMMARY
Agronomy trials with Higaturu comprised three main areas of interest:

Factorial fertiliser trials: (i) N.P.K.Mg at Mamba Estate; (ii) SOA.EFB at Sangara; (iii) N.P at Sangara and Ambogo.

Outcome:
N.P.K.Mg trial –K increased yield as rachis K level of 0.46 for the control indicates that K is limiting yield production in this area. SOA increased yields in the presence of EFB in 2010
Urea.TSP (mature) – established in late 2006 and no treatment outcomes as yet.
Urea.TSP (immature) – established in late 2007 and Urea increased yield.

N source trial: N source trial established at Sangara Estate to determine the relative effect of different N sources and the optimum N rate for the volcanic soils at Higaturu.

***Outcome*:** Yield of different types of N are similar (36 t/ha) and yield increased with increasing rate of N up to 1.68 kg N per palm (32 to 38 t/ha, control only 12.1 t/ha).

Spacing, thinning and density trial: one trial has been established at Ambogo Estate to determine the effect spacing configuration, thinning and density will have on oil palm.

***Outcome*:** After thinning, the un-thinned densities yields were higher than the un-thinned densities

A synopsis for the trial work undertaken with Higaturu Oil Palms Limited is provided (Tables 1 and 2). A short recommendation for trial work operation and plantation management based on our results is also provided.

Table 1. Higaturu Oil Palms Ltd: Synopsis of 2010 PNGOPRA trial results and recommendations

Trial	Palm Age	Yield t/ha	Yield Components	Tissue (% dm)	Vegetative	Notes
324 Sangara N type x rate Soil: Volcanic ash	13	N type (NS) N rate 32 to 38 Control 12	N rate B/ha 1626 to 1726 (NS) N rate SBW 22 (NS)	N type LN 2.3 (NS) N rate LN 2.18 to 2.39 RN 0.28 to 0.32 LP 0.144; RP 0.182 LK 0.71; RK 1.69 LMg 0.2, LB 18	N rate PCS 43 to 48 LAI 5.84 (S)	Highest yield: 0.84 kg N/palm) B high
326 Sangara SOA, EFB (factorial) Soil: Volcanic ash	10	SOA 31-36 (S) EFB 32-35.7	SOA B/ha 1439 (NS) SOA SBW 24(S)	EFB LK 0.69 (S) RK 1.12 to 1.61 LN 2.42; RN 0.30 LP 0.142; RP 0.09 LMg 0.21, LB 15ppm	PCS 48 (NS) FP 24 (NS) LAI 6.3 (NS)	Yield response to N commenced after 8 years
329 Mamba SOA, TSP, MOP, KIE (factorial) Soil: Volcanic ash	12	SOA, TSP, MOP, Kie 24.8 (NS)	MOP B/ha 890 (NS) MOP SBW 26.6-28.5 (S)	SOA LN 2.46 (NS) RN 0.28 (NS) TSP LP 0.159 (NS) RP 0.08 to 0.10 MOP LK 0.58 to 0.73 RK 0.42 to 1.36 KIE LMg 0.17 to 0.33 LB 16	MOP PCS 51.9 (NS) LAI 6.42-6.87 (S) Kie LAI 6.8 (NS)	Tissue: K required N high B edequate LAI high
334 Sangara Urea, TSP Soil: Volcanic ash	10	N and P, 34.6 (NS)	B/ha 1712 (NS) SBW 20.3 (NS)	Urea LN 2.48 (NS) RN 0.296 (NS) TSP LP 0.148 (NS) RP 0.130(NS)	PCS 46.59 (NS) FP 16 (NS) LAI 6.24 (NS)	No response as yet
335 Ambogo Urea, TSP Soil: Volcanic ash	3	Urea 19-22 (S) TSP 20.2 (NS)	Urea B/ha 3666-3837 (NS) Urea SBW 5.16-5.63 (S)	Urea LN 2.69-2.77 (NS) RN 0.300 (S) TSP LP 0.160 (NS)	PCS 16.27 (NS) Urea FA 5.0 (NS) BI 0.49 (NS)	Significant responses to Urea

Table 2. Apparent adequate tissue nutrient levels:

Leaflet (% DM)					Rachis (% DM)		
N	P	K	Mg	B	N	P	K
2.45	0.145	0.65	0.20	15 (ppm)	0.32	0.08	1.3

Recommendations to Higaturu Oil Palm:

- On the volcanic soils in Oro Province an oil palm yield of 35 t/ha should be attainable. Some of the soils have very high inherent N fertility and these soils require less N input. Monitoring of available N is essential to ensure that soil supply keeps up with demand.
- N source trial suggests no difference between products in yield response; purchase on price and ease of handling.
- Tissue testing and vegetative measurement criteria will help in determining deficiencies of particular nutrients.
- Most of the focus for nutrition should be on N, followed by K and P. Tissue Mg levels appear to be adequate. Boron is low in all trials and needs to be applied as a basal.
- Plantation management (harvest time, pruning, clean weeded circles, fertiliser application and timing etc) all play a large role in the potential to optimize production.

Trial 324 Nitrogen Source Trial on Volcanic soils, Sangara Estate (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

The trial was established to test relative effect of different nitrogen fertilisers on volcanic ash soils. The trial design was Randomised Complete Block Design (RCBD). Five different sources of N were tested at 3 different levels; each treatment was replicated 4 times. N-type treatment had no significant effect on FFB yield in 2010 and for the combined 2008-2010 period however PCS, LAI, FDM TDM and VDM were significantly affected in 2010. N-rate treatment had a significant effect on yield, tissue N and most physiological growth parameters. For most variables, the between N-rate difference was significant for 0.42 kg N per palm and either 0.84 or 1.68 kg N per palm but not for 0.84 and 1.68 kg N per palm. Compared to the grand mean yield of 35.9 t/ha for palms that received N fertiliser, mean yield for the palms that did not receive N fertiliser was only 12 t/ha in 2010. This indicates the importance of N for oil palm production on volcanic ash soil.

The results of this trial indicate that there are no differences in uptake and performance of the five most commonly used sources of N fertilisers, for oil palm grown on volcanic soils at Higaturu. For plantation management N fertiliser can be purchased on price and ease of application without loss of productivity.

INTRODUCTION

Nitrogen is the most limiting nutrient in oil palm growth and production. Oil palm requires substantial amounts of N to incorporate into organic compounds including proteins, nucleic acids and growth regulators. It was established that N is the major limiting element in soils derived from Mt Lamington volcanic ash material. However, it is not known which fertiliser is a better source for this environment both in relation to high yields and the long-term sustainability of the soils. Results from completed trials such as 309 and 310, which were both located on an outwash plain, showed that SOA is a better source of N compared to AMC or urea, in these ex grassland sandy loam soils. Whether this is the case on other soils is not known. Hence, the purpose of this trial is to test relative effectiveness of different nitrogen fertilisers on Higaturu Soils (Volcanic Plains). The trial commenced in January 2001, about 5 years after field planting. Other background information on the trial is presented in Table 1. Pre-treatment soil data for the trial field indicate high levels of N, organic matter and Ca (Table 2). Exchangeable K and Mg, and CEC are moderate, while pH is generally neutral.

Table 1. Trial 324 background information.

Trial number	**324**	Company	Kula Oil Palm
Estate	Sangara	Block No.	Sangara AB0020 & AB0030
Planting Density	135 palms/ha	Soil Type	Higaturu Soils
Pattern	Triangular	Drainage	Good
Date planted	1996	Topography	Flat
Age after planting	14	Altitude	71.18m asl
Recording Started	2001	Previous Land-use	Replanted oil palm
Planting material	Dami D x P	Area under trial soil type (ha)	32.22
Progeny	Unknown	Asst.Agronomist in charge	Susan Tomda

Table 2. Initial soil analysis results from soil samples taken in 2000

Depth	pH in	Exch K	Exch Ca	Exch Mg	CEC	OM	Total N	Avail N	Olsen P	P Ret	Boron	Sulphate S
cm	water	cmol/kg				%	%	kg/ha	mg/kg	%	mg/kg	mg/kg
0-10	6.3	0.39	9.5	1.5	14.5	4.4	0.28	178.8	19.5	34.5	0.5	3.8
10-20	6.4	0.30	7.0	0.83	10.8	1.8	0.12	52.8	6.0	49.8	0.2	4.3
20-30	6.7	0.28	8.6	1.13	12.6	1.1	0.07	18.8	6.3	67.3	0.2	5.5
30-60	6.8	0.34	10.0	1.88	15.7	1.1	0.05	10.0	13.3	84.5	0.1	10.3
Control												
0-10	6.1	0.42	7.4	1.57	13.1	4.1	0.25	144	20	31	0.4	3
10-20	6.1	0.41	6.6	0.72	12.1	2.0	0.17	56	8	41	0.3	5
20-30	6.4	0.37	7.4	0.87	11.7	1.1	0.10	20	8	62	0.1	10
30-60	6.7	0.31	9.3	1.82	14.4	0.9	0.08	<10	18	83	<0.1	12

METHODS

Experimental Design and Treatments

This trial was a Randomised Complete Block Design (RCBD) with a treatment structure of 5 N sources x 3 rates x 4 replicates, resulting in 60 plots. For each replicate, 15 treatments were randomly allocated to 15 plots. There was one extra plot for every replicate block, which was the control plot (0 N) and all the 4 control plots were situated at the edge of the trial. In total there were 64 plots in this trial. Each plot consisted of 36 palms, the central 16 were recorded and the outer 20 were guard palms. To minimise poaching of nutrients by roots of palms between plots, trenches were dug around the edges of the plots in 2001/02. The N sources were ammonium sulphate (SOA), ammonium chloride (AMC), ammonium nitrate (AMN), urea and diammonium phosphate (DAP). The rates applied provide equivalent amounts of N for the different N sources (Table 3). Fertiliser treatments were applied in 3 doses per year. Blanket application of MOP at 2 kg per palm per year (2 doses per year) was applied to all palms in the trial field since the trial commenced. In 2008, 2009 and 2010, no AMN and DAP were applied due to unavailability and not being easily accessible. All palms within the trial field received an annual blanket application of kieserite, TSP and Calcium borate (B) as well, at 1.0, 0.5 and 0.2 kg per palm respectively. This trial was the same design as Trial 125 in Kumbango. See 2001 Proposals for background.

Table 3. Nitrogen source treatments and rates

	Amount (kg/palm/year)		
Nitrogen Source	**Rate 1**	**Rate 2**	**Rate 3**
Ammonium sulphate	2.0	4.0	8.0
Ammonium chloride	1.6	3.2	6.4
Urea	0.9	1.8	3.6
Ammonium nitrate	1.2	2.4	4.8
Di-ammonium phosphate	2.3	4.6	9.2
	(g N/palm/year)		
All sources	420	840	1680

Data Collection
Recordings and measurements were taken on the central 16 palms in each plot. The number of bunches and bunch weights were recorded at 10 day harvesting intervals in line with company practice on an individual palm basis and totalled for each plot, then totalled for each harvest and expressed as per ha per year. Single bunch weight (SBW) was calculated from these data. Leaf sampling was carried out once annually according to standard procedures and analysed for nutrient concentrations using standard analytical procedures. Vegetative measurements were also done annually.

Statistical Analysis
Analysis of variance (Two-way ANOVA) of the main effects of fertiliser and their interactions were carried out for each of the variables of interest using the GenStat statistical program. Data collected from the control plots were not used in the analysis of variance (ANOVA) but mean values were used for comparing treatment effects.

RESULTS and DISCUSSION

Effects of treatments on FFB yield and its components
The effects of different N fertiliser sources and their rates on FFB yield and its components are presented in Tables 4 and 5. The difference in FFB yield between different N-fertiliser types was not statistically significant in 2010 and for the 2008-2010 periods (Tables 4 and 5). Since the trial commenced in 2001, N-type had no significant effect on yield. However, yield response to N-rate has been significant since 2003. In 2010 and the combined 2008-2010 period, the significant effect on yield was mainly due to a combined increase in the number of bunches (BNO) and single bunch weight (SBW). There was no difference between annual N-rates 0.84 and 1.68 kg per palm but the differences between either 0.42 and 0.84, and 0.42 and 1.68 kg per palm were significant. There was significant effect on the SBW in 2010 and combined 2008-2010 period (Table 4 and 5). In 2010 the difference in yield between +N and –N was about 24 t/ha. The average yield for +N was 36 t/ha and the average yield for –N was 12 t/ha in 2010. This indicates the importance of N in oil palm FFB production in this environment.

Table 4. Effects (p values) of treatments on FFB yield and its components in 2010 and 2008–2010.

Source	2010			2008 – 2010		
	Yield	**BNO**	**SBW**	**Yield**	**BNO**	**SBW**
Type	0.185	0.670	**<0.001**	0.305	0.712	**0.020**
Rate	**<0.001**	**<0.019**	**<0001**	**<0.001**	**<0.001**	**0.002**
Type. Rate	0.891	0.851	0.167	0.986	0.953	0.341
CV %	*10.9*	*11.4*	*6.0*	*7.7*	*8.4*	*4.7*

p values <0.05 are shown in bold.

Table 5. Main effects of treatments on FFB yield (t/ha) for 2008 - 2010 and 2010.

	2010			2008 – 2010		
Treatments	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**
Control	12.1 (7.8)	778	14.1	14.3 (10.6)	981	13.9
SOA	37.3	1640	**22.7**	36.0	1653	**21.8**
AMC	36.3	1626	**22.6**	36.5	1686	**21.8**
Urea	35.4	1671	**21.2**	34.9	1668	**20.9**
AMN	36.3	1726	**21.1**	36.1	1731	**20.8**
DAP	33.6	1628	**20.7**	34.4	1670	**20.7**
l.s.d.$_{0.05}$			*1.065*			*0.815*
Rate 1	**32.3**	**1561**	**20.7**	**31.7**	**1552**	**20.5**
Rate 2	**37.9**	**1732**	**21.9**	**37.2**	**1744**	**21.4**
Rate 3	**37.5**	**1681**	**22.4**	**37.7**	**1750**	**21.6**
l.s.d.$_{0.05}$	*2.486*	*120.3*	*0.823*	*1.737*	*90.2*	*0.632*
Grand mean	35.9	1658	21.7	35.6	1682	21.2
SE	3.903	188.8	1.292	2.727	141.7	0.992
CV %	*10.9*	*11.4*	*6.0*	*7.7*	*8.4*	*4.7*

p values <0.05 are shown in bold.

Effects of treatments on leaf (F17) nutrient concentrations

The effects of N-type and rates on leaf and rachis tissues are presented in Tables 6 and 7. N-type had a significant effect on rachis P (<0.001) contents only in 2010. Concentration of rachis P in the DAP treated plots was greater than in other N types treated plots. On the other hand, leaflet Ash, N, P and K, and rachis N contents were increased with N rates. Rachis P was depressed with N rates implying high N in the leaflets remobilising rachis P into the leaflets. The leaflet N concentration for the control plots was below the value considered critical (2.3%DM) for oil palm, compared to leaflet N concentrations for palms that received fertiliser, The data shows accumulation of P and K in the rachis from the basal applications.

Table 6. Effects (p values) of treatments on frond 17 nutrient concentrations in 2010.

Source		Leaflets nutrient concentrations							Rachis nutrient concentrations			
		Ash	N	P	K	Mg	B		Ash	N	P	K
Type		0.436	0.161	0.220	0.210	0.381	0.151		0.363	0.325	**<0.001**	0.718
Rate		0.380	**<0.001**	**0.006**	0.153	0.408	0.530		0.028	**0.002**	**<0.001**	0.636
Type. Rate		0.165	0.097	0.281	0.018	0.753	0.253		0.319	0.624	0.153	0.456
CV %		5.1	3.2	2.8	6.5	13.4	16.8		7.6	9.2	14.6	9.2

p values less than 0.05 are in bold.

Table 7. Trial 324, main effects of treatments on frond 17 leaf let and rachis nutrient concentrations in 2010, in units of % dry matter. Values for plots receiving zero N (control) were not included in the analysis of variance.

Treatment	Leaflet nutrient concentrations (% DM)						Rachis nutrient concentrations (% DM)			
	Ash	N	P	K	Mg	B (ppm)	Ash	N	P	K
Control	15.6	2.05	0.140	0.68	0.24	20	6.4	0.29	0.392	2.18
SOA	15.5	2.33	0.144	0.73	0.19	16	5.3	0.31	**0.156**	1.69
AMC	15.6	2.32	0.146	0.71	0.21	18	5.6	0.30	**0.162**	1.73
Urea	15.2	2.27	0.144	0.71	0.21	20	5.6	0.29	**0.182**	1.64
AMN	15.3	2.27	0.143	0.69	0.20	19	5.4	0.28	**0.186**	1.67
DAP	15.7	2.29	0.144	0.72	0.21	18	5.4	0.30	**0.239**	1.70
l.s.d.$_{0.05}$									0.0222	
Rate 1	15.4	**2.18**	**0.142**	0.70	0.20	18	5.7	**0.28**	**0.223**	1.72
Rate 2	15.3	**2.32**	**0.145**	0.72	0.20	19	5.3	**0.29**	**0.183**	1.67
Rate 3	15.7	**2.39**	**0.146**	0.73	0.21	18	5.4	**0.31**	**0.149**	1.68
l.s.d.$_{0.05}$		*0.0613*	*0.003*					*0.0174*	*0.0172*	
GM	15.5	2.30	0.144	0.71	0.20	18	5.5	0.29	0.185	1.69
SE	0.785	0.004	0.004	0.0463	0.0271	3.069	0.416	0.027	0.0271	0.1565
CV %	5.1	3.2	2.8	6.5	13.4	16.8	7.6	9.2	14.6	9.2

p values less than 0.05 are shown in bold.

Effects of fertiliser treatments on Vegetative parameters

N-type treatment had a significant effect on PCS (p=0.010), LAI (p=0.004) FDM (p=0.002), TDM, FDM and VDM (Tables 9 and 10). Petiole cross section of palms in AMC fertilised plots were greater than those in the other N source treated plots but this was not reflected in the dry matter production. However, the significant effect of N type on the vegetative dry matter production did not translate to significant differences in yield though AMC fertilised plots did produce the highest yield.

N-rate treatment had a significant effect on all the physiological parameters except for HI and BI (Tables 9 and 10). The differences between 0.42 and either 0.84 or 1.68 kg of N per palm were significant but not between 0.84 and 1.68 kg of N per palm (l.s.d.$_{0.05}$.). Generally, physiological parameters in the control plots were lower than in the N fertilised plots. These results correspond well with yield and leaf tissue results.

Table 9. Effect (p values) of treatments on vegetative growth parameters in 2010.

Source				Radiation interception			Dry matter production				
	FL	**HI**	**PCS**	**FP**	**FA**	**LAI**	**FDM**	**BDM**	**TDM**	**VDM**	**BI**
Fert. type	0.091	0.351	**0.010**	0.064	0.101	**0.004**	**0.002**	0.193	**0.002**	**0.001**	0.288
Rate	**0.019**	0.086	**<0.001**	**<0.001**	**0.017**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	**<0.001**	0.054
Type.Rate	0.408	0.544	0.940	0.073	0.273	0.192	0.375	0.883	0.394	0.394	0.848
CV %	*2.4*	*17.8*	*5.4*	*4.0*	*3.6*	*5.4*	*6.3*	*11.1*	*7.1*	*5.9*	*5.4*

p values less than 0.05 are shown in bold.

FL = frond length (cm), HI = Height increment (cm), PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM).

Table 10. Main effects of treatments on vegetative growth parameters in 2010.

Treatments				Radiation interception			Dry matter production (t/ha/yr)				BI
	FL	**HI**	**PCS**	**FP**	**FA**	**LAI**	**FDM**	**BDM**	**TDM**	**VDM**	
Control	540.9	62.3	27.6	21.1	9.6	4.26	8.7	6.9	17.3	10.4	0.36
SOA	663.4	77.0	**46.1**	23.9	13.5	**5.94**	**15.7**	19.9	**39.7**	**19.8**	0.50
AMC	661.7	72.8	**47.1**	23.3	13.6	**6.03**	**15.8**	19.6	**39.4**	**19.7**	0.50
Urea	648.9	67.9	**43.4**	22.8	13.1	**5.55**	**14.3**	18.9	**36.9**	**18.0**	0.51
AMN	659.6	67.6	**45.3**	23.1	13.3	**5.73**	**15.1**	19.3	**38.1**	**18.9**	0.50
DAP	650.9	70.4	**45.6**	23.0	13.4	**5.93**	**15.1**	17.9	**36.7**	**18.7**	0.50
$lsd_{0.05}$			*2.018*			*0.262*	*0.790*		***2.211***	*0.920*	
Rate 1	**648.5**	**65.9**	**42.9**	**22.1**	**13.1**	**5.58**	**13.7**	**17.2**	**34.3**	**17.1**	0.50
Rate 2	**661.0**	**73.2**	**45.9**	**23.3**	**13.5**	**5.83**	**15.4**	**20.2**	**39.5**	**19.3**	0.51
Rate 3	**661.1**	**74.3**	**47.7**	**24.3**	**13.5**	**6.10**	**16.6**	**19.9**	**40.6**	**20.7**	0.50
$lsd_{0.05}$	*9.92*	*8.09*	*1.563*	*0.596*		*0.203*	*0.612*	*1.349*	*1.715*	*0.713*	
GM	656.9	71.1	45.5	23.2	13.4	5.84	15.2	19.1	38.2	19.0	0.50
SE	15.58	12.69	2.454	0.935	0.485	0.318	1.961	2.117	2.693	1.119	0.026
CV %	2.4	17.8	*5.4*	*4.0*	*3.6*	*5.4*	*6.3*	*11.1*	*7.1*	*5.9*	*5.4*

Significant effects ($p<0.05$) are shown in bold.

FL = frond length (cm), HI = Height increment (cm), PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM).

CONCLUSION

N-type treatment had no significant effect on yield and its components. However, significant effects were seen on rachis P concentrations, petiole cross section and dry matter production in 2010. The non significant effect on yield was consistent since the trial started in 2001. N-rate treatment had a significant effect on yield, tissue N and most physiological growth parameters. Increasing N rate from 0.42 kg per palm to higher rates increased yield, leaflet N and HI, PCS, FP, FA, LAI, FDM, BDM, TDM and VDM production. Yield, leaflet N concentration and physiological growth parameters for the palms that did not receive N fertiliser were comparatively lower than the palms that received N fertiliser. This indicates that without fertiliser N, oil palm production cannot be sustained or increased.

Trial 326: Nitrogen x EFB Trial on Volcanic Soils, Sangara Estate (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

This trial tests 4 rates of sulphate of ammonia (SOA) and 3 rates of empty fruit bunch (EFB) in a factorial combination, resulting in 12 treatments. The trial design is Randomised Complete Block Design (RCBD). The 12 treatments were randomly allocated within a block of 12 plots and each treatment was replicated 5 times, resulting in 60 plots. The purpose of the trial was to provide information on minimum EFB and N requirements of palm to help formulate fertiliser

recommendations on volcanic plain soils of Higaturu, Popondetta. SOA had a significant effect on yield in 2010 (p=0.003) but not the combined yield in 2008-2010 period. There was an increase in single bunch weight in 2010 despite a decrease in bunch number from 2009. Empty fruit bunch increased yield from 32.1 to 35.7 t/ha. SOA treatment had significant effect on leaflet and rachis N concentrations. EFB significantly increased leaflet N and K, and rachis P and K concentrations but lowered leaflet Mg and B contents. Regardless of treatment effects only nutrients of rachis N, P and K were above their respective critical concentrations compare to concentrations of leaflets (less than critical values). SOA had a significant effects on PCS (p=0.004), FP, LAI, FDM, TDM and VDM but not any other measured or calculated vegetative growth parameter. EFB significantly increased all the vegetative parameters except for FP, FA, LAI and BI

INTRODUCTION

The trial was established in 2002 at Higaturu Oil Palms (Popondetta) to provide information on minimum EFB and N requirements of oil palm to help formulate fertiliser recommendations on volcanic plain soils. Nitrogen is by far the main nutrient limiting fresh fruit bunch (FFB) production in oil palm and thus large amounts are required to increase yields of FFB. However, N requirement can be reduced when applied in combination with EFB as shown by results from closed PNGOPRA field trials 311 and 312. In trial 312, no FFB yield plateau was reached when increasing SOA from 0 to 6kg of SOA per palm but FFB yield did plateau off at a combined application of 4kg of SOA and 250 kg of EFB per palm per year. In trials 311 and 312, only 1 rate of EFB (250 kg/palm/year) was tested. This trial was designed to test 3 rates to determine which rate would produce optimum FFB yield, when applied in combination with varying rates of SOA. EFB contains 0.6, 2.0 and 0.05 % (dry matter) of N, K and P respectively. Background information of trial 326 is presented in Table 1. Pre-treatment soil data indicate that pH is slightly acidic in the topsoil and becomes less acidic at soil depth (Table 2). CEC falls between the low and moderate category, with adequate levels of exchangeable Mg. Exchangeable K is moderate in the top 0-10 cm layer, the next three layers have low levels of exchangeable K. Organic matter contents and total N are quite reasonable.

Table 1. Trial 326 background information.

Trial number	**326**	Company	Kula Oil Palms
Estate	Sangara	Block No.	Sangara AB0280
Planting Density	135 palms/ha	Soil Type	Volcanic ash
Pattern	Triangular	Drainage	Good
Date planted	1999	Topography	Slightly undulating
Age after planting	11	Altitude	188.70 m asl
Recording Started	2002	Previous Land-use	Oil palm
Planting material	Dami D x P	Area under trial soil type (ha)	28.67
Progeny	Not known	Asst.Agronomist in charge	Susan Tomda

Table 2. Pre-treatment soil analysis results from samples taken in 2002.

Depth (cm)	**pH**	**Exch K (cmol/kg)**	**Exch Ca**	**Exch Mg**	**Exch Na**	**CEC**	**Res. K**	**Base Sat. (%)**	**Org. Matter (%)**	**Total N (%)**	**Olsen P (mg/kg)**	**Sulfate S (mg/kg)**	**Org S**
0-10	5.5	0.28	5.5	1.09	<0.05	13	<0.1	51	4.4	0.25	6	7	7
10-20	5.6	0.18	4.6	0.71	<0.05	11	0.1	52	2.4	0.14	3	6	3
20-30	5.9	0.12	5.3	0.83	0.09	9	0.1	63	1.5	0.09	3	6	2
30-60	6.1	0.13	6.5	1.23	0.16	12	<0.1	67	0.9	0.07	4	11	1

METHODS

The SOA.EFB trial was set up as a 4 x 3 factorial arrangement, resulting in 12 treatments (Table 3). The trial design is Randomised Complete Block Design (RCBD). There are 12 treatments, replicated 5 times, resulting in 60 plots. Each plot consists of 36 palms, with the inner 16 being the recorded and the outer 20 being the guard palms. See 2001 Proposals for background. SOA treatments are applied in 3 doses per year. EFB treatments are applied once every year.

The plots are surrounded by a trench to prevent nutrient poaching between plots. Palms that are not in the plots but are in the same block are termed perimeter palms, and they receive 2 kg per palm of urea.Every palm within the trial field receives basal applications of 1 kg Kieserite, 0.5 kg of TSP and 0.2 kg of Calcium Borate annually. Recordings and measurements are taken on the central 16 palms in each plot. The number of bunches and bunch weights are recorded at 10 days harvest intervals on an individual palm basis and totalled for each plot, then totalled for each harvest and expressed per ha per year. Single bunch weight (SBW) was calculated from these data. Leaf sampling is carried out according to standard procedures and analysed for nutrient concentrations using standard analytical procedures. Analysis of variance of the main effects of fertiliser and their interactions were carried out for each of the variables of interest using the GenStat statistical program.

Table 3. Fertiliser treatments and levels for Trial 326.

Treatments	**Amount (kg/palm/yr)**			
	Level 1	**Level 2**	**Level 3**	**Level 4**
SOA	0	2.5	5.0	7.5
EFB	0	130	390	-

RESULTS and DISCUSSION

Effects of treatment on FFB yield and its components

Effects of fertiliser on yield and its components are presented in Tables 4 and 5. SOA for the first time after since 2002 (after 8 years) had a significant effect on FFB yield (p=0.003) in 2010. EFB also increased yields in 2010 and in 2008-2010. The increases in yield were due to significant increase in the single bunch weights and the number of bunches though latter component was not statistically significant. The mean yield was 34.6 t/ha in 2010 compared to 33.5 t/ha in 2009.

Table 4. Effects (p values) of treatments on FFB yield and its components in 2010 and 2008-2010.

	2010				**2008 – 2010**		
Source	**FFB yield**	**BNO**	**SBW**		**FFB yield**	**BNO**	**SBW**
SOA	**0.003**	0.482	**0.006**		0.063	0.702	**0.019**
EFB	**0.003**	0.204	**0.017**		**0.010**	0.352	**0.027**
SOA.EFB	0.739	0.994	0.562		0.680	0.925	0.377
CV %	*10.0*	*10.9*	*6.8*		*8.7*	*10.0*	*5.7*

Table 5. Main effects of treatments on FFB yield (t/ha) in 2010 and from 2008 to 2010.

Treatments	**2010**			**2008-2010**		
	FFB yield (t/ha)	**BNO/ha**	**SBW (kg)**	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**
SOA 0	**31.4**	1387	**22.6**	32.0	1490	**21.5**
SOA 2.5	**36.1**	1472	**24.5**	35.5	1522	**22.8**
SOA 5.0	**34.7**	1439	**24.2**	32.7	1458	**22.5**
SOA 7.5	**35.6**	1457	**24.5**	34.2	1500	**22.9**
$l.s.d_{0.05}$	*2.533*					
EFB 0	**32.1**	1389	**23.2**	31.6	1456	**21.8**
EFB 130	**35.5**	1478	**24.1**	34.2	1524	**22.5**
EFB 390	**35.7**	1448	**24.7**	34.2	1497	**23.0**
$l.s.d_{0.05}$	*2.194*					*0.817*
GM	34.4	1439	24.0	33.3	1492	22.4
SE	3.451	157.1	1.622	2.908	149.8	1.285
CV %	10.0	10.9	6.8	8.7	10.0	5.7

Effects of interaction between treatments on FFB yield

There was no significant interaction of SOA.EFB but the highest yield of 37.7 t/ha was obtained at 2.5 kg SOA/palm/year and 390 kg EFB per palm (Table 6).

Table 6. Effect of SOA and EFB (two-way interactions) on FFB yield (t/ha/yr) in 2010. The interaction was not significant (p=0.739).

	EFB 0	EFB 130	EFB 390
SOA 0	28.3	32.3	33.8
SOA 2.5	33.1	**37.4**	**37.7**
SOA 5.0	32.7	**35.1**	**36.2**
SOA 7.5	34.6	**37.3**	**35.1**
Grand mean: 34.4	*sed 2.182*		

Effects of SOA and EFB treatments on leaf (F17) nutrient concentrations

SOA treatment had a positive significant effect on leaflet N and rachis N and K concentrations in 2010 (Tables 7 and 8). EFB treatment had a significant effect on the concentrations of leaflet Ash, N and K, and rachis P and K (Tables 7 and 8) in 2010. The increase in rachis K concentrations was due to the high content of K in EFB (approx 2.0% DM).

Table 7. Effects (p values) of treatments on frond 17 (F17) nutrient concentrations 2010 (Trial 326).

	Leaflets						Rachis			
Source	**Ash**	**N**	**P**	**K**	**Mg**	**B**	**Ash**	**N**	**P**	**K**
SOA	0.361	**<0.001**	0.923	0.462	0.173	0.239	**0.049**	**<0.001**	0.057	**0.009**
EFB	**0.004**	**<0.001**	0.052	**0.002**	0.090	0.080	**<0.001**	0.285	**<0.001**	**<0.001**
SOA.EFB	0.935	**0.012**	0.416	0.548	0.554	0.656	0.403	**0.003**	0.601	0.533
CV%	*5.0*	*2.9*	*3.2*	*7.7*	*12.7*	*7.0*	*9.9*	*5.8*	*14.1*	*14.9*

p values <0.05 are indicated in bold.

Table 8. Main effects of treatments on F17 nutrient concentrations in 2010, in units of % dry matter, except for B (mg/kg) (Trial 326).

Treatments	**Leaflet nutrient concentrations (% DM)**						**Rachis nutrient concentrations (% DM)**			
	Ash	**N**	**P**	**K**	**Mg**	**B**	**Ash**	**N**	**P**	**K**
SOA 0	15.8	**2.34**	0.142	0.71	0.22	15	4.7	**0.29**	**0.099**	**1.28**
SOA 2.5	15.5	**2.45**	0.143	0.70	0.21	15	4.7	**0.30**	**0.086**	**1.31**
SOA 5.0	15.5	**2.44**	0.142	0.69	0.20	14	4.9	**0.32**	**0.090**	**1.46**
SOA 7.5	15.9	**2.45**	0.143	0.68	0.20	15	5.1	**0.32**	**0.088**	**1.50**
$l.s.d_{0.05}$		*0.05*						*0.013*	*0.009*	*0.151*
EFB 0	**16.1**	**2.37**	0.140	**0.66**	0.22	15	**4.3**	0.30	**0.081**	**1.12**
EFB 130	**15.7**	**2.43**	0.142	**0.70**	0.20	15	**5.0**	0.31	**0.089**	**1.43**
EFB 390	**15.3**	**2.46**	0.144	**0.72**	0.20	14	**5.3**	0.31	**0.103**	**1.61**
$l.s.d_{0.05}$	*0.496*	*0.045*		*0.034*			*0.303*		*0.008*	*0.131*
GM	15.7	2.42	0.142	0.69	0.21	15	4.8	0.30	0.0911	1.39
SE	0.781	0.071	0.004	0.053	0.026	1.027	0.477	0.0176	0.0129	0.206
CV%	5.0	2.9	3.2	7.7	12.7	7.0	9.9	5.8	14.1	14.9

Effects with p<0.05are shown in bold.

Effects of fertiliser treatments on Vegetative parameters

The effects of SOA and EFB of measured vegetative growth parameters are presented in Tables 9 and 10. SOA had significant effects on PCS, FP, LAI and all dry matter components 2010, however the effects did not affect the BI. EFB continued to have significant effects on PCS and dry matter production but did not affect radiation interception parameters and BI.

Table 9. Effect (p values) of treatments on vegetative growth parameters in 2010.

Source				Radiation interception			Dry matter production				
	FL	HI	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
SOA	0.589	0.936	**0.004**	**<0.001**	0.308	**0.005**	**<0.001**	**0.002**	**<0.001**	**<0.001**	0.392
EFB	0.870	0.675	**0.047**	0.189	0.122	0.104	**0.020**	**0.002**	**<0.001**	**0.007**	0.191
SOA.EFB	0.544	0.378	0.864	0.313	0.690	0.547	0.381	0.839	0.485	0.344	0.881
CV %	*3.1*	*13.1*	*6.0*	*6.3*	*4.5*	*6.3*	*8.0*	*10.3*	*6.5*	*7.3*	*6.4*

p values less than 0.05 are shown in bold.

FL = frond length (cm), HI = Height increment (cm), PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM).

Table 10. Main effects of treatments on vegetative growth parameters in 2010.

Treatments				Radiation interception			Dry matter production (t/ha/yr)				BI
	FL	HI	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	
SOA 0	680.7	120.5	**46.0**	**21.9**	13.0	**6.0**	**14.4**	**16.6**	**34.5**	**17.9**	0.48
SOA 2.5	686.7	124.0	**48.0**	**23.9**	13.3	**6.4**	**16.5**	**19.1**	**39.5**	**20.4**	0.48
SOA 5.0	691.0	123.5	**49.0**	**24.0**	13.3	**6.5**	**16.8**	**18.4**	**39.1**	**20.8**	0.47
SOA 7.5	683.6	122.5	**49.9**	**24.6**	13.4	**6.5**	**17.6**	**18.9**	**40.6**	**21.7**	0.47
$lsd_{0.05}$			2.13	0.941		0.29	0.96	1.38	1.85	1.08	
EFB 130	687.0	124.7	**48.5**	23.3	13.4	6.3	**16.2**	**18.8**	**38.9**	**20.1**	0.48
EFB 390	685.9	123.0	**49.3**	24.1	13.4	6.5	**17.0**	**19.0**	**40.0**	**20.0**	0.47
$lsd_{0.05}$	683.5		*1.85*				*0.83*	*1.20*	***1.60***	*0.93*	
GM	685.5	122.6	48.3	23.6	13.3	6.3	16.35	18.2	38.4	20.2	0.47
SE	21.26	16.03	2.907	1.479	0.602	0.398	1.310	1.876	2.51	1.465	0.030
CV %	3.1	13.1	6.0	6.3	4.5	6.3	8.0	10.3	6.5	7.3	6.4

Significant effects ($p<0.05$) are shown in bold.

FL = frond length (cm), HI = Height increment (cm), PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM).

CONCLUSION

SOA had a significant effect on yield for the first time in 8 years. EFB continued to have significant effects on yield (and its components), leaf tissue nutrient concentrations and vegetative parameters. High yields are obtained in the presence of SOA and EFB.

Trial 329: Nitrogen, Potassium, Phosphorus and Magnesium Trial on Mamba Soils (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

The N.P.K.Mg trial was established on Mamba soils in Oro Province to provide a guide to fertiliser recommendations to estates and oil palm smallholder growers in this area. The trial block was planted in 1997 and the trial commenced in September 2002. The fertiliser treatments included SOA (2 rates); and MOP, Kieserite and TSP, all tested at 3 rates. There were no effects of fertilisers on yield in 2010, however only MOP treatment had been having significant effects on yield in the past. Leaf K levels were increased significantly by higher rates of MOP treatment but for MOP 0, K level dropped below the critical of 1.0% (rachis K), indicating that K is limiting nutrient in this area. One reason for other fertiliser treatments having no significantly effect on variables measured is that soil N, P, Mg levels

are high in the trial area, thus any response to N, P and Mg treatments are unlikely in the short to intermediate term. However, Mg content in the leaflets has been increasing from addition of Kie but this was not reflected in FFB yield responses.

INTRODUCTION

The trial was established with the intention to provide information for fertiliser recommendations for estates and smallholders in the Kokoda Valley, and Ilimo/Papaki and Mamba areas. Some back ground information about this trial is presented in Table 1.

Table 1. Trial 329 back ground information.

Trial number	**329**	Company	Kula Oil Palms
Estate	Mamba	Block No.	Komo Div. Block.AC0260
Planting Density	135 palms/ha	Soil Type	Mamba Soils
Pattern	Triangular	Drainage	Poor
Date planted	1997	Topography	Flat
Age after planting	10	Altitude	340.30 m asl
Recording Started	Sep 2001	Previous Land-use	Cocoa Plantation
Planting material	Dami D x P	Area under trial soil type (ha)	26.16
Progeny	Not known	Asst.Agronomist in charge	Susan Tomda

Soils of Ilimo/Kokoda and Mamba areas are different from soils of the Popondetta plains. The soils at Mamba are generally acidic (pH in water), are intermediate in cation exchange capacity (CEC) and have high P retention (Table 2). The soils are susceptible to frequent water-logging. Total N, OM%, total P, exchangeable K and exchangeable Mg are high in the top 10 cm of the soil and decrease progressively down the soil profile down to 60 cm.

Table 2. Soil chemical characteristics for bulked samples taken from each of the three experimental blocks in 2001.

Depth (cm)	pH	Olsen P	P Ret.	Exch. K	Exch. Ca	Exch. Mg	CEC	Org. Matter	Total N	Avail. N	Sulfate S	B
		mg/kg	(%)	(cmolc/kg)				(%)	(%)	(kg/ha)	(mg/kg)	
0-10	5.6	22	98	0.37	7.5	1.62	25.5	15.6	0.84	137	16	0.4
10-20	5.3	8	100	0.16	0.6	0.22	16.2	9.4	0.51	51	98	0.2
20-30	5.3	5	100	0.13	<0.5	0.11	11.6	6.3	0.36	23	184	0.1
30-60	5.4	7	92	0.14	<0.5	0.11	8.1	3.0	0.19	<10	176	0.1
0-10	5.6	17	99	0.43	6.3	1.41	24.2	14.4	0.81	130	23	0.4
10-20	5.3	6	100	0.16	0.9	0.24	14.9	8.9	0.52	55	133	0.2
20-30	5.4	5	100	0.17	0.6	0.19	12.9	7.5	0.38	38	202	0.1
30-60	5.5	7	95	0.18	<0.5	0.11	8.4	3.5	0.20	<10	201	<0.1
0-10	5.8	14	96	0.37	9.3	1.94	25.1	13.9	0.81	128	16	0.3
10-20	5.6	5	100	0.22	1.3	0.33	14.5	9.1	0.52	58	75	0.2
20-30	5.6	5	100	0.18	0.7	0.19	11.0	6.8	0.40	23	155	0.1
30-60	5.6	7	97	0.17	<0.5	0.14	8.5	4.0	0.23	<10	182	0.1
	Mean values											
0-10	5.7	17	98	0.39	7.7	1.66	24.9	14.6	0.82	132	18.3	0.4
10-20	5.4	6	100	0.18	0.9	0.26	15.2	9.1	0.52	55	102	0.2
20-30	5.4	5	100	0.16	<0.5	0.16	11.8	6.9	0.38	34	180	0.1
30-60	5.5	7	95	0.17	<0.5	0.12	8.3	3.5	0.21	<10	186	0.1

METHODS

The N P K Mg trial was set up as a 2 x 3x 3 x 3 factorial arrangement, resulting in 54 treatments with 36 palms per plot (Table 3). The 54 treatments were not replicated, and were arranged in 3 blocks of 18 plots. Fertilisers used were ammonium sulphate (SOA), triple superphosphate (TSP), potassium chloride (MOP) and kieserite (KIE) (Table 3). The fertiliser treatments were applied in 3 doses per year. The plots were surrounded by a trench to prevent plot-to-plot nutrient poaching. Palms that were not in plots but were in the same block were termed perimeter palms, and were fertilised according to plantation practice.The trial area received a basal application of borate at 50 g/palm/year. Recordings and measurements were taken on the central 16 palms in each plot. The number of bunches and bunch weights were recorded on 10 day harvesting intervals in line with company practice on an individual palm basis and totalled for each plot, then totalled for each harvest and expressed per ha per year. Single bunch weight (SBW) was calculated from these data. Leaf sampling was carried out according to standard procedures and analysed for nutrient concentrations using standard analytical procedures. Analysis of variance of the main effects of fertiliser and their interactions were carried out for each of the variables of interest using the GenStat statistical program.

Table 3. Fertiliser levels and rates used in Trial 329

Fertiliser treatments	Amount (kg/palm/year)		
	Level 1	Level 2	Level 3
SOA	2	4	
TSP	0	2	4
MOP	0	2	4
KIE	0	2	4

RESULTS and DISCUSSION

Main effects of treatments on FFB yield over the trial period

SOA did not affect yield in 2010 but had a positive effect for 2008-2010 period (Tables 4 and 5). The yield in 2010 increased by 1 tonne/ha but the increase was not statistically significant. One possible explanation for the lack of N response is that leaflet N concentrations were in the adequate range, indicating that N nutrition is not limiting yield. The reason for the high inherent N nutrient status is that soil organic matter and total N are high. High levels of soil organic matter and total N result in high levels of mineralization and available N, thus responses to N fertiliser are unlikely until soil N reserves are depleted with time. Similar to the effects of SOA treatment, TSP and KIE treatments had no significant effect on FFB yield in 2010 and 2008-2010 during the course of the trial except for MOP which affected yield and its components. On the other hand, increasing MOP from 0 to 4 kg per palm resulted in an increase (by 2-3 t/ha) in 2010 and 2008-2010. The mean yield in 2010 was 24.8 t/ha.

Table 4. Effects (p values) of treatments on FFB yield and its components in the combined harvest for 2008 – 2010 and for 2010 alone. p values less than 0.05 are in bold.

	2010				2008- 2010		
Source	**Yield**	**BNO**	**SBW**		**Yield**	**BNO**	**SBW**
SOA	0.123	**0.036**	0.946		**0.007**	**0.015**	0.688
TSP	0.072	**0.004**	0.560		0.388	0.094	0.396
MOP	0.196	0.734	**0.030**		**0.002**	0.282	**0.006**
KIE	0.250	0.517	0.214		0.189	0.240	0.871
SOA.TSP	0.365	**0.018**	0.429		0.947	0.299	0.195
SOA.MOP	**0.015**	**0.003**	0.984		**0.004**	0.063	0.145
TSP.MOP	0.263	0.251	0.400		0.955	0.276	0.168
SOA.KIE	0.485	0.181	0.715		0.701	0.930	0.638
TSP.KIE	0.329	0.252	0.446		0.089	0.237	0.315
MOP.KIE	**0.042**	**0.002**	0.560		0.141	0.144	0.572
CV %	*10.3*	*6.5*	*7.0*		*6.7*	*7.1*	*5.4*

Table 5. Main effects of treatments on FFB yield (t/ha) for the combined harvest for 2008 – 2010 and 2010 alone (Yield, Bunch No and SBW in bold are significant at P<0.05).

Treatments	2010			2008 – 2010		
(kg/palm/yr)	FFB yield (t/ha)	BNO/ha	SBW (kg)	FFB yield (t/ha)	BNO	SBW (kg)
SOA 2.0	24.2	**870**	27.8	**22.4**	**860**	26.0
SOA 4.0	25.4	**910**	27.9	**24.0**	**913**	26.2
$Lsd_{0.05}$		*36.38*		*0.980*	*39.66*	
TSP 0.0	23.8	**860**	27.6	23.0	885	26.0
TSP 2.0	24.5	**866**	28.3	22.8	861	26.5
TSP 4.0	26.1	**944**	27.6	23.6	914	25.8
		44.56				
MOP 0.0	23.8	897	**26.6**	**21.5**	866	**24.9**
MOP 2.0	25.4	891	**28.5**	**23.9**	892	**26.8**
MOP 4.0	25.1	882	**28.5**	**24.0**	901	**26.7**
$Lsd_{0.05}$			1.504	*1.200*		*1.076*
KIE 0.0	23.9	879	27.2	23.1	890	26.0
KIE 2.0	25.2	902	27.9	23.7	904	26.1
KIE 4.0	25.2	890	28.4	22.6	865	26.2
GM	24.8	890	27.8	23.1	887	26.1
SE	2.549	57.97	1.958	1.561	63.19	1.399
CV %	10.3	6.5	7.0	6.7	7.1	5.4

Effects of treatments on leaf (F17) nutrient concentrations

The effects of fertiliser treatments on leaf tissue nutrient contents are presented in Tables 6 and 7. SOA affected rachis N and P concentrations only in 2010. TSP treatment had a significantly effect on rachis P concentrations only. MOP treatment had a significant effect on leaflet K, Mg and B and rachis Ash, P and K concentrations. MOP increased leaflet K and rachis Ash, P and K but suppressed leaflet Ash, Mg and B contents. The rachis K content at nil MOP fertilised plots was very low at 0.42 % DM. The positive effect of MOP on leaf tissue K contents is also reflected in responses in yield. Kieserite increased only leaflet Mg concentrations in 2010. The mean nutrient contents were above their respective critical concentrations except for rachis K which was low at 0.96 % DM.

Table 6. Effects (p values) of treatments on frond 17 (F17) nutrient concentrations 2010 (Trial 329).

Source	Leaflets						Rachis			
	Ash	N	P	K	Mg	B	Ash	N	P	K
SOA	0.288	0.223	0.106	0.455	0.499	0.942	0.265	**0.013**	**0.009**	0.348
TSP	0.983	0.903	0.690	0.746	0.265	0.615	0.875	0.741	**0.041**	0.780
MOP	**0.017**	0.877	0.403	**<0.001**	**0.025**	**0.006**	**<0.001**	0.645	**0.035**	**<0.001**
KIE	**0.009**	0.629	0.058	0.708	**<0.001**	0.929	0.651	0.768	0.661	0.247
SOA.TSP	0.913	0.893	0.738	0.305	**0.013**	0.321	0.926	0.082	0.596	0.951
SOA.MOP	0.443	0.396	0.191	0.776	0.252	0.362	0.724	0.922	0.523	0.262
TSP.MOP	0.149	0.358	0.638	0.087	0.093	0.754	0.311	0.397	0.952	0.213
SOA.KIE	0.924	0.742	0.746	0.871	0.271	0.298	0.660	0.142	0.833	0.436
TSP.KIE	0.199	0.916	0.267	0.073	0.285	0.067	0.961	0.949	0.913	0.627
MOP.KIE	0.522	0.374	0.078	0.102	0.307	0.450	0.330	0.324	0.551	0.222
CV%	*9.7*	*7.4*	*2.4*	*11.2*		*11.5*	*18.4*	*6.1*	*18.4*	*22.7*

p values <0.05 are indicated in bold.

Table 7. Main effects of treatments on F17 nutrient concentrations in 2010, in units of % dry matter, except for B (mg/kg) (Trial 329).

Source	Leaflet nutrient contents						Rachis nutrient contents			
	Ash	**N**	**P**	**K**	**Mg**	**B**	**Ash**	**N**	**P**	**K**
SOA 2.0	8.9	2.43	0.158	0.66	0.29	15.8	3.6	**0.27**	**0.10**	0.99
SOA 4.0	9.2	2.49	0.159	0.67	0.25	15.8	3.4	**0.29**	**0.09**	0.93
$Lsd_{0.05}$								*0.0107*	*0.0107*	
TSP 0.0	9.1	2.48	0.159	0.67	0.24	16.1	3.6	0.28	**0.08**	0.99
TSP 2.0	9.1	2.45	0.158	0.67	0.27	15.5	3.5	0.28	**0.09**	0.94
TSP 4.0	9.0	2.46	0.159	0.65	0.26	15.8	3.5	0.28	**0.10**	0.94
MOP 0.0	**9.7**	2.47	0.159	**0.58**	**0.27**	**17.4**	**2.6**	0.28	**0.08**	**0.42**
MOP 2.0	**8.8**	2.44	0.158	**0.68**	**0.26**	**15.2**	**3.7**	0.28	**0.09**	**1.09**
MOP 4.0	**8.8**	2.46	0.159	**0.73**	**0.22**	**14.8**	**4.2**	0.28	**0.10**	**1.36**
$Lsd_{0.05}$	*0.677*			*0.057*	*0.035*	*1.398*	*0.4934*		*0.0132*	*0.1669*
KIE 0.0	**9.8**	2.43	0.157	0.66	**0.17**	15.7	3.6	0.28	0.09	0.90
KIE 2.0	**8.9**	2.46	0.160	0.67	**0.26**	15.9	3.6	0.28	0.10	1.03
KIE 4.0	**8.6**	2.49	0.159	0.65	**0.33**	15.8	3.4	0.28	0.09	0.94
$l.s.d_{0.05}$	*0.677*				*0.035*					
GM	9.1	2.46	0.159	0.66	0.25	15.8	3.5	0.28	0.09	0.96
SE	0.881	0.183	0.004	0.075	0.046	1.819	0.642	0.0171	0.0171	0.2171
CV%	9.7	7.4	2.4	11.2	18.2	11.5	18.1	6.1	18.4	22.7

Effects with $p<0.05$are shown in bold

Effects of fertiliser treatments on Vegetative parameters

The effects of fertiliser treatments on vegetative growth parameters are presented in Tables 8 and 9. SOA had a positive effect on LAI, FDM, TDM and VDM in 2010. TSP and Kieserite did not affect any of the measured parameters while MOP affected PCS, FA and LAI.

Table 8. Effect (p values) of treatments on vegetative growth parameters in 2010.

Source				Radiation interception			Dry matter production				
	FL	**HI**	**PCS**	**FP**	**FA**	**LAI**	**FDM**	**BDM**	**TDM**	**VDM**	**BI**
SOA	0.875		0.323	0.067	0.157	**0.044**	**0.042**	0.079	**0.036**	**0.039**	0.802
TSP	0.826		0.141	0.713	0.192	0.663	0.337	0.064	0.125	0.293	0.225
MOP	0.854		**0.025**	0.170	**0.030**	**0.027**	0.170	0.095	0.097	0.151	0.253
KIE	0.925		0.372	0.203	0.765	0.938	0.099	0.107	0.065	0.087	0.554
SOA.TSP	0.137		0.242	0.212	0.914	0.793	0.273	0.179	0.911	0.385	**0.021**
SOA.MOP	0.930		0.751	0.967	0.761	0.651	0.983	**0.003**	0.045	0.812	**0.002**
TSP.MOP	0.480		0.157	0.808	0.799	0.808	0.395	0.183	0.307	0.394	0.122
SOA.KIE	0.714		0.901	0.942	0.406	0.317	0.997	0.815	0.930	0.994	0.770
TSP.KIE	0.741		0.770	0.996	0.773	0.916	0.976	0.247	0.702	0.979	0.179
MOP.KIE	0.702		0.402	0.484	0.868	0.797	0.673	0.022	0.121	0.584	0.054
CV%	*4.5*		*4.4*	*6.7*	*5.5*	*7.7*	*7.7*	*9.4*	*7.4*	*7.5*	*5.1*

p values less than 0.05 are shown in bold.

FL = frond length (cm), HI = Height increment (cm), PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM).

Table 9. Main effects of treatments on vegetative growth parameters in 2010.

Treatments			**Radiation interception**			**Dry matter production (t/ha/yr)**				**BI**
	FL	**PCS**	**FP**	**FA**	**LAI**	**FDM**	**BDM**	**TDM**	**VDM**	
SOA 2	697.8	50.5	22.4	13.57	**6.58**	**15.1**	12.7	**30.8**	**18.2**	0.41
SOA 4	696.4	52.0	21.2	13.90	**6.92**	**15.9**	13.4	**32.5**	**19.1**	0.41
$l.s.d_{0.05}$					*0.328*	*0.748*		*1.475*	*0.880*	
TSP 0	693.9	51.1	20.7	13.78	6.75	15.1	12.5	30.7	18.2	0.41
TSP 2	697.0	52.8	20.8	13.45	6.67	15.7	12.9	31.7	18.8	0.40
TSP 4	700.5	51.9	21.0	13.97	6.84	15.6	13.6	32.5	18.9	0.42
$l.s.d_{0.05}$										
MOP 0	697.0	**50.5**	20.8	**13.21**	**6.42**	15.1	**12.4**	**30.6**	18.1	0.40
MOP 2	700.2	**52.0**	20.7	**14.04**	**6.98**	15.4	**13.3**	**31.9**	18.6	0.42
MOP 4	694.2	**53.2**	20.9	**13.95**	**6.87**	15.9	**13.3**	**32.5**	19.2	0.41
$l.s.d_{0.05}$		*1.744*		*0.614*	*0.401*					
KIE 0	699.5	51.3	20.3	13.82	6.74	14.9	**12.4**	**30.4**	17.9	0.41
KIE 2	696.3	52.4	21.2	13.76	6.79	15.8	**13.3**	**32.3**	19.1	0.41
KIE 4	695.6	52.1	21.0	13.63	6.74	15.7	**13.3**	**32.2**	18.9	0.41
$l.s.d_{0.05}$										
GM	697.1	51.9	20.8	13.74	6.75	15.5	13.0	31.7	18.6	0.41
SE	31.67	2.269	1.402	0.752	0.522	1.192	1.221	2.351	1.402	0.021
CV %	4.5	4.4	6.7	5.5	7.7	7.7	9.4	7.4	7.5	5.1

Significant effects ($p<0.05$) are shown in bold.

FL = frond length (cm), HI = Height increment (cm), PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM).

CONCLUSION

Of all the fertiliser treatments only MOP had a major positive effect on FFB yield (though insignificant in 2010), leaf tissues and physiological parameters in 2010. Increasing MOP from 0 kg per palm per year to any other rate increased yield by 1 to 3 t/ha. Leaf K levels and dry matter production, specifically BDM and TDM were also increased by higher rates of MOP. We expect that the lack of N response is due to high inherent N soil nutrient status. The high levels of soil organic matter and total N results in high levels of N mineralization making nitrate and ammonium freely available. These results were similar to the previous year's results.

Trial 334: Nitrogen x Phosphorus Trial (Mature Phase) on Volcanic Ash Soils, Sangara Estate (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

This trial tests 3 rates of urea and 5 rates TSP in a factorial combination, resulting in 15 treatments. The trial design is Randomised Complete Block Design (RCBD). The 15 treatments were randomly allocated and replicated 3 times, resulting in 45 plots. The purpose of the trial was to determine the optimum P and N supply rate and to determine critical P (or N/P ratio) deficiency level in leaflets and rachis of palms of different age and with differing N status.

INTRODUCTION

There has been little response to P fertiliser in previous trials in Higaturu. However P leaf levels have been falling over the last few years in Sangara Estate (0.154 in 2000; 0.143 in 2004) whilst the critical level has been increasing (0.158 in 2000; 0.164 in 2004) as a result of improved N nutrition. The critical leaf level for P also changes with palm age. Thus it has been decided to start a new trial with a wide range of P supply rates and palms of different age. In addition, N supply can affect the movement of P from rachis to leaflet; such that at low N supply, increasing P supply only results in increase P accumulation in the rachis and not improved P nutrition of leaflets. Thus this trial also has a number of rates of N so that there is a better understanding of the relation between N and P nutrition – especially with respect to leaf and rachis nutrient levels. Background information of trial 324 is presented in Table 1.

Table 1. Trial 334 background information.

Trial number	334	Company	Kula Oil Palms
Estate	Sangara	Block No.	AB0190,AB0210,AB220
Planting Density	135 palms/ha	Soil Type	Volcanic ash
Pattern	Triangular	Drainage	Good
Date planted	1999	Topography	Flat
Age after planting	11	Altitude(m)	104.79
Recording Started	2006	Previous Land-use	Oil palm replant
Planting material	Dami D x P	Area under trial soil type (ha)	30.83
Progeny	Not known	Asst.Agronomist in charge	Susan Tomda

METHODS

Urea treatment is to be applied three times per year while TSP will be applied twice a year (Table 2). Fertiliser applications started in 2007. Every palm within the trial field receives basal applications of 1 kg Kieserite, 2 kg MOP per palm as basal. Recordings and measurements are taken on the central 16 palms in each plot. The number of bunches and bunch weights are recorded on 10 days harvesting intervals on an individual palm basis and totalled for each plot, then totalled for each harvest and expressed per ha per year. Leaf sampling is carried out according to standard procedures and analysed for nutrient concentrations using standard analytical procedures. Analysis of variance of the main effects of fertiliser and their interactions were carried out for each of the variables of interest using the GenStat statistical program.

Table 2. Fertiliser treatments and levels for Trial 334.

Treatment	**Amount (kg/palm/year**				
	Level 1	**Level 2**	**Level 3**	**Level 4**	**Level 5**
Urea	1.0	2.0	5.0	-	-
TSP	0.0	2.0	4.0	6.0	10.0

RESULTS and DISCUSSION

Effects of treatment on FFB yield and its components

There was no effect of Urea and TSP on FFB yield and yield components in 2010 and 2008-2010 Tables 3 and 4). The mean FFB yield was 34.0 t/ha in 2010.

Table 3. Effects (p values) of treatments on FFB yield and its components in 2010.

Source	**2010**		
	FFB yield	**BNO**	**SBW**
Urea	0.058	0.411	0.086
TSP	0.281	0.211	0.527
Urea.x TSP	0.500	0.737	0.990
CV %	*9.3*	*11.0*	*6.3*

Table 4. Main effects of treatments on FFB yield (t/ha) for the combined harvest for 2008-2010 and 2010.

Treatments	2010			2008-2010		
	FFB yield (t/ha)	**BNO/ha**	**SBW (kg)**	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**
Urea 1	33.9	1689	20.1	34.2	1720	19.9
Urea 2	32.6	1609	20.3	34.6	1712	20.2
Urea 3	35.5	1685	21.2	35.1	1704	20.7
TSP 1	34.8	1656	21.0	35.1	1707	20.6
TSP 2	35.1	1767	19.9	34.8	1763	19.8
TSP 3	32.1	1553	20.7	33.1	1627	20.4
TSP 4	34.4	1678	20.5	36.0	1776	20.4
TSP 5	33.7	1650	20.5	34.1	1688	20.3
GM	34.0	1661	20.5	34.6	1712	20.3
SE	3.174	183.2	1.296	2.094	135.5	0.928
CV %	9.3	11.0	6.3	6.1	7.9	4.6

p values <0.05 are shown in bold.

Effects of interaction between treatments on FFB yield

There was no significant interaction between Urea and TSP on FFB yield but the highest yield of 37.2 t/ha was obtained at urea-3 and TSP-1 levels. It is still early to report actual responses (Table 5).

Table 5. Effect of Urea and TSP (two-way interactions) on FFB yield (t/ha/yr) in 2010. The interaction was not significant (p=0.500).

	TSP-1	**TSP-2**	**TSP-3**	**TSP-4**	**TSP-5**
Urea-1	34.2	35.6	30.2	35.5	34.2
Urea-2	32.9	34.8	29.6	33.8	31.8
Urea-3	37.2	35.0	36.4	33.7	35.0
Grand mean	34.6				

Effects of Urea and TSP treatments on leaf (F17) nutrient concentrations

Though the results indicate significant effects of SOA on rachis P and TSP on Mg but the actual values are not very clear to interpret (Tables 6 and 7). The trial will be monitored with time to see if there will be any effects in the future. Mean nutrient concentrations for leaflets and rachis of all the plots were above their respective critical levels.

Table 6. Effects (p values) of treatments on frond 17 (F17) nutrient concentrations 2010. p values <0.05 are indicated in bold.

Source	Leaflet						Rachis			
	Ash	**N**	**P**	**K**	**Mg**	**B**	**Ash**	**N**	**P**	**K**
Urea	0.807	0.086	0.057	0.602	0.547	0.348	0.459	0.773	**0.002**	0.761
TSP	0.391	0.198	0.211	0.464	**0.021**	0.594	0.547	0.314	0.062	0.862
Urea.TSP	0.669	0.311	**0.038**	0.351	0.785	0.208	0.315	0.322	0.212	0.221
CV%	*3.3*	*2.5*	*2.4*	*5.3*	*10.2*	*6.8*	*10.3*	*6.2*	*13.9*	*13.0*

Table 7. Main effects of treatments on F17 nutrient concentrations in 2010, in units of % dry matter, except for B (mg/kg) (Trial 334).

Treatments	Leaflet nutrient contents (% DM)						Rachis nutrient contents (% DM)			
	Ash	N	P	K	Mg	B (ppm)	Ash	N	P	K
Urea-1	14.2	2.46	0.147	0.79	0.22	14.9	5.0	0.293	**0.15**	1.50
Urea-2	14.3	2.48	0.148	0.78	0.22	14.5	5.0	0.298	**0.15**	1.54
Urea-3	14.3	2.51	0.150	0.79	0.21	14.4	5.2	0.297	**0.15**	1.54
l.s.d$_{0.05}$									0.014	
TSP-1	14.1	2.46	0.147	0.79	**0.21**	14.9	4.9	0.297	0.12	1.51
TSP-2	14.4	2.52	0.147	0.80	**0.22**	14.3	5.3	0.298	0.12	1.57
TSP-3	14.1	2.45	0.147	0.78	**0.22**	14.4	4.9	0.302	0.12	1.51
TSP-4	14.4	2.48	0.150	0.79	**0.23**	14.8	5.0	0.284	0.14	1.48
TSP-5	14.4	2.50	0.150	0.77	**0.22**	14.6	5.1	0.299	0.14	1.57
l.s.d$_{0.05}$					0.0215					
GM	14.3	2.48	0.148	0.79	0.22	14.6	5.1	0.296	0.130	1.53
SE	0.475	0.062	0.004	0.042	0.022	0.989	0.522	0.018	0.018	0.199
CV %	3.3	2.5	2.4	5.3	10.2	6.8	10.3	6.2	13.9	13.0

Effects with p<0.05are shown in bold.

Effects fertiliser treatments on vegetative parameters

Urea treatment had no significant effect on all vegetative parameters except TDM (p=0.05). TSP also did not have any effect on the measured vegetative parameters. There was a significant interaction between Urea and TSP but is not sure if the interaction was true (Tables 8 and 9).

Table 8. Effects (p values) of treatments on F#17 nutrient concentrations 2010.

Source				Radiation interception			Dry matter production				
	FL	HI	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	BI
Urea	0.501	0.868	0.111	0.551	0.207	0.865	0.211	0.049	**0.050**	0.172	0.134
TSP	0.943	0.472	0.540	0.892	0.087	0.466	0.895	0.210	0.643	0.982	0.152
Urea x TSP	0.948	0.938	0.822	0.154	**0.003**	0.387	0.318	0.438	0.262	0.273	0.613
CV %	4.9	24	*6.6*	*4.8*	*4.0*	*6.5*	*8.6*	*9.0*	*6.6*	*7.6*	*4.6*

p values <0.05 are indicated in bold.

Table 9. Main effects of treatments on vegetative growth parameters in 2010.

Treatments				Radiation interception			Dry matter production (t/ha/yr)				BI
	FL	HI	PCS	FP	FA	LAI	FDM	BDM	TDM	VDM	
Urea-1	671.3	68.9	45.2	16.6	13.8	6.26	10.8	17.8	**31.8**	14.0	0.56
Urea-2	658.3	66.1	47.5	16.5	13.6	6.27	11.3	17.2	**31.6**	14.4	0.54
Urea-3	658.3	66.3	47.1	16.8	13.4	6.20	11.4	18.7	**33.4**	14.8	0.59
lsd $_{0.05}$									*1.591*		
TSP-1	668.0	59.3	46.8	16.4	13.9	6.32	11.1	18.3	32.6	14.3	0.56
TSP-2	658.3	72.7	45.2	16.8	13.3	6.68	10.9	18.6	32.8	14.2	0.57
TSP-3	669.3	66.4	47.7	16.6	13.4	6.20	11.4	16.9	31.4	14.5	0.54
TSP-4	669.8	66.4	46.4	16.8	13.7	6.20	11.2	18.1	32.5	14.4	0.56
TSP-5	666.6	70.6	46.8	16.7	13.9	6.42	11.2	17.6	32.0	14.4	0.55
lsd $_{0.05}$											
Grand mean	666.4	67.1	46.6	16.7	13.6	6.24	11.2	17.9	32.3	14.4	0.55
SE	32.56	16.10	3.056	0.801	0.544	0.406	0.964	1.607	2.133	1.096	0.026
CV %	4.9	24.0	*6.6*	*4.8*	*4.0*	*6.5*	*8.6*	*9.0*	*6.6*	*7.6*	*4.6*

Significant effects ($p<0.05$) are shown in bold.

FL = frond length (cm), FLI = Frond length increment (cm), PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM).

CONCLUSION

The trial commenced in 2007 and there it was still early to report any true responses to fertiliser treatments.

Trial 335. Nitrogen x TSP Trial (Immature Phase) on Outwash Plains Soils, Ambogo Estate (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

This trial tests 3 rates of urea and 5 rates TSP in a factorial combination, resulting in 15 treatments. The design of the trial is a Randomised Complete Block Design (RCBD). The 15 treatments were randomly allocated and replicated 4 times, resulting in 60 plots. The purpose of the trial was to determine the optimum P and N supply rate and to determine critical P (or N/P ratio) deficiency level in leaflets and rachis of palms of different age and with differing N status.

INTRODUCTION

There has been little response to P fertiliser in previous trials in Higaturu. However P leaf levels have been falling over the last few years in Sangara Estate (0.154 in 2000; 0.143 in 2004) whilst the critical level has been increasing (0.158 in 2000; 0.164 in 2004) as a result of improved N nutrition. The critical leaf level for P also changes with palm age. Thus it has been decided to start a new trial with a wide range of P supply rates and palms of different age. In addition, N supply can affect the movement of P from rachis to leaflet; such that at low N supply, increasing P supply only results in increase P accumulation in the rachis and not improved P nutrition of leaflets. Thus this trial also has a number of rates of N so that there is a better understanding of the relation between N and P nutrition – especially with respect to leaf and rachis nutrient levels.

Table 1. Trial 335 background information.

Trial number	335	Company	Kula Oil Palms
Estate	Ambogo	Block No.	Ambogo AA0220
Planting Density	135 palms/ha	Soil Type	Volcanic outwash plains
Pattern	Triangular	Drainage	Good
Date planted	Oct/Nov 2007	Topography	Flat
Age after planting	3	Altitude	54.75m asl
Recording Started	2008	Previous Land-use	Oil palm replant
Planting material	Dami D x P	Area under trial soil type (ha)	24.56
Progeny	4 known Progenies	Asst.Agronomist in charge	Susan Tomda

METHODS

The Urea.TSP trial was set up as a 3 x 5 factorial arrangement, resulting in 15 treatments. The design of the trial is Randomised Complete Block Design (RCBD). The 15 treatments were replicated 4 times, resulting in 60 plots. Each plot consists of 36 palms, with the inner 16 being the recorded and the outer 20 being the guard palms. Planned fertiliser treatment applications are as scheduled (Tables 2 and 3). Soils sampling, initial leaf tissues and vegetative measurements were done in 2008. Yield recording will commence in 2009. Recordings and measurements are taken on the central 16 palms in each plot. The number of bunches and bunch weights are recorded on 10 day intervals on an individual palm basis and totalled for each plot, then totalled for each harvest and expressed per ha per year. Single bunch weight (SBW) was calculated from these data. Leaf sampling is carried out according to standard procedures and analysed for nutrient concentrations using standard analytical procedures.Analysis of variance of the main effects of fertiliser and their interactions are carried out for each of the variables using the GenStat statistical program.

Table 2. P Fertiliser schedule (g TSP/palm).

Year	Age	P Rate (kg TSP/palm/yr)				
		0	2	4	6	10
Planting	Hole	200	200	200	200	200
1st	6m	0	300	600	900	1,500
	12m	0	300	600	900	1,500
	Year 1 total	***0***	***600***	***1,200***	***1,800***	***3,000***
2nd	18m	0	450	900	1,350	2,250
	24m	0	450	900	1,350	2,250
	Year 2 total	***0***	***900***	***1,800***	***2,700***	***4,500***
3rd	30m	0	500	1,000	1,500	2,500
	36m	0	500	1,000	1,500	2,500
	Year 3 total	***0***	***1,000***	***2,000***	***3,000***	***5,000***
4th	42m	0	750	1,500	2,250	3,750
	48m	0	750	1,500	2,250	3,750
	Year 4 total	***0***	***1,500***	***3,000***	***4,500***	***7,500***
5th onwards	Split 1	0	1,000	2,000	3,000	5,000
	Split 2	0	1,000	2,000	3,000	5,000
	Year 5 and onwards total	***0***	***2,000***	***4,000***	***6,000***	***10,000***

Table 3. N Fertiliser schedule (g Urea/palm)

Year	Age	N Rate (kg Urea/palm/yr)		
		1	2	5
		------------- *g Urea/palm* ------------		
Planting	Hole	0	0	0
1st	1m	20	40	100
	3m	40	80	200
	6m	40	80	200
	9m	40	80	200
	12m	60	120	300
	Year 1 total	***200***	***400***	***1,000***
2nd	16m	120	240	600
	20m	120	240	600
	24m	160	320	800
	Year 2 total	***400***	***800***	***2,000***
3rd	28m	160	320	800
	32m	200	400	1,000
	36m	240	480	1,200
	Year 3 total	***600***	***1,200***	***3,000***
4th	40m	240	480	1,200
	44m	280	560	1,400
	48m	280	560	1,400
	Year 4 total	***800***	***1,600***	***4,000***
5th onwards	Split 1	320	640	1,600
	Split 2	320	640	1,600
	Split 3	360	720	1,800
	Year 5 and onwards total	***1,000***	***2,000***	***5,000***

RESULTS and DISCUSSION

Yield and yield components

Effects of fertiliser on yield and its components are presented in Tables 4 and 5. 2009 was the first year of yield recording and was the second year after field planting however, urea has already affected yield and single bunch weight (SBW). Urea increased FFB yield and this was due to an increase in the number of bunches and single bunch weight. There was no response to TSP and no interactions between Urea and TSP treatments.

Table 4. Effects (p values) of treatments on FFB yield and its components in 2010.

Source	**2010**		
	FFB yield	**BNO**	**SBW**
Urea	**0.003**	0.147	**<0.001**
TSP	0.847	0.671	0.404
Urea.x TSP	0.965	0.913	0.792
CV %	*11.5*	*9.3*	*6.5*

Table 5. Main effects of treatments on FFB yield (t/ha) in 2010

Treatments	2010		
	FFB yield (t/ha)	**BNO/ha**	**SBW (kg)**
Urea-1	**18.96**	3666	**5.16**
Urea-2	**19.91**	3632	**5.49**
Urea-3	**21.60**	3837	**5.63**
l.s.d$_{0.05}$	*1.479*		*0.226*
TSP-1	20.20	3607	5.61
TSP-2	19.51	3671	5.35
TSP-3	20.41	3753	5.44
TSP-4	19.98	3720	5.36
TSP-5	20.61	3808	5.40
Grand Mean	20.16	3712	5.43
SE	2.321	345.9	0.354
CV %	11.5	9.3	6.5

Effects of interaction between treatments on FFB yield

There was no significant interaction effect of Urea. TSP but the highest yield of 22.8 t/ha was obtained at urea-3 and TSP-5 (Table 6). It is still very early to report actual response.

Table 6. Effect of SOA and EFB (two-way interactions) on FFB yield (t/ha/yr) in 2010.

	TSP-1	TSP-2	TSP-3	TSP-4	TSP-5
Urea-1	18.77	19.24	19.76	18.24	18.78
Urea-2	20.13	18.92	19.99	20.27	20.26
Urea-3	21.71	20.62	21.48	21.43	22.88
Grand mean	20.16		Sed=1.641		

Monthly yields have increased and is fluctuating at around 2.2 t/ha at 40 months while the number of bunches also fluctuating at around 340 during the same period (Figures 1 and 2). Mean single bunch weight increased from <0.5 kg to 7.2 kg during the 40 months (Figure 3)

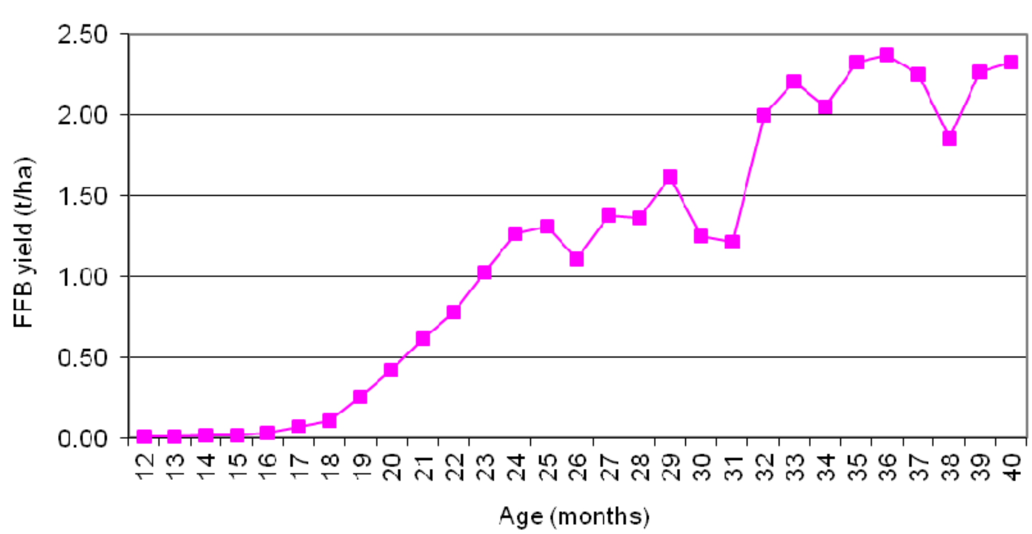

Figure 1. Mean FFB yield in t/ha from month 12 to month 40

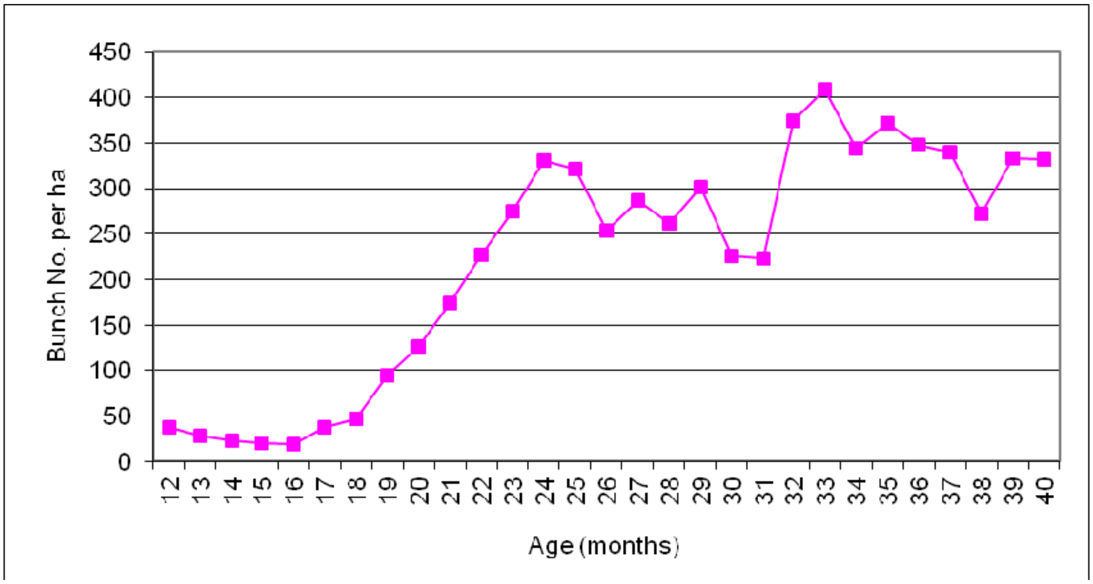

Figure 2. Mean number of bunches per ha from month 12 to month 40

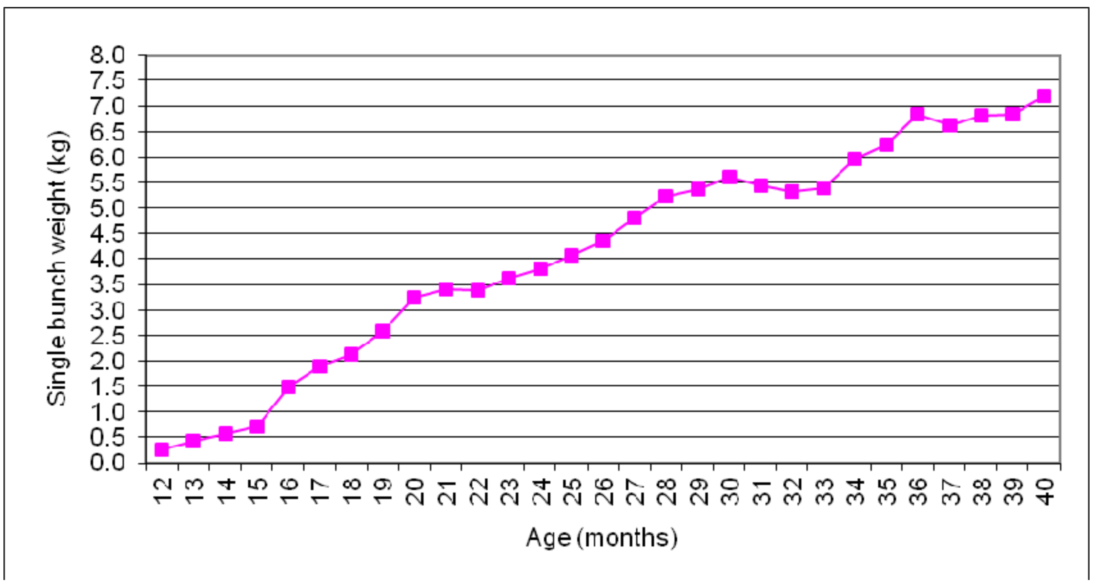

Figure 3. Mean single bunch weight from month 12 to month 40

Effects of Urea and TSP treatments on leaf (F17) nutrient concentrations

There was no significant effect on urea treatment on leaflet concentrations. However, Urea significantly increased rachis N and P while TSP increased leaflet ash only (Tables 7 and 8).

Table 7. Effects (p values) of treatments on frond 17 nutrient concentrations 2010. p values <0.05 are indicated in bold.

Source	Leaflets						Rachis			
	Ash	N	P	K	Mg	B	Ash	N	P	K
Urea	0.331	0.058	0.482	0.890	0.487	0.647	0.977	**0.004**	**0.013**	0.098
TSP	**0.043**	0.757	0.280	0.572	0.588	0.691	0.639	0.947	0.405	0.291
Urea.TSP	0.483	0.699	0.167	0.790	0.958	0.058	0.086	0.168	0.871	**0.022**
CV%	*8.6*	*4.2*	*2.7*	*8.1*	*9.7*	*12.2*	*16.0*	*6.8*	*27.1*	*8.9*

Table 8. Main effects of treatments on F17 nutrient concentrations in 2010, in units of % dry matter, except for B (mg/kg).

Treatments	Leaflet nutrient contents						Rachis nutrient contents			
	Ash	N	P	K	Mg	B	Ash	N	P	K
Urea-1	12.26	2.69	0.165	0.932	0.321	31.48	5.65	**0.288**	**0.188**	1.679
Urea-2	11.99	2.76	0.164	0.930	0.325	31.55	5.70	**0.301**	**0.166**	1.732
Urea-3	12.49	2.77	0.166	0.921	0.313	32.52	5.70	**0.311**	**0.144**	1.627
l.s.d$_{0.05}$								0.013	0.029	
TSP-1	**11.51**	2.72	0.163	0.947	0.324	32.25	5.66	0.300	0.146	1.753
TSP-2	**11.95**	2.72	0.165	0.949	0.329	32.00	6.03	0.298	0.178	1.693
TSP-3	**12.49**	2.73	0.166	0.909	0.313	32.97	5.50	0.299	0.161	1.667
TSP-4	**12.63**	2.75	0.165	0.913	0.320	31.20	5.67	0.304	0.174	1.662
TSP-5	**12.64**	2.78	0.166	0.920	0.312	30.85	5.55	0.299	0.174	1.662
l.s.d$_{0.05}$	0.864									
GM	12.25	2.74	0.165	0.928	0.319	31.85	5.68	0.300	0.166	1.679
SE	1.050	0.116	0.005	0.074	0.031	3.900	0.907	0.020	0.045	0.149
CV %	8.6	4.2	2.7	8.1	9.7	12.2	16.0	6.8	27.1	8.9

Effects with $p<0.05$are shown in bold

Urea significantly increased frond length, radiation interception parameters and dry matter production except BI and PCS. TSP does not affect any physiological parameters (Tables 9 and 10).

Table 9. Effects (p values) of treatments on frond 17 (F17) nutrient concentrations 2010.

Source				Radiation interception			Dry matter production				
	FL	PCS		FP	FA	LAI	FDM	BDM	TDM	VDM	BI
Urea	**0.029**	0.075		**0.049**	**0.002**	**0.016**	**0.026**	**0.005**	**0.002**	**0.012**	0.193
TSP	0.993	0.680		0.281	0.084	0.400	0.689	0.830	0.753	0.685	0.808
Urea x TSP	0.0986	0.668		0.327	0.825	0.529	0.428	0.958	0.892	0.485	0.737
CV %	4.3	*8.7*		*4.0*	*6.8*	*7.3*	*9.3*	*12.1*	*21.67*	*8.7*	*6.3*

p values <0.05 are indicated in bold.

Table 10. Trial 335, main effects of treatments on vegetative growth parameters in 2010.

Treatments				Radiation interception			Dry matter production (t/ha/yr)				BI
	FL	PCS		FP	FA	LAI	FDM	BDM	TDM	VDM	
Urea-1	**391.0**	15.72		**34.5**	4.81	**3.03**	**8.42**	**10.1**	**20.5**	**10.48**	0.48
Urea-2	**393.3**	16.33		**35.6**	4.92	**3.11**	**9.0**	**10.5**	**21.7**	**11.17**	0.48
Urea-3	**404.9**	16.76		**35.2**	5.2	**3.25**	**9.10**	**11.4**	**22.8**	**11.38**	0.50
lsd $_{0.05}$	10.88			0.889		0.146	0.526	0.823	1.185	0.610	
TSP-1	396.6	16.1		35.1	5.0	3.14	9.03	10.7	21.9	11.2	0.49
TSP-2	395.4	15.94		35.6	5.0	3.19	8.83	10.4	21.3	11.0	0.49
TSP-3	396.6	16.36		34.4	5.0	3.12	8.71	10.8	21.6	11.0	0.50
TSP-4	395.3	15.95		34.9	5.0	3.02	8.63	10.6	21.4	11.0	0.49
TSP-5	398.2	16.49		35.3	5.0	3.18	9.02	10.8	22.2	11.4	0.49
lsd $_{0.05}$											
Grand mean	396.4	16.27		35.1	5.0	3.13	8.84	10.7	21.7	11.01	0.49
SE	17.08	1.415		1.396	0.337	0.2290	0.825	1.293	1.861	0.958	0.031
CV %	4.3	*8.7*		*4.0*	*6.8*	*7.3*	*9.3*	*12.1*	*8.6*	*8.7*	*6.3*

Significant effects ($p<0.05$) are shown in bold.
FL = frond length (cm), FLI = Frond length increment (cm), PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM).

CONCLUSION

Urea has affected yield (and components), leaf tissue nutrient contents and physiological growth parameters in 2010 while TSP did have any effect except for leaflet ash.

Trial 331 Spacing and Thinning Trial, Ambogo Estate, Higaturu Oil Palm (RSPO 4.2, 4.3, 8.1)

SUMMARY

The trial was designed to test the effects of spacing configuration, thinning and planting density on fresh fruit bunch (FFB) yield and other variables of interest. From field planting, there were six densities treatments (128, 135, 143, 192, 203 and 215 palms/ha) but at 5 years of age (May 2006), the densities 192, 203 and 215 were thinned to 128, 135 and 143, respectively, which now become the replicate of the three originally lower densities but with different spacing configurations. Prior to thinning, a significantly high number of bunches (BNO) were produced at densities 192, 203 and 215 compared to the three lower densities. In 2006, the increase in the BNO resulted in significantly higher FFB yields. At lower densities, single bunch weight (SBW) was significantly higher.

INTRODUCTION

The purpose of the trial was to determine the effects of spacing configuration, thinning and density on palms, cover crops and soils, with a view to facilitating mechanical in-field collection. Mechanical removal of FFB from the field after harvest was an issue when the trial started. Mechanical removal is intended to reduce harvesting costs. Little is known about the impact that machine traffic has on the physical properties and long-term sustainability of the soils. Wider avenue spacing may allow more sunlight, better cover crop growth and less soil damage in the trafficked inter-rows. Soils of the trial area belong to the Ambogo/Penderetta families, which are of recent alluvially re-deposited volcanic ash, with loamy topsoil and sandy loam subsoil, and seasonally high water tables. Other background information of the trial is presented in Table 1.

Table 1. Trial 331 back ground information

Trial number	**331**	Company	Kula Oil Palms
Estate	Ambogo	Block No.	Ambogo AA0050
Planting Density	See Table 2	Soil Type	Alluvial flood plain
Pattern	Triangular	Drainage	Good
Date planted	2001	Topography	Flat
Age after planting	9	Altitude	79.81m asl
Recording Started	Jan 2002	Previous Land-use	Oil Palm plantation
Planting material	Dami D x P	Area under trial soil type (ha)	33.23
Progeny	Mixed Dami DxP	Asst.Agronomist in charge	Susan Tomda

METHODS

Design and treatments

Initially there were 6 treatments of different planting densities with equilateral triangular spacing (Table 2). In treatments 4, 5 and 6 every third row was removed 5 years after planting (May 2006) and treatments 1, 2 and 3 remained as planted. The final densities of treatments 4, 5 and 6 were the same as treatments 1, 2 and 3 but they have closely spaced pairs of rows with wide avenues between the pairs. There were 3 replicates of the 6 spacing treatments, giving a total of 18 plots. Each plot had 4 rows of recorded palms and these plots were surrounded by guard palms. In 2002, about a year after the palms were planted, 7 cover crops were sown in small plots throughout replicate 2 of the spacing trial in order to assess their performance under the different light and traffic conditions of the different spacing treatments. The cover crops were Pueraria, Calapogonium, Mucuna, Vigna, Desmodium, Centrosema and Stylo. The cover crop trial was discontinued as there was poor germination and establishment.

Table 2. Treatment allocations in Trial 331. 'Thinning' involves the removal of every third row 5 years after planting in treatments 4, 5 and 6.

Treatment No	Initial density (palms/ha)	Triangular spacing (m)	Initial number of rows/plot	Density after thinning (palms/ha)	Inter-row width after thinning (m)
1	128	9.50	7	128	8.2
2	135	9.25	7	135	8.0
3	143	9.00	7	143	7.8
4	192	7.75	8	128	13.4 & 6.7
5	203	7.55	9	135	13.1 & 6.5
6	215	7.33	9	143	12.7 & 6.4

Data Collection

Recordings and measurements were taken on the 4 rows of palms in each plot. The number of bunches and bunch weights were recorded fortnightly on an individual palm basis (individual palms not numbered) and totalled for each plot, then totalled for each harvest and expressed per ha per year. Single bunch weight was calculated from this data. During 2007, every recorded palm in each plot and record data against each numbered palm in the computer database system. Leaf sampling was carried out once annually according to standard procedures and analysed for nutrient concentrations using standard analytical procedures. Every 5th palm in every recorded row of palms was leaf sampled and vegetative measurements were also taken from same palms.

Statistical Analysis

Analysis of variance (One-way ANOVA) of the main effects of density treatments was carried out for each of the variables of interest using the GenStat statistical program.

RESULTS and DISCUSSION

Effects of density treatment on yield and yield components

Density treatments had a significant effect on yield and bunch number in 2010 and combine 2008-2010 (Tables 3 and 4). Treatments 1, 2 and 3 (un-thinned) produced yield which were significantly higher than the thinned densities. This was due to significantly higher number of bunches from the un-thinned densities. The yields after thinning in 2006 have been generally greater than 30 t/ha (Table 5).

Table 3. Effects (p values) of treatments on FFB yield and its components in 2008 and combined 2008-2010

Source	2010			2008 – 2010		
	Yield	BNO	SBW	Yield	BNO	SBW
Density treatment	**0.048**	0.172	0.109	**0.004**	**0.026**	0.074

Table 4. Main effects of treatments on FFB yield (t/ha) in 2008 and combined 2008-2010 (treatments which are significantly different at P<0.05 are presented in bold).

	2010			2008 – 2010		
Density Treatment	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**
128	**34.7**	1781	19.6	**36.0**	2050	17.7
135	**33.0**	1785	18.7	**35.6**	2063	16.9
143	**34.1**	1796	19.2	**35.0**	2035	17.4
128(192)	**32.4**	1630	20.1	**32.9**	1844	18.0
135(203)	**31.6**	1645	19.4	**31.7**	1839	17.4
143(215)	**30.8**	1629	19.1	**31.8**	1868	17.2
$l.s.d._{0.05}$	*2.546*			*2.045*		
GM	32.8	1711	19.3	33.7	1950	17.5
SE	1.399	104.1	0.534	1.124	93.0	0.384
CV %	4.3	6.1	2.8	3.3	4.8	2.2

(..) previous density

Table 5. FFB yield from the different densities from 2003 to 2010.

Treatment	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
128	15.3	21.4	29.4	29.6	39.4	37.1	36.2	34.7
135	14.4	21.4	29.2	29	37.6	35.6	35.1	33.0
143	16.0	20.2	28.4	29.9	38.4	35.6	35.3	34.1
128(192)	23.2	28.5	32.4	40.2	34.4	33.5	32.6	32.4
135(203)	19.5	28.2	26.5	37.8	32.6	32.3	31.4	31.6
143(215)	22.7	29.2	28.2	41.4	32.4	32.6	32.6	30.8
Significance						ns	ns	p=0.048
$l.s.d._{0.05}$								2.546
Grand mean	18.5	25.1	29.0	34.7	35.8	34.4	33.9	32.8

Leaf tissue nutrient concentrations

There was no difference in leaf tissue nutrient contents in 2010 (Tables 6 and 7). The nutrient concentrations were above their respective critical values for oil palm.

Table 6. P values of frond 17 nutrient concentrations 2010.

Source	**Leaflet**						**Rachis**			
	Ash	**N**	**P**	**K**	**Mg**	**B**	**Ash**	**N**	**P**	**K**
Density	0.739	0.646	0.816	0.146	0.688	0.707	0.435	0.072	0.758	0.579
CV%	*3.1*	*2.4*	*2.1*	*4.4*	*5.5*	*11.7*	*6.6*	*4.0*	*9.3*	*5.7*

p values <0.05 are indicated in bold.

Table 7. Main effects of treatments on F17 nutrient concentrations in 2010, in units of % dry matter, except for B (mg/kg).

Density	**Leaflet nutrient contents**						**Rachis nutrient content**			
	Ash	**N**	**P**	**K**	**Mg**	**B**	**Ash**	**N**	**P**	**K**
128	12.38	2.46	0.153	0.71	0.29	20	5.8	0.29	0.169	1.87
135	12.42	2.43	0.155	0.74	0.29	20	6.0	0.29	0.186	1.94
143	12.31	2.47	0.152	0.72	0.28	22	5.8	0.28	0.169	1.90
128 (192)	12.11	2.44	0.154	0.79	0.27	19	6.2	0.31	0.177	2.01
135 (203)	12.05	2.50	0.154	0.74	0.29	21	6.4	0.31	0.177	2.01
143 (215)	12.10	2.48	0.153	0.74	0.29	19	6.1	0.28	0.169	1.91
GM	12.23	2.46	0.154	0.74	0.28	20	6.0	0.29	0.174	1.94

Effects with p<0.05 are shown in bold.
(..) previous density

CONCLUSIONS

The density treatment had a significant effect on yield in 2010 and combined 2008-2010 period, with the higher yields achieved in un-thinned plots, Treatments 1, 2 and 3 (compared to treatments 4, 5 and

6). The number of bunches were significantly higher for the three un-thinned densities. Leaf tissue nutrient levels were generally at adequate levels.

NBPOL, KULA GROUP, POLIAMBA ESTATES, NEW IRELAND PROVINCE

(Murom Banabas and Paul Simin)

SUMMARY AND SYNOPSIS

A single fertiliser response trial was undertaken with Poliamba Estates in 2010:

Factorial trial response to B and K: two types of Boron fertiliser (CaB and NaB) were compared to a zero control in a factorial combination with two rates of MOP.

Outcome: thus far after two years of treatment implementation there has been no yield response to either B or MOP. However, leaf boron levels have increased with applied B fertiliser, but K levels have not changed (and this nutrient is present at an adequate level).

Poliamba Estates: Synopsis of 2010 PNGOPRA trial results and recommendations

Trial	Palm Age	Yield t/ha	Yield Components	Tissue % DM	Notes
254 Poliamba B, MOP (factorial) Soil: Clay over coral	22	SOA x MOP 27.6 (NS)	BHA 1004 (NS) SBW 27.5 (NS)	MOP LK 0.74 (NS) RK 1.76 B LB 15 to 17 mg/kg LN 2.58, RN 0.33: LP 0.153, RP 0.135 LMg 0.24	Plantation standards improved. Crop recovery is higher. In 2007 and 2008 CaB was not available, trial has been changed to a NxKxB trial.

Recommendations to Poliamba Estates:

- At Poliamba 30+ t/ha FFB should be attainable in mature plantations
- Tissue testing and vegetative measurement criteria will help in determining deficiencies of particular nutrients
- Most of the focus for nutrition should be on N, followed by P and K, followed by Mg and B
- Economic return from different fertiliser strategies can be calculated if costs of production are provided to OPRA
- Plantation management (harvest time, pruning, clean weeded circles, fertiliser application and timing etc) all play a large role in the potential to optimize production

Trial 254: Boron Requirement Trial at Poliamba (RSPO 4.2, 4.3, 4.6, 8.1)

SUMMARY

The trial is in its fourth year of full monitoring and assessment. All 3 fertiliser treatments affected yield and or tissue nutrient concentrations in 2009. CaB was not available in 2007/2008 and the trial was changed in 2008 to a NxKxB trial.

METHODS

Trial Background Information

Nitrogen, Boron and Potassium deficiency is evident in many blocks at Poliamba. This trial is designed to provide information that will help make recommendations for N, K and B fertiliser applications at Poliamba. Specifically, the original trial was designed to test responses to Ca borate or Na borate at two rates, and secondly, to test the interaction between Boron with Potassium. CaB was not available in 2007 and the trial was changed in early 2008 to an NxKxB trial. Background information to the trial is supplied in Table 1.

Table 1. Trial 254 background information.

Trial number	**254**	Company	CTP Poliamba Ltd.
Plantation	Maramakas	Block No.	MKS 210 E2
Planting Density	128 palms/ha	Soil Type	Brown clay over raised coral
Pattern	Triangular	Drainage	Free, except for in depressions
Date planted	1989	Topography	Undulating, depressions and sink holes
Age after planting	22 years	Altitude	50 m asl
Recording Started	2005	Previous Landuse	Coconut plantation/forest
Progeny	unknown	Area under trial soil type (ha)	3170
Planting material	Dami D x P	Supervisor	Paul Simin

Experimental Design and Treatments

After the change in trial design (see 2007 Annual Report) the current treatments consist of 2 rates of N; 2 rates of MOP and 3 rates of B – replicated 4 times for a total of 48 plots. The trial layout is a randomized block design, with pre-treatment measurements and soil depth used as covariates if necessary. 12 treatments x 4 replicates was analysed using ANOVA. Basal fertilisers applied to all plots: TSP 1 kg / palm, Kieserite 1 kg / palm and Urea 2kg / palm. The trial treatments were first applied in 2005 and this was the fourth full year of monitoring and assessment.

Changes made to trial design (T254) in early 2008

Originally the trial was a Boron type by rate (NaB vs CaB, applied at 0, 0.08 and 0.16kg/palm) and a MOP rate (2.5 and 7.5 kg/palm). However, in 2007 and 2008 it became difficult to source CaB and it was decided to change the trial to a rate trial using different rates of N, K and B. The change in treatment application was implemented in April 2008. The CaB treatment plots now receive the same rate of NaB; the MOP treatment plots remained the same; and two rates of AC were implemented (4 and 8 kg/palm) (Table 2).

Table 2. Trial 254 new trial layout (April 2008)

Plot	Rep	AC	MOP	NaB	Plot	Rep	AC	MOP	NaB
1	2	4	2.5	0	25	2	4	2.5	0.08
2	2	8	2.5	0	26	3	8	2.5	0.08
3	4	4	2.5	0	27	3	8	7.5	0.08
4	3	4	2.5	0.08	28	3	4	7.5	0
5	4	8	2.5	0.08	29	3	8	7.5	0.16
6	2	4	2.5	0.16	30	1	4	7.5	0
7	3	4	7.5	0.16	31	1	4	7.5	0.08
8	2	8	7.5	0.16	32	3	8	7.5	0
9	4	8	2.5	0.16	33	2	4	7.5	0.08
10	1	4	2.5	0	34	4	8	7.5	0
11	4	8	7.5	0.16	35	2	8	7.5	0.08
12	3	4	2.5	0.16	36	4	8	2.5	0
13	4	4	7.5	0	37	1	8	2.5	0.08
14	1	4	2.5	0.08	38	3	8	2.5	0.16
15	1	8	7.5	0.16	39	4	4	2.5	0.16
16	1	8	2.5	0	40	4	4	2.5	0.08
17	1	4	7.5	0.16	41	4	4	7.5	0.16
18	2	4	7.5	0	42	1	8	7.5	0.08
19	1	4	2.5	0.16	43	4	4	7.5	0.08
20	2	4	7.5	0.16	44	1	8	2.5	0.16
21	2	8	2.5	0.08	45	2	8	7.5	0
22	4	8	7.5	0.08	46	3	4	7.5	0.08
23	3	4	2.5	0	47	2	8	2.5	0.16
24	3	8	2.5	0	48	1	8	7.5	0

Treatment fertilisers

The treatment fertilisers applied every year are:

- N as AC applied at 4 and 8 kg/palm applied twice per year
- K as MOP applied at 2.5 and 7.5 kg/palm applied twice per year
- B as NaB applied at 0, 0.08 and 0.16 kg/palm applied once per year

Basal fertiliser: TSP at 1kg/p and Kieserite at 1kg/palm, both once per year

RESULTS and DISCUSSION

Yield and its components

Effects of fertiliser treatments on FFB yield and its components are presented in Tables 3 and 4. AC and MOP significantly increased FFB yield by 3 and 2 t/ha respectively in 2010 (see Table 4). There was no effect of boron, and the mean yield was 27.6 t/ha in 2010, compared to 33 t/ha in 2009. Though statistically not significant, increased yields due to addition of AC were further enhanced with MOP (Table 5). The yields were averaged over all levels of B because there was no clear response trend addition of B. Prior to the trial starting the soil depth immediately adjacent to each palm was measured and this was used as a co-variate in the Anova analysis; the pre-treatment data for 2004 was also tested as a co-variate. There was no improvement in the explanation of yield resulting from the different fertiliser treatments if soil depth was used as the co-variate. When the pre-treatment data for 2004 was used as the co-variate the explanation of the effect of the fertiliser treatment on yield was slightly improved (but still not significant).

Table 3. Trial 254, effects (p values) of treatments on FFB yield and its components for 2010 and 2008 to 2010 (3 years averaged data).

Source		**2010**				**2008 to 2010**		
		Yield	**BN**	**SBW**		**Yield**	**BN**	**SBW**
AC		**<0.001**	**0.006**	0.444		**<0.001**	0.052	0.501
MOP		**0.016**	**0.043**	0.899		0.979	0.995	0.835
BORATE		0.117	0.226	0.352		0.273	0.081	0.462
AC.MOP		0.489	0.289	0.365		0.177	0.407	0.948
AC.Borate		0.070	0.110	0.796		0.192	0.431	0.622
MOP.Borate		0.175	0.913	0.173		0.569	0.153	0.091

P values less than 0.05 are presented in bold.

Table 4. Trial 254, effects of treatments on FFB yield and its components for 2010 and 2008 to 2010
2.29 (3 years averaged data).

	2010			**2008-2010**		
Treatments (kg/palm)	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**	**FFB yield (t/ha)**	**BNO/ha**	**SBW (kg)**
AC 4.0	**26.0**	**956**	27.3	**29.2**	1159	25.4
8.0	**29.1**	**1053**	27.7	**30.9**	1210	25.8
l.s.d.$_{0.05}$	*1.476*	*67.9*		*0.853*		
MOP 2.5	**26.6**	**969**	27.6	30.0	1185	25.7
7.5	**28.5**	**1039**	27.5	30.0	1185	25.6
l.s.d.$_{0.05}$	1.476	67.9				
Borate 0	27.2	1014	27.0	30.2	1201	25.3
0.08	28.6	1035	27.7	30.4	1210	25.4
0.16	26.8	964	27.9	29.6	1143	26.1
GM	27.6	1004	27.5	30.0	1185	25.6
Se	2.519	115.9	1.85	1.45	87.7	1.87
CV %	9.1	11.5	6.7	4.8	7.4	7.3

P values less than 0.05 are presented in bold.

Table 5. Trial 254, Effect of AC and MOP on FFB yield in 2010.

	MOP 2.5	MOP7.5
AC 4.0	24.9	27.2
AC 8.0	28.4	29.7

Yield over time

Over the course of the trial (established in late 2002 with the treatments first applied in 2005) there has been a steady increase in yield from 17 t/ha in 2003 to 32 t/ha in 2007 and stabilised thereafter (Figure 1). A 5-6 t/ha increase in yield was observed from 2005/2006 to 2007 – this was primarily due to improved harvesting and plantation standards. In 2008 the yield declined by about 2.5 t/ha, due to fewer bunches being harvested, however the crop recovered to 33 t/ha in 2009 but fell to 27 t/ha in 2010.

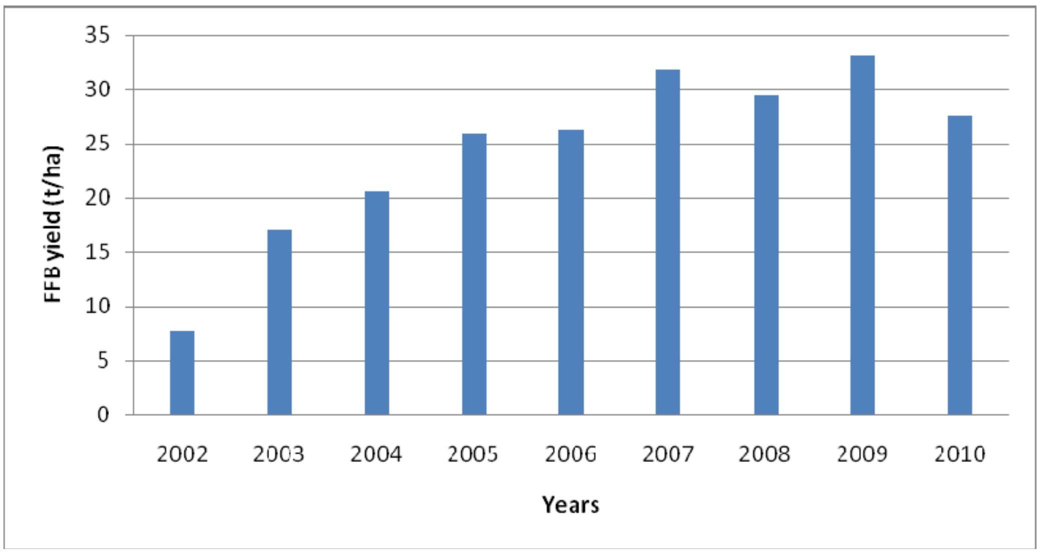

Figure 1. Trial yield since establishment in 2002.

Tissue nutrient concentrations

Effects of fertiliser treatments on leaf tissue nutrient concentrations are presented in Tables 6 and 7.

AC significantly increased leaflet Ash, N and P, and rachis N concentrations in 2010. MOP lowered leaflet N but increased rachis Ash and K concentrations. Borate significantly increased B concentrations in the leaflets however this was not reflected in yield responses.

Table 6. Trial 254, p values of treatment effects on F17 nutrient concentrations in 2010.

Source	Leaflet nutrient concentrations								Rachis nutrient concentrations			
	Ash	N	P	K	Mg	Ca	B	S	Ash	N	P	K
AC	**0.035**	**0.007**	**0.043**	0.949	0.676	0.581	0.082	**0.002**	0.910	**0.036**	0.901	0.372
MOP	0.723	**0.094**	0.118	0.188	0.765	0.428	0.334	0.325	**<0.001**	0.254	0.107	**<0.001**
Borate	0.164	0.323	0.687	0.892	0.039	0.946	0.086	0.477	0.280	0.936	0.150	0.557
AC.MOP	0.577	0.754	0.854	0.949	0.142	0.428	0.366	0.325	0.489	0.419	0.680	0.738
AC.Borate	0.640	0.078	0.154	0.552	0.249	0.659	0.934	0.037	0.495	0.276	0.714	0.561
MOP.Borate	0.760	0.473	0.662	0.178	0.499	0.553	0.773	0.037	0.205	0.222	0.550	0.500

Effects with p<0.05 are shown in bold.

Table 7. Trial 254, main effects of treatments on frond 17 nutrient concentrations in 2010, in units of dry matter % except for B (mg/kg).

Treatments	**Leaflet nutrient contents (% DM)**								**Rachis nutrient contents (% DM)**			
(kg/palm)	**Ash**	**N**	**P**	**K**	**Mg**	**Ca**	**B (ppm)**	**S**	**Ash**	**N**	**P**	**K**
AC 4.0	7.1	**2.54**	**0.152**	0.76	0.24	1.03	17.6	0.19	5.2	**0.32**	0.136	1.77
8.0	6.7	**2.61**	**0.154**	0.76	0.24	1.01	16.0	0.20	5.2	**0.35**	0.135	1.71
l.s.d.$_{0.05}$	0.345	0.048	0.0027							0.0248		
MOP 2.5	6.9	2.60	0.154	0.75	0.24	1.03	17.2	0.20	**4.9**	0.34	0.127	1.64
7.5	6.9	2.55	0.152	0.77	0.24	1.01	16.3	0.20	**5.5**	0.33	0.144	1.84
l.s.d.$_{0.05}$									0.304			
Borate 0	7.1	2.58	0.154	0.76	0.23	1.01	15.3	0.20	5.1	0.33	0.126	1.74
0.08	6.8	2.59	0.153	0.76	0.23	1.02	17.5	0.20	5.4	0.33	0.130	1.78
0.16	6.8	2.55	0.152	0.76	0.25	1.03	17.5	0.20	5.1	0.33	0.150	1.70
l.s.d.$_{0.05}$					0.0172							
GM	6.9	2.58	0.153	0.76	0.24	1.02	16.8	0.20	5.2	0.33	0.135	1.74
Se	0.589	0.082	0.005	0.045	0.024	0.106	3.17	0.007	0.519	0.042	0.0357	0.193
CV %	8.5	3.2	3.1	5.9	10.0	10.4	18.9	3.7	9.9	12.7	26.4	11.1

P values less than 0.05 are indicated in bold.

The mean concentrations (% DM) of leaflet N (2.58) and rachis N (0.33); leaflet P (0.153) and rachis P (0.135); and leaflet Mg (0.24) and rachis K (1.74) were all adequate.

Effects of fertiliser treatments on vegetative growth parameters

The effects of fertiliser treatments on physiological growth parameters are presented in Tables 8 and 9. In 2010, AC significantly increased PCS and dry matter production. however MOP and Borate did not have any effect on any of the measure vegetative parameters.

Table 8. Trial 254, p values of effects of fertiliser treatments on vegetative growth parameters in 2010.

Source				Radiation interception			Dry matter production				
	FL	PCS		FP	FA	LAI	FDM	BDM	TDM	VDM	BI
AC	0.585	**0.010**		0.793	0.831	0.369	**0.007**	**<0.001**	**<0.001**	**0.004**	0.675
MOP	0.684	0.182		0.105	0.300	0.248	0.534	0.105	0.105	0.448	0.311
Borate	0.538	0.480		0.309	0.665	0.404	0.559	0.526	0.526	0.589	0.213
AC.MOP	0.775	0.718		0.163	0.575	0.212	0.323	0.616	0.616	0.344	0.249
AC.Borate	0.232	0.338		0.475	0.561	0.567	0.255	0.082	0.082	0.223	0.382
MOP.Borate	0.299	0.949		0.195	0.148	0.171	0.814	0.814	0.814	0.881	0.203
CV %											

P values less than 0.05 are shown in bold.

Table 9. Trial 254, main effects of fertiliser treatments on the vegetative growth parameters in 2010.

Source				Radiation interception			Dry matter production (t/ha/yr)				
	FL	PCS		FP	FA	LAI	FDM	BDM	TDM	VDM	BI
AC 4.0	602	**45.6**		23.3	13.6	5.55	**14.4**	**13.8**	**31.4**	**17.6**	0.44
8.0	605	**50.8**		23.4	13.6	5.68	**16.1**	**15.5**	**35.1**	**19.6**	0.44
l.s.d.$_{0.05}$		*3.83*					*1.197*	*0.785*	*1.648*	*1.340*	
MOP 2.5	602	46.9		23.7	13.4	5.54	15.1	14.2	32.5	18.3	0.44
7.5	605	49.5		23.0	13.7	5.70	15.5	15.0	33.4	18.9	0.44
Borate 0	602	47.6		23.1	13.6	5.65	14.9	14.5	32.7	18.2	0.44
0.08	600	47.2		23.8	13.7	5.72	15.2	15.2	33.8	18.6	0.45
0.16	609	49.8		23.1	13.4	5.49	15.7	14.2	33.2	19.0	0.43
GM	604	48.2		23.3	13.6	5.62	15.3	14.6	33.2	18.6	0.44
Se	24.1	6.541		1.464	0.980	0.493	2.043	1.339	2.812	2.287	0.030
CV %	4.0	13.6		6.3	7.2	8.8	13.4	9.2	8.5	12.3	6.9

P values less than 0.05 are shown in bold

FL = Frond length (cm); HI = Height increment (cm); PCS = Petiole cross-section (cm^2); FP = annual frond production (new fronds/year); FA = Frond Area (m^2); LAI = Leaf Area Index; FDM = Frond Dry Matter production; BDM = Bunch Dry Matter production; TDM = Total Dry Matter production; VDM = Vegetative Dry Matter production; BI = Bunch Index (calculated as BDM/TDM)

CONCLUSION
AC had a significant effect on yield, leaf tissue nutrient concentrations and dry matter production. Muriate of Potash (MOP) also affected yield and leaf tissue K contents but did not affect measured vegetative parameters. Borate fertiliser had no effect on yield and vegetative parameters but significantly increased B concentrations in the leaflets.

SMALLHOLDER TRIALS

(Winston Eremu and Steven Nake)

Trial 218: Intercropping trial, Sege VOP, Bialla, WNBP (RSPO 4.2, 4.3, 5.1, 6.1, 8.1)

BACKGROUND
The trial site is a 2.3 hectare block at Sege VOP, Cenaka Division of the Bialla Oil Palm Project. The site was mapped out by GPS team from HOPL technical services division (TSD) team assisted by OPRA/OPIC in the beginning of 2010. The block will be divided into two sub-blocks, half planted as normal (normal stand) and the other half intercropped with food crops. Comparison will be made between the two sub-blocks on yield, palm vegetative growth, dry matter production for the food crops and other parameters. The background information is shown in Table 1.

PURPOSE

- To plant food crops in between palms in various spacing so eventually becomes a food security demonstration block.
- To build up some data base on intercropping, eventually become useful information to help equip small holder growers to improve their farming methods.

Table1. Trial 218 background information.

Trial number	**218**	Company	Small holder - OPIC
Estate	OPIC	Block No.	Sege VOP
Planting Density	120 palms/ha	Soil Type	Volcanic
Pattern	Triangular	Drainage	Freely draining
Date planted	2011	Topography	Flat
Age after planting	Not yet	Altitude	20 m asl
Recording Started	Not yet	Previous Land-use	Old garden left to fallow
Progeny	Unknown*	Area under trial soil type (ha)	Not known
Planting material	Dami D x P	Agronomist in charge	Susan Tomda/Steven Nake

WORK DONE SO FAR

- Site selected
- Area mapped out (Hargy GPS team)
- Trial designed on the map ready for setting it out.
- Awareness made through the OPIC
- Slashing of bush/grass
- Lining

A diagram of how the trial is set out is shown in Figure 1.

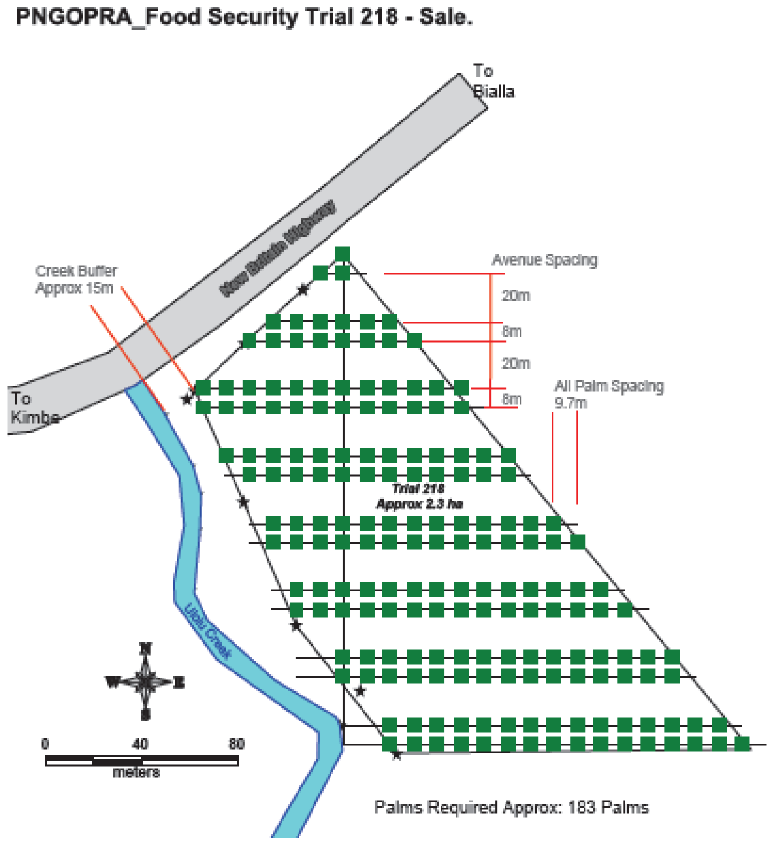

Figure 1. Locality map showing how the trial will be set out.

Trial 219: Smallholder leaf sampling, Bialla Oil Palm Project (RSPO 4.2, 4.3, 8.1)

OVERVIEW

PNGOPRA also participates in smallholder holder research and extension throughout smallholder blocks in PNG. This is done in collaboration with OPIC and the smallholder affairs department within the milling companies. This report highlights what was carried out for smallholder section in Bialla Oil Palm Project in 2010

Main activities of smallholder in the Bialla project in 2010 were:

- Smallholder leaf sampling.
- Fields days
- NBC Radio program for Oil Palm Growers in West New Britain Province.

PURPOSE

To determine nutrient status of smallholder oil palms blocks from leaf tissue concentrations.

BACKGROUND

Bialla smallholder oil palm project (LSS and VOP) was established in mid 1970's. It is made up of (3) three Divisions, -Cenaka, (Divison-1), Maututu (Division-2) and Meramera, (Division-3), extending from Haila river in the West to the border of East and West New Britain provinces on the East, covering about 13-15,000ha. Nitrogen fertilisers (Ammonium Chloride and Ammonium Nitrate) are supplied to LSS and VOP blocks by OPIC and applied either by the block owners or contractors. The fertilisers are applied at the rate of 2.0 kg AC/palm/year or equivalent Ammonium Nitrate at 1.50 kg/palm/year. The first leaf sampling was done in 2003 and then in 2004 (no data available). There was no sampling done until in 2009 when PNGOPRA was asked to do the exercise.

SMALLHOLDER BLOCK SELECTION AND SAMPLING

In July and early August 2010, a total of 73 blocks from LSS and VOP were randomly selected, 20-24 blocks were chosen from the 3 divisions in the project area. The selected blocks from the 3 divisions were further grouped into 11 classes according to topographical features as presented in Table 1. The leaf samples were then collected from palms 5-10 years old, which were marked for future reference and sampling. Leaf and rachis samples were collected from frond 17 on 4-7 palms per block. The collected leaf tissue samples were sent to AAR for analysis.

Table 1. The table shows the topographical groupings

Division	*Group & Block location*	*Topography/Features*	*No blocks*
1	1- Lalopo, Uasilau,Sale	Flood plains/swamp	7
1	2-Kaiamo, Sulu, Malasi, Kiawa	Rock/ stones/sandy	7
1	3- Tiauru, Matauruру	Flat/foothills	7
2	4- Mataliliu, Ewase, Apupul, Baikekea	Flat/foothills	5
2	5- Bubu, Welolo	Sloppy/flat/swamp	8
2	6- Barema, Pakesi, Gigipuna	Flood plains/rocky/hills	7
3	7- Soi	Flood plains/ foot hills	7
3	8- Kabaya	Flat/ foot hills	7
3	9- Tianepou, Mauba, Galelolo	Flat/rocky, Kunai	7
3	10- Noau, Gamupa	Flat /gradual slope	6
3	11- Noua/Nantabu	Steep hills	5
			73

RESULTS.

The nutrient contents of the analysed leaf tissues are presented in Tables 2 and 3. Leaflet N and P contents are below the adequate levels of 2.45 – 2.50 % DM and 0.148 % DM respectively. Leaflet K, Mg and B concentrations are reasonable. Rachis K contents low. The palms are nutritionally deficient especially for N and K across all the 3 divisions especially from blocks in Groups 1, 2 and 9. These areas though are flat; they have rocks, stones and are sandy in texture.

Table 2. Leaf tissue nutrient concentrations of the 73 blocks in the 11 groups within the 3 divisions 2010

Division	*Group*	***Leaflet nutrient concentration(% DM)***					***Rachis nutrient concentration (%DM)***		
		N	**P**	**K**	**Mg**	**B**	**N**	**P**	**K**
1	1	2.28	0.135	0.67	0.266	12.3	0.25	0.055	1.06
1	2	2.14	0.127	0.63	0.283	15.4	0.24	0.039	1.00
1	3	2.32	0.134	0.74	0.194	15.5	0.24	0.039	1.42
Division 1 mean		***2.25***	***0.132***	***0.68***	***0.248***	***14.40***	***0.24***	***0.04***	***1.16***
2	4	2.21	0.131	0.76	0.202	19.9	0.24	0.053	1.39
2	5	2.31	0.133	0.74	0.219	16.3	0.24	0.053	1.47
2	6	2.29	0.131	0.75	0.220	15.7	0.25	0.039	1.31
2	7	2.30	0.131	0.76	0.243	16.6	0.24	0.045	1.13
2	8	2.22	0.129	0.66	0.209	21.4	0.23	0.037	1.33
Division 2 mean		***2.27***	***0.131***	***0.73***	***0.219***	***17.98***	***0.24***	***0.05***	***1.33***
3	9	2.06	0.126	0.60	0.338	19.0	0.23	0.046	1.05
3	10	2.24	0.130	0.76	0.250	14.5	0.22	0.047	1.35
3	11	2.23	0.124	0.79	0.252	12.3	0.22	0.041	1.66
Division 3 mean		***2.18***	***0.127***	***0.72***	***0.280***	***15.27***	***0.22***	***0.04***	***1.35***
Overall Project Mean		**2.24**	**0.130**	**0.71**	**0.242**	**16.2**	**0.24**	**0.045**	**1.28**

Table 3. Tissue nutrient concentration for leaflets and rachis summarized in divisions for the 73 blocks in 2010

Divisions	*Leaflet nutrient concentration(% DM)*					*Rachis nutrient concentration (%DM)*		
	N	**P**	**K**	**Mg**	**B**	**N**	**P**	**K**
1- Cheneka	2.24	0.131	0.67	0.254	14.2	0.24	0.043	1.12
2- Maututu	2.30	0.133	0.74	0.212	17.1	0.24	0.051	1.42
3- Meramera	2.21	0.128	0.72	0.252	16.9	0.23	0.044	1.29
Mean	**2.24**	**0.130**	**0.71**	**0.242**	**16.2**	**0.24**	**0.045**	**1.28**

DISCUSSION AND CONCLUSION.

Nitrogen and K contents in both the leaflet and rachis tissues are low (below the adequate levels) across the 3 divisions. There could be a lot of reasons for having low N levels, which includes non application of fertilisers, rejected or disputed blocks, differences in palm age, poor upkeep, old blocks due for planting and palms planted on steep terrain.

FIELD DAYS AND RADIO BROADCAST

There were number of field days scheduled for each month for growers to attend in selected areas in each division. Common questions raised during the field days include:

- Can company supply EFB as alternative fertiliser source?
- Why growers applying only Ammonium Chloride (AC) or Ammonium Nitrate (AN)- N-sources and not others as the HOPL plantations do?
- What is the difference between the N sources of fertilisers (AC & AN)?
- When is the appropriate time for fertiliser applications?
- How many rounds of fertiliser application per year?
- What are the effects on the yield if the fertiliser delivery is delayed?
- Comparison of the two planting materials from Dami in terms of yield.

Radio broadcasts were also a means of disseminating the technical information to the growers. PNGOPRA Bialla had two broadcast session in 2010. Topics covered in field days and radio talks were:

- What is PNGOPRA and its functions.
- The main effects of fertiliser (N) applications, in relation to yield, rates to apply and when is appropriate time to apply.
- Emphasis on the importance of fertiliser applications backed by trial results.
- Gains and losses on fertiliser applications against yield productions.
- Sanitation - to increase yield, isolate blocks from pest and disease infestation.
- Awareness to report in advance when blocks are infested with sexava and ganoderma, on its symptoms and dangers.
- Report on annual report of how well the smallholders were doing in yield productions per year, against trial and plantations results.
- Budgeting income from the block and how to improve on their spending.

Trial 150: Hoskins Smallholder fertiliser/BMP demonstration blocks (WNBP) (RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1) (Steven Nake and Graham Dikop)

SUMMARY

The FFB yields (t/ha), bunches per hectare (BHA) and the tissue nutrients (N and K) in both the leaflets and rachis have increased since the establishment of the 20 smallholder trials. The positive response was not attributed to the fertiliser treatments (no significant effect) but more related to improvement made to the general upkeep (block standard practice) of these blocks. With improvements made to the general condition of the blocks, the yields increased by 3-10 fold. Similarly, the number of bunches per hectare have also increased substantially. The N levels in both leaflet and rachis are slightly below the adequate levels.

BACKGROUND

The smallholder sector in PNG makes up about 42 % of the oil palm growing area however produces about only 32 % of the total crop. The average smallholder yield averages at 14 t/ha (range = 0.5 – 17 t/ha) while the plantations yields averages at 22 t/ha (range = 7 – 27 t/ha). The trials across the country indicate yields of 30 – 35 t/ha are obtainable. The benefits of increased yields from the smallholder blocks can be substantial and are very important for the oil palm industry. The smallholders hold the key to a substantial untapped potential in production. Setting up of demonstration plots and experiments in smallholder blocks are one important way of contributing to increasing yields in the smallholder blocks, however trial and demonstration work with smallholders is never straight forward. The reasons behind the low production and productivity are complex. Smallholder Trials-Demonstration blocks in Hoskins Project were started in 2008 with the following aims:

- Demonstrate best management practices with smallholders (extension);
- Develop robust criteria for fertiliser decisions with smallholders (research).

The main issues which are taken into account when undertaking trial/demonstration work with smallholders are:

- Uneven block management (to the extent that uneven production is achieved across the block due to poor management of weeds, harvest and pruning standards, fertiliser application etc).
- Uneven harvest across the site (because of a lack of labour).
- Time demands on smallholders are such that at times there may be no or very little work carried out in the blocks at all.
- Interest by the smallholder in participating in such trials and demonstration decline with time.
- The trial treatments have to be meaningful (i.e. visual) but simple (we cannot afford to run complicated, replicated trials on smallholder blocks).

MATERIALS AND METHODS

Site Selection

Blocks with low production, poor block upkeep and obvious symptoms of N deficiency on the palms (i.e. pale leaflet colour, small/reduced frond area, smaller PCS, erected fronds (with less small and less number of bunches) were selected for the trial/demonstration work. Most of these blocks were proposed by OPIC and confirmed by OPRA Agronomist upon site inspection. If the growers agree for the use of their block to set up the trial, then land usage agreement forms were completed and signed by the 3 parties (Grower/OPIC/OPRA). Information on Trial Blocks are presented in Table 1. Smallholder blocks are usually planted at 120 palms/ha (palms planted 9.8m apart with 8.5m between rows), thus in one hectare there are 12 rows and each row has 10 palms.

Table 1. Block data information on Trial 150

	Block No.	LSS/VOP	Division	Year Planted	No. of Palms/block	Year trial started	1st Fert treatment applied
1	138	Waisisi, CRP	Siki	1999	240	2009	June, 2009
2	1	Porapora VOP	Siki	2000	240	2009	Nov, 2009
3	2247	Siki LSS	Siki	1991	240	2010	April, 2010
4	750	Banaule VOP	Kavui	1999	120	2009	Oct, 2009
5	1681	Kavui Sect 5	Kavui	1997	240	2009	Oct, 2009
6	1719	Kavui Sect 7	Kavui	1998	240	2009	Oct, 2009
7	1093	Kavui Sect 11	Kavui	1999	240	2009	Feb, 2010
8	354	Kapore Sect 7	Kavui	2002	240	2009	Not applied
9	1169	Buvusi Sect 5	Buvusi	1997	240	2010	Feb, 2010
10	1186	Buvusi Sect 6	Buvusi	1997	240	2009	Nov, 2009
11	1312	Buvusi Sect 9	Buvusi	1996	240	2009	Feb, 2010
12	1532	Galai 1, Sect 14	Buvusi	2000	240	2009	Feb, 2010
13	980	Sarakolok Sect 6	Nahavio	1998	240	2009	May, 2009
14	984	Sarakolok Sect 6	Nahavio	1994	240	2009	Nov, 2009
15	510	Tamba, Sect 5	Nahavio	1991	240	2009	Nov, 2009
16	114	Ubae VOP	Salelubu	2000	240	2009	May, 2009
17	16	Kukula VOP	Salelubu	1998	240	2009	May, 2009
18	906	Mamota, Sect 8B	Salelubu	1999	480	2009	May, 2009
19	921	Mamota, Sect 8B	Salelubu	1991	720	2009	May, 2009
20	26	Marapu VOP	Salelubu	2001	240	2009	May, 2009

Experimental Design and Treatments

The trial layout is shown in Figure 1. The trial block consists of 4 rows of each treatment, total of 12 rows. However, only 10 palms in the two central rows in each treatment are used for various measurements and data collection (yield recording, vegetative measurements etc). Thus a treatment consists of two rows of 10 palms (total of 20 palms/treatment). Fertiliser treatments are applied to both the recorded palms and the guard row palms surrounding the recorded palms (with the same colour code). Other palms not included in the plots (outside the treatments) but still within the trial block are fertilised as well using the standard rate (2 kg AN/palm/year).

Fertiliser treatments are:

- **control** (current block fertiliser practice)
- OPIC **recommended** rate (2kg AN/palm)
- **recommended plus** (3 kg AN/palm + 1kg MOP)

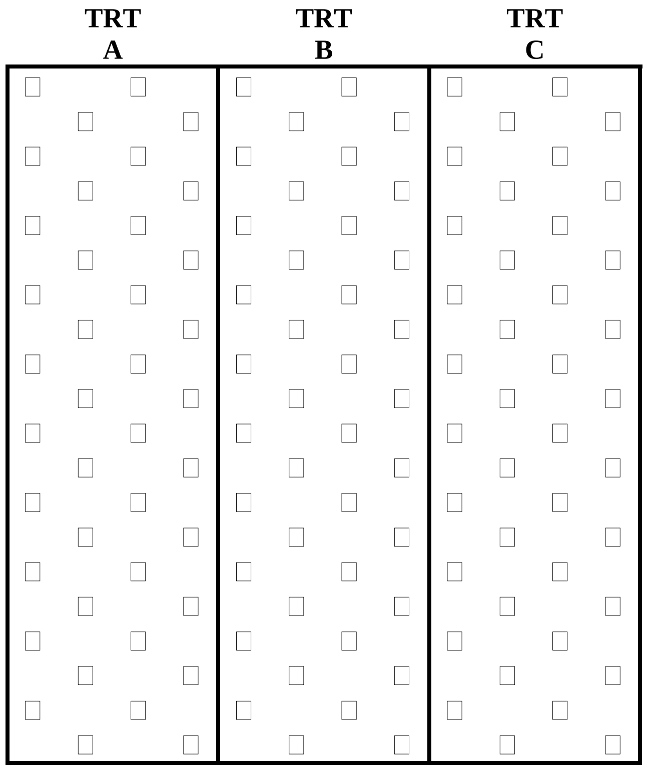

Figure 1. Treatment layout on a 1 ha block

Measurements and data collection done in the trial blocks

- Fortnightly yield recording (which includes recording number and weight of bunches). Some of the trials setup in 2009, did not have any yield data (t/ha) because only the number of harvested bunches were recorded with no weighing done fortnightly.
- Leaf sampling for leaflet nutrient analysis – once a year
- Black bunch count – done every quarter
- Normal upkeep work – as and when required
- Monthly field assessment

RESULTS

The measured yield and bunch number per hectare and the tissue nutrient concentrations are shown in Tables 2 and 3. Statistically, there were no significant differences on the yield and bunch number per hectare and the nutrient levels in the leaf tissues as a result of the fertiliser treatments. Because of no response, individual treatment data is not presented in this report, instead the overall block data (yield, bunch/ha and tissue nutrient concentrations), regardless of the fertiliser treatments are discussed.

Yield and bunch number per hectare per block in 2010

Regardless of the fertiliser treatments, there was a substantial increase in block yield (t/ha) and number of harvested bunches per hectare in 2010 compared to 2009 for the blocks that had complete data for these 2 years (Figure 2). In 2010, 11 trial blocks (50 %) had yields greater than 10 t/ha, of which 6 of them had yields above 15 t/ha and 1 block yielding more than 20 t/ha. The remaining 8 blocks had less than 10 t/ha. The increase in yields were obviously caused by an increase in the number of bunches harvested per hectare from each of the trial blocks. There were also increases in the number of bunches/ha in the trial blocks that had bunch numbers recorded in 2009-2010 (Figure 3). All the blocks (except 984 and 510) are producing more than 500 bunches/ha, of which 7 blocks have recorded more than 1000 bunches/ha in 2010. In 2009, only 1 block produced more than 1000 bunches/ha, 3 blocks above 500 bunches/ha while the rest were producing less than 500 bunches/ha. In general, the yields have increased by 3-10 fold and bunches per hectare were also elevated by 2-7 fold (Figures 2 and 3).

Table 2. Yield and bunch number/ha in the 20 smallholder trial blocks in 2010

		2009		2010	
	Trial Block	**Yield (t/ha)**	**BHA (Bunch/ha)**	**Yield (t/ha)**	**BHA (Bunch/ha)**
1[a]	**01**	-	-	14.7	1770
2[b]	**138**	-	270	7.3	872
3[a]	**2247**	-	-	12.0	634
4	**750**	2.6	220	6.9	804
5[b]	**1681**	-	960	17.5	1170
6	**1719**	8.8	268	21.6	1550
7[b]	**1093**	-	440	14.9	1140
8[a]	**1169**	-	-	10.3	698
9[b]	**1186**	-	214	8.5	664
10[a]	**1312**	-	-	3.3	562
11[a]	**1532**	-	-	7.7	812
12[b]	**510**	-	206	3.7	346
13	**980**	0.6	426	12.5	884
14[a]	**984**	-	-	4.9	392
15	**16**	3.4	564	12.8	1072
16	**26**	5.6	290	8.6	972
17	**114**	3.2	1134	18.6	1514
18	**906**	2.8	596	15.1	1084
19[a]	**921**	-	-	10.2	798
20[bc]	**354**	-	217	-	-

a – No yield and bunch/ha data for 2009 because trial commenced in 2010
b - No yield data for 2009 because only number of bunches harvested were recorded with no weighing done
c – Trial 354 was closed in 2010 because the negligence by the growers (i.e. lack of cooperation).

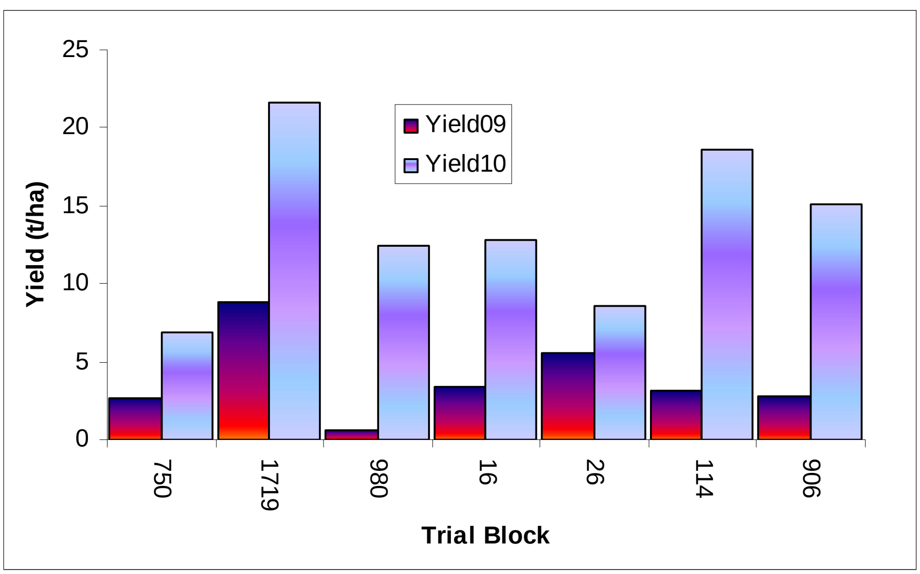

Figure 2. Yield (t/ha) in 2009 and 2010 from 7 selected trial blocks.

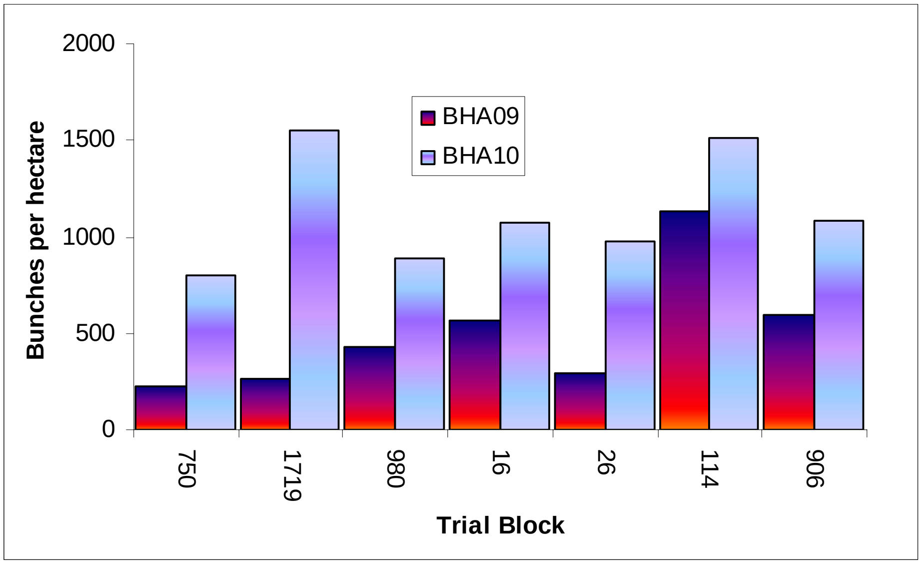

Figure 3. Bunches per hectare (BHA) in 2009 and 2010 from 7 selected trial blocks.

Tissue nutrient concentration

The results of leaf tissue N and K concentrations are presented in Table 3. Leaflet and rachis N concentrations in 2010 generally increased from 2009. Despite the increase, the leaflet N levels are still below the adequate levels (2.45 – 2.50 % dm). This is because most of these blocks have not been receiving any fertilisers for some time, thus the low N levels prior to the treatment application. Similarly, rachis N has increased in 2010 increased from 2009 levels but the levels are still below the adequate N in the rachis (0.32 % dm). Leaflet K have also increased in 2010 with the K levels in most blocks well above the adequate level while a few still below the adequate level (0.65 % dm). All rachis K levels are within the adequate levels, except for few of the blocks.

Table 3. Nutrient levels (% dm) in leaflet/rachis tissues in the smallholder trial blocks in 2009 and 2010

		Leaflet (%dm)		Leaflet (%dm)		Rachis (%dm)		Rachis (% dm)	
		2009	2010	2009	2010	2009	2010	2009	2010
	Trial Block	N	N	K	K	N	N	K	K
1	**01**	2.42	2.43	0.73	0.77	0.22	0.27	1.22	1.40
2	**138**	1.67	2.18	0.62	0.70	0.26	0.27	1.35	0.90
3	**2247**	-	2.02	-	0.47	-	0.31	-	1.10
4	**750**	2.10	2.20	0.73	0.69	0.27	0.29	1.67	1.82
5	**1681**	2.20	2.25	0.73	0.67	0.26	0.29	1.34	1.46
6	**1719**	2.32	2.30	0.63	0.61	0.31	0.31	1.33	1.19
7	**1093**	2.11	2.17	0.66	0.66	0.26	0.26	1.05	0.85
8	**1169**	-	1.95	-	0.61	-	0.25	-	1.05
9	**1186**	2.19	2.21	0.71	0.78	0.28	0.30	1.47	1.74
10	**1312**	1.74	2.02	0.65	0.71	0.21	0.27	1.07	1.64
11	**1532**	1.90	2.23	0.67	0.71	0.21	0.27	0.90	1.18
12	**510**	1.77	2.02	0.74	0.71	0.21	0.26	1.34	1.66
13	**980**	1.75	2.22	0.64	0.71	0.25	0.28	1.04	1.20
14	**984**	1.83	1.92	0.57	0.64	0.23	0.23	1.48	1.35
15	**16**	2.19	2.29	0.78	0.83	0.24	0.26	1.59	1.59
16	**26**	1.87	2.13	0.80	0.85	0.19	0.22	1.33	1.40
17	**114**	2.24	2.25	0.70	0.74	0.26	0.29	1.73	1.47
18	**906**	2.20	2.26	0.88	0.90	0.24	0.25	1.54	1.63
19	**921**	1.97	2.00	0.86	0.84	0.23	0.27	1.67	1.71
20	**354**	2.20	-	0.69	-	0.25	-	1.33	-
Adequate levels		**2.45 -2.50 % dm**		**0.65 % dm**		**0.32 % dm**		**1.2 % dm**	

DISCUSSION

Yield response to fertiliser normally takes around 2-3 years, whereas tissue levels in the oil palm leaves can respond within 12 months. The results have shown that there was no yield response due fertiliser (treatment) application. Though the leaflet and rachis levels of N and K for all the trial blocks have increased from 2009 levels, they are still below the adequate level. It is more likely that another round of fertiliser application (in 2011) will push the levels of both nutrients in the leaflets to within the adequate levels. This could be the reason why the trials have not shown any significant yield response, despite the substantial increase in yields with the trial blocks. The question is why the substantial increase in yield? Obviously, the increase in FFB yields was a result of good management practice carried out in all these blocks since they were converted into fertiliser demonstration trials. Before treatments were applied, the following management practice and upkeep work were carried out:

- Slashing of shrubs, undergrowths, weeds etc.
- Weeded circle sprayed and weeds removed to allow easy access to loose fruit collection
- Thorough pruning done on all the palms to plantation standards (i.e. 1-2 fronds below the oldest black bunch).
- Re-alignment of harvest paths, which also included relocation of frond piles
- Emphasised on no skip harvesting, i.e. harvesting has to be done every harvest. This is slowly improving though couple of blocks are now doing 100% complete harvest.
- Fertiliser application to experimental (recorded palms) as well as perimeter palms (i.e. palms not used for recording but inside the trial block).
- Maintaining very close communication and working relationship with the growers so they understand the importance of this trial.

Therefore, the results from these trials have shown that FFB yields can be increased 3-10 fold through proper and timely application of block management practices. When we go into the third year of fertiliser (treatment) application (2011), we should hopefully see some response to the fertiliser treatments and a further increase in FFB yields.

CONCLUSION

There were no yield and leaf tissue nutrient contents responses to fertiliser treatments in 2010. The increase in yields by 3-10 fold is due mostly to improved block management and recovery of all the ripe bunches. Increased leaf tissue N and K concentrations are due to addition of fertilisers in 2009.

OTHER OBSERVATIONS (Extension)

- Fertiliser trial blocks utilized for extension purposes. In 2010, blocks 1719, 750, 1186 and 2247 were used for OPIC field day.
- Some of the growers have taken the initiative to adopt practices and knowledge learnt from the trial block on their other blocks.
- Some growers in the vicinity of the trial blocks have also taken great interest in the trials and have implemented some of the practices on their oil palm blocks.
- Most of the block owners have changed their attitude towards working in their blocks after realizing that the yields (in terms of tonnes harvested per fortnight) have increased.
- One of the growers (Block 980 Sarakolok Sect 7 has purchased a generator, DVD player and TV screen. His block which has now been converted into the fertiliser trial has not been harvested for the last 3-4 years because there was no crop on the palms. He was planning to replant this block, but now the condition of the block has improved and he is getting money from the block.

Smallholder Research Report in 2010, Oro Oil Palm Project

(Merolyn Koia and Murom Banabas)

INTRODUCTION

Smallholder sector within the oil palm industry comprises about half the oil palm planted area however contributes only 30-40 % of the total crop production in a year. The low proportion of total crop production happens for a variety of reasons ranging from socio-cultural-economic to agronomic to infrastructure related issues. Studies into socio-economic and cultural constraints to production are carried out by the Socio-economic Section and the reports are presented separately. This section deals specifically with addressing agronomic issues. The formal fertiliser trials have demonstrated especially in Popondetta and Milne Bay that fertilisers significantly increase annual yields however smallholder yields are generally low at 10-15 t/ha while in some plantations yields are at 30-35 t/ha. The agronomic involvement in smallholder studies include leaf tissue sampling and block assessments in selected blocks in Bialla and Popondetta, fertiliser trials in Hoskings, and fertiliser demonstration blocks in Poliamba and Milne Bay BMP blocks.

Smallholders are also not only involved in oil palm production but are involved in a number of other activities to sustain their livelihoods. A very important income source identified by Socioeconomic studies within smallholder blocks is the sale of food crops in the local markets. PNGOPRA has set up a number of smallholder food security demonstrations in smallholder blocks and is funded under AIGS. This is a joint project between Agronomy and Socio-economics Sections within PNGOPRA.

Smallholder activities are ongoing in all oil palm project areas around the country. This report highlights the four main areas of work for the smallholder sector in the Oro Oil Palm Project in 2010.

Main thrust of smallholder work:
1. Smallholder Leaf Sampling
2. Field Inspections (Visits)
3. Field Days
4. Radio Program for Oil Palm Growers in Oro Province.

TRIAL 336 - SMALL HOLDER LEAF SAMPLING (RSPO 4.2, 4.3, 8.1)

Leaf sampling was carried out in selected representative blocks of the five Oil Palm Project Divisions; Sorovi, Igora, Saiho, Aeka and Ilimo Divisions. Leaf tissues were collected from frond 17 from 58 smallholder blocks and sent to AAR Laboratory in Malaysia for nutrient analysis**.** The results for each division are presented in Table 1. The mean nutrient contents of all the major nutrient elements were well below the critical levels. Nitrogen, the most important nutrient is required in all blocks in the 5 divisions as suggested by the low N contents in the sampled blocks. The K contents in the rachis were also low but N status has to be improved first. However, there were some blocks that had nutrient contents that were above the critical levels as indicated by the range of values. There are a range of reasons or possible combinations of reasons for the large range of values and they include; lack of fertiliser application, differences in palm age, negligence of block upkeep and very old palms due for replanting. In essence, the palms are very low in nutrients and need inorganic fertiliser inputs especially nitrogen and potassium fertilisers.

Table 1. Mean nutrient contents of 58 smallholder blocks in 2010

Division	**Leaflet (% DM, except B ppm)**					**Rachis (% DM)**		
	N	**P**	**K**	**Mg**	**B**	**N**	**P**	**K**
Aeka (6)	1.80	0.131	0.63	0.31	12	0.25	0.120	0.97
Igora (13)	2.00	0.131	0.71	0.24	13	0.26	0.071	0.89
Ilimo (10)	2.01	0.139	0.62	0.26	12	0.29	0.118	0.77
Saiho (11)	2.02	0.135	0.63	0.27	13	0.25	0.061	0.65
Sorovi (18)	2.06	0.134	0.72	0.28	14	0.26	0.118	1.14
Mean	2.00	0.134	0.67	0.27	13	0.26	0.097	0.91
Min	1.59	0.115	0.30	0.17	10	0.20	0.040	0.24
Max	2.49	0.155	0.95	0.45	22	0.33	0.249	1.65
Critical value	*2.45*	*0.145*	*0.65*	*0.20*	*15*	*0.32*	*0.08*	*1.30*

(..) = number of blocks

SMALLHOLDER BLOCK ASSESSMENTS (RSPO 4.1-6, 4.8, 5.1, 8.1)

While taking leaf tissue samples for nutrient analysis, visible nutrient deficiency from the surrounding 6 palms and legume cover crops were assessed. The upkeep standards and pest and disease were also assessed and given a score out of three (refer to Figures 1a and 1b for criteria used for assessment). The summarised scores are presented in Table 2

Small holder block – hygiene and block management assessment

Block: **Division:**	**Date:**	**Inspected by:**

No	**Insect/Nutrient deficiency**	**Score**	**Insect/Nutrient deficiency**	**Score**
1	**Insect type:** **(i) % defoliation** 1. more than 25% 2. 1 to 25% 3. none		**Insect type:** **(ii) spears or fronds damaged** 1. 3 or more 2. 1 to 2 3. none	
2	**Palm Nutrient deficiency:** 1. 3 palms or more 2. 1 to 2 3. none		**Palm Nutrient deficiency:** 1. 3 palms or more 2. 1 to 2 3. none	
3	**Ground cover nutrient def:** 1. more than 25% of plants 2. 5 to 25% of plants 3. less than 5% of plants		**Ground cover nutrient def:** 1. more than 25% of plants 2. 5 to 25% of plants 3. less than 5% of plants	

Small holder block – hygiene and block management assessment

Block: **Division:**	**Date:**	**Inspected by:**

No	**Insect/Nutrient deficiency**	**Score**	**Insect/Nutrient deficiency**	**Score**
1	**Insect type:** **(i) % defoliation** 1. more than 25% 2. 1 to 25% 3. none		**Insect type:** **(ii) spears or fronds damaged** 1. 3 or more 2. 1 to 2 3. none	
2	**Palm Nutrient deficiency:** 1. 3 palms or more 2. 1 to 2 3. none		**Palm Nutrient deficiency:** 1. 3 palms or more 2. 1 to 2 3. none	
3	**Ground cover nutrient def:** 1. more than 25% of plants 2. 5 to 25% of plants 3. less than 5% of plants		**Ground cover nutrient def:** 1. more than 25% of plants 2. 5 to 25% of plants 3. less than 5% of plants	

No	**Criteria or Standard**	**Score**	**No**	**Criteria or Standard**	**Score**
4	**Harvest - Fruit on the ground:** 1. more than 30 fruit on ground 2. 5 to 30 3. less than 5		10	**Trunk weeds, woody or vines:** 1. more than 20% trunk covered 2. 1 to 20% 3. none	
5	**Weeded Circle:** 1. more than 50% ground cover 2. 10 to 50% 3. less than 10%		11	**Trunk weeds ferns:** 1. more than 80% (crown hidden) 2. 50 to 80% 3. less than 50%	
6	**Legume cover plants (LCP):** 1. less than 10% 2. 10 to 50%		12	**Pruning – less than 7 years old:** 1. 4 or more below lowest bunch 2. three to four	

Figure 1a. Inspection form for smallholder blocks.

Procedures for under taking assessment:

- Select 6 palms randomly in block (each of these are called a palm site)
- At each palm site make the observations for the six surrounding palms (not including the palm you have selected to make your observations from)
- At each palm site record each of the criteria/standards listed and on the recording sheet fill in the average of the six palm sites

Details for each criteria/standard

No	Criteria or Standard
1	**Insects** • Record type of insect and extent of defoliation or frond damage
2	**Nutrient deficient palms** • Write in which nutrient is deficient and record no of palms (out of six) with the visual deficiency
3	**Ground cover deficiency** • Write in nutrient deficiency and record % of plants with the visual deficiency
4	**Harvest fruit on ground** • Assess number of loose fruit (total of fresh, old and rotten)
5	**Weeded circle** • Assess % of ground covered in the weeded circle with vegetation
6	**Legume cover plants** • Between the palms, assess % of ground covered with legume cover plants
7	**Weed ground cover (woody or grass weeds: Momordica, Kunai, Mimosa, Chromolaena, Weldaka)** • Between the palms, assess % of ground covered with these weeds
8	**Fronds stacks** • Record the placement of pruned fronds
9	**Harvest paths** • Record status of harvest paths
10	**Trunk weeds (woody or vines)** • Record % of trunk covered with woody weeds or vines
11	**Trunk weeds (ferns)** • Record % of trunk covered with ferns (at level 1 you cannot see bunches in the crown)
12	**Pruning (depending on palm age)** • Record the number of fronds below the most mature bunch
13	**Ganoderma** • How many of the six palms in each location have Ganoderma brackets
14	**Rat damage** • On either harvested bunches or bunches still on palms plus male flowers record the number of bunches plus male flowers with rat damage

Figure1b. Procedures for filling in smallholder block inspection forms

Table 2. Smallholder block assessments scores in 2010

Criteria used for scoring block assessment	Divisions				Average Score
	Igora (13)	Ilimo (10)	Saiho (17)	Sorovi (18)	
Palm Nutrient Deficiency	2.0	1.6	1.9	2.2	2.0
Block Standard	3.0	2.6	3.0	2.9	2.9
Frond stack	2.3	2.4	2.2	2.1	2.2
Ganoderma	3.0	3.0	3.0	3.0	3.0
Ground cover-deficiency	3.0	2.9	2.9	3.0	3.0
Harvest standard	2.9	3.0	2.9	2.9	2.9
Harvest paths	2.1	2.3	1.8	1.3	1.8
Insect Damage	2.5	2.9	2.9	2.9	2.8
LPC	2.3	2.3	2.6	2.4	2.4
Pruning <7years	3.0			2.8	2.9
Pruning >7years	2.5	2.0	2.4	2.1	2.3
Rat Damage	3.0	2.9	3.0	3.0	3.0
Trunk weeds/ferns	3.0	2.6	3.0	2.7	2.8
Trunk weeds/woods/vines	2.4	2.0	2.3	1.9	2.2
Weeded circle	1.5	1.9	1.5	1.6	1.6
Weed-ground cover	1.5	1.7	1.4	1.6	1.5

(..) = number of blocks (Note, Aeka is included with Saiho)

The mean nutrient deficiency score was 1.9 suggesting 1-2 (10-30 %) palms of the surrounding six palms showed nutrient deficiency symptoms. Nutrient deficiency was common across all blocks in all the 5 divisions and this is also reflected in the tissue analysis results in Table 1. General block upkeep (weeded circles, harvest paths and general weeds) were low in all the divisions, averaging at 2.0. The low to average score in nutrient deficiency scoring correlates well with the low nutrient concentrations in the leaflets discussed earlier. Average pruning standards were 2.9 for palms < 7 years and 2.3 for palms >7. The lower average at palms >7 years implies palms are probably too tall for pruning or only palms with bunches are being pruned. Harvesting standards are very high with an average score of 2.9 for all the divisions. Insects pests, diseases and rat damage scored very high (2.8-3.0) implying no major problems with pests and diseases in the blocks. The assessments indicate that there is average and above average scores in agronomic upkeep standards and pests and disease free blocks, however there are low scores in nutrient deficiency across all the divisions. Harvesting at various frequencies is most likely leading to more nutrients leaving the blocks than going in and this could affect the long term sustainability of smallholder oil palm productivity.

FIELD VISITS

There were field visits to smallholder blocks for various activities; Socio-economic surveys at 100 blocks, Agronomy leaf sampling at 58 blocks and Sustainability project 15 blocks.

FIELD DAYS AND RADIO BROADCASTS

There were 3 different extension methods used during the year with OPIC. The first involved large number of growers (100-150) from a division and referred to as major field days. The second involved smaller number of growers (7-10) coming to PNGOPRA fertiliser trials and shown around the trial plots and third was radio broadcasts.

The field days and radio broad casts were organized by OPIC and PNGOPRA attended to these presentations (Table 3).

Table 3. Number of field days and radio broadcasts in 2010

Extension mode	Section		Total
	Agronomy and others	Agronomy alone	
Field days (Major)	1		1
Field days (Minor)		22	22
Radio broadcasts			0

Common questions asked by the growers were:

- difference between the 1st and 2nd planting materials.
- why the company applying MOP (red marasin) & SOA (white marasin) while the growers only given SOA to apply.
- can the fertiliser application be divided into smaller portions.
- what is the orange spots/colour on the palm leaves.
- when and why is the company not giving fertilisers on time as per the calendar schedule.

The main topics presented to growers during field days were:

- What is PNGOPRA and its functions
- The Importance of fertiliser, the main type of fertiliser (SOA), main role of SOA in the oil palm production, the rates to apply in immature and mature palms.
- Fertiliser application calendar
- Block sanitation- to slow down the pest population (especially sexava and Stick insects in all the small holder blocks).
- Budgeting and savings of earnings from oil palm
- Biological control measures to control pest and weeds at the growers' level.

- Ganoderma awareness -Tok save to all block holders to check all the palms in their block for symptoms of ganoderma and also the brackets and report to their Area Extension Officers.
- Environment and sustainability project
- Food security and OPRA-OPIC food security project
- Impacts of HIV-AIDS on oil palm production

Trial 337: Smallholder oil palm/food crop intercropping demo block, Sangara (AIGS funded) (RSPO 4.2, 4.3, 5.1, 6.1, 8.1)

SUMMARY
The planting in the second 2 ha was done and planting of food and tree crops in the wide avenues commenced. Monitoring and data collection commenced in 2009 and continued into 2010.

BACKGROUND
Food gardening is a primary livelihood activity of smallholders. All smallholder households grow sufficient food to meet their food requirements, and the sale of garden foods at local markets provides women with an important source of income. Smallholders spend considerably more time in gardening than they do in oil palm related work. In 2000, women allocated almost 2.5 times as much of their labour to gardening than to oil palm, whereas, for men, gardening and oil palm were of about equal importance in terms of the time allocated to each activity (Koczberski et al. 2001). The same study also demonstrated the importance of food gardens for maintaining food security: dietary recall surveys during a period of low oil palm prices revealed that almost 80% of meal ingredients were from household food gardens. Food gardens provide a buffer against falling oil palm prices and provide income security for the smallholder growers and their families.

Fundamental to addressing the increasing population and land pressures on the LSSs is the need to explore innovative ways of cultivating cash crops to free up land for food production. One potential strategy emerged from a six year trial since 2002 to assess different planting densities and spacing of oil palm in the plantation sector for use of machines for infield collection of harvested fruit. Yield data for the past 6 years have shown no yield penalty from shortened inter-palm distance with wider avenue plots. Broader avenues meant more light was able to penetrate to ground level with a consequent increase in vegetation cover thus reducing soil compaction from the use of machines. However, these findings for the plantation sector are of great significance to the smallholder sector because alternative planting patterns with wider avenues can enable intercropping of oil palm with food crops and fuel wood species while maintaining per ha oil palm yields. There have been no agronomy trials in oil palm smallholder blocks in PNG to address food security, and this trial will be very important for current and future smallholdings, and the technology developed here has the potential to be transferred to other tree crop industries like cocoa and coffee.

The trial was set up to:

- help develop effective policies for enhancing food and livelihood security amongst smallholder oil palm growers
- development strategies for intercropping oil palm with food and fuel wood crops which will have relevance for other export cash crops
- increase food production for domestic consumption and sale at local markets
- diversify and increase incomes, especially beneficial to women and blocks with large resident populations
- produce fuel wood and food on-block thereby reducing pressure on environmentally sensitive areas such as creeks and river banks and on steep slopes.

Thus, greater understanding of how commodity crops can be intercropped with food crops and fuel wood species is vital for developing sustainable farming systems in PNG.

METHOD

Intercropping trials.
Three to five smallholder blocks will be selected for this trial in each of the four oil palm growing projects. Depending on block sizes, the experimental areas will vary from 2 to 4 hectares each. The experimental area in each block will be divided into two: the first half will be planted with oil palm at the normal equilateral spacing of 128 palms per ha, while the second half of the block will be planted at the same density of 128 but with shorter planting distances between the palms and wider avenue widths between every second row of palms. The blocks will not be necessary divided into equal halves; the selected growers will have a choice of the sizes they prefer for the demonstration/study purposes. In the first half of the block (normal equilateral planting distance), legume cover crop will be established with no food crop. In the second half of the block, the wide avenue rows will be divided into plots. The plots will be planted with (a) food crops (b) legume cover crops and (c) tree crops (fuel wood spp). The food crops will be rotated with legume cover crops within the wide avenue rows. The oil palms in both the normal and altered planting arrangements will receive fertilisers at the smallholder recommended rates. To date, work has started in only one block at Sangara while negotiations are underway for more.

DESIGN AND ANALYSIS

There will be no strict statistical design used for this experiment. The blocks will be divided into 2 and not necessary equal parts, will depend on the farmers wish. One half will be planted with normal equal spacing arrangements while the other with altered spacing arrangement. Soils and plant tissue samples were collected randomly and replicated in odd numbers for analysis. Block information is shown in Table 1.

Table 1. Trial 337, Block information

Trial number	**337**	Soil Type	Volcanic ash plain
Block owner	Mr. R. Safitoa	Drainage	Good
Block No.	050136	Topography	Flat
Location	Sangara	Altitude	m asl
Division	Sorovi	Previous Land-use	Oil Palm
Planting Density	128		
	128	Agronomist in charge	Susan Tomda
Pattern	Triangular		
Date planted	2008		
	2010		
Planting material	Dami D x P		
Progeny	Mixed Dami DxP		
Recording Started	2010 (Food crops)		

DATA COLLECTION

Plant tissue samples including yield and vegetative tissues will be collected and dry matter production determined. The measurements will be done to determine nutrient movement in and out of the smallholder blocks.

RESULTS AND DISCUSSION
Monitoring in progress.

Trial 520 Milne Bay Smallholder fertiliser/BMP demonstration blocks (RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1) (Wawada Kanama and Murom Banabas)

Work in progress

Trial 256 New Ireland Smallholder fertiliser/BMP demonstration blocks (RSPO 4.2, 4.3, 4.5, 4.6, 4.8, 8.1) (Paul Simin and Murom Banabas)

BACKGROUND
In February 2008, OPIC, CTP Poliamba LTD, and PNGOPRA agreed to set up two fertiliser demonstration blocks (in different locations) within the smallholder blocks in New Ireland. Many smallholder blocks were very low yielding and the demonstration plots were to show best management practices to smallholder oil palm growers in New Ireland.

TRIAL SETUP
The demonstration trials started in 2008 and some of the information about the blocks is presented in (Table 1). Each of the 2 blocks has a different number of palms with nil fertilised and fertilised plots. At Lakurumau, Block 5655 has 40 palms not receiving any fertilisers while the rest of the block received fertilisers. Yield recording is done on the 40 nil fertilised palms and from 80 of the fertilised palms. The fertilised palms in both blocks received 6 kg SOA and 2 kg MOP per palm per year in 2008 but SOA was reduced to 3 kg and while MOP remained at 2 kg/palm/year in 2009 and thereafter.

Table 1. Trial 256 demonstration blocks information

Trial number	**256**	Soil Type	On raised coral
Block owner	Siri	Drainage	Good
Block No.	2655	Topography	Flat
Location	Lakurumau	Altitude	m asl
Division		Previous Land-use	Food gardens
Planting Density	(a)		
	(b)	Supervisor in charge	Paul Simin
Pattern	Triangular		
Date planted	(a)		
	(b)		
Trial started	March 2008		
Planting material	Dami D x P		
Progeny	Mixed Dami DxP		
Recording Started	2010 (Food crops)		

METHODS
Yield data is collected on a fortnightly basis from the nil fertilised and selected fertilised palms while petiole cross section is measured twice a year l. Leaf tissues are collected once a year for nutrient analysis.

RESULTS AND DISCUSSION
Yield data and petiole cross section data are presented in Table 2 for Lakurumau Block. Data collection started in June 2009. The fertilised palms yielded more bunches and had higher single bunch weights than nil fertilised palms. This resulted in higher FFB yields from the fertilised palms

than from the nil fertilised palms. In 2010, fertilised palms yielded 24.9 t/ha compared to 7.6 t/ha from the nil fertilised palms, a large difference of 17.3 tonnes. The effect of fertiliser was also reflected in the PCS values. PCS from the fertilised palms were greater than from the nil fertilised palms.

Table 2. Trial 256, Yield, yield components and petiole cross section measurements in 2009 and 2010.

Year	Treatment	FFB yield (t/ha)	BN (Bunches/ha)	SBW (kg)	PCS-1	PCS-2
2009	- Fert	7.7	573	13.4	20.0	20.8
	+ Fert	9.1	590	15.4	23.4	27.8
2010	- Fert	7.6	477	15.9	26.9	28.3
	+ Fert	24.9	1272	19.6	34.0	37.1

PCS = petiole cross section (cm^2) measured in April (PCS-1) and October (PCS-2)

Leaf tissue samples were collected and analysed in 2009 and 2010, and the analysed results are presented in Table 3 for (Lakurumau) and Table 4 for Kafkaf. At both blocks, leaflet N, K and rachis K were higher in the fertilised palms compared to the nil fertilised palm in both 2009 and 2010. Though the leaflets N increased to above adequate levels (2.50 % DM), leaflet and rachis K contents were still very low. The increase in rachis K from 0.20 % DM to 0.69 % at Lakurumau in 2010 corresponded with a yield increase of 17.3 t/ha, during the same period. Though there were increases in rachis K contents in 2009 and 2010, the contents are still lower than the critical levels of 1.35% DM.

Table 3. Trial 256, Leaf tissue nutrient contents (% DM except B in ppm) in 2009 and 2010 at Block 2655 Lakurumau.

Year	Treatment	Leaflet								Rachis			
		Ash	N	P	K	Mg	Ca	B	S	Ash	N	P	K
2009	- Fert	7.62	2.10	0.150	0.42	0.49	1.61	21.8		3.47	0.26	0.156	0.24
	+ Fert	7.67	2.27	0.152	0.44	0.49	1.44	14.5		3.60	0.29	0.145	0.30
2010	- Fert	6.68	2.33	0.152	0.42	0.36	1.38	17.0	0.18	3.45	0.27	0.114	0.20
	+ Fert	6.11	2.59	0.157	0.61	0.27	1.17	12.3	0.20	3.43	0.37	0.118	0.69

Table 4. Trial 256, Leaf tissue nutrient contents (% DM except B in ppm) in 2009 and 2010 at Block 1513 at Kafkaf..

Year	Treatment	Leaflet								Rachis			
		Ash	N	P	K	Mg	Ca	B	S	Ash	N	P	K
2009	- Fert	9.14	1.84	0.132	0.24	0.71	1.63	20.6		3.76	0.43	0.103	0.16
	+ Fert	7.85	2.53	0.152	0.42	0.38	1.28	16.9		3.92	0.43	0.091	0.26
2010	- Fert	9.51	2.03	0.132	0.28	0.67	1.48	17.1	0.17	3.88	0.41	0.085	0.12
	+ Fert	7.97	2.6	0.153	0.46	0.36	1.24	16.1	0.21	3.62	0.37	0.113	0.32

CONCLUSION

Addition of AC and MOP greatly improved yield and yield components, fronds petiole cross sections and leaf tissue N and K contents. Fertiliser addition increased yields from 7.6 t/ha in nil fertilised plots to 24.9 t/ha in fertilised palms in 2010.

Trial 257 New Ireland Oil palm smallholder food security demonstration blocks (RSPO 4.2, 4.8, 5.1, 6.1, 8.1)

SUMMARY
Work in progress

BACKGROUND
Refer to Trial 337

BLOCK DETAILS AND TRIAL SET UP
The set up of the food security demonstration site in New Ireland is different from Popondetta. The food security plot was set up outside of the block and fenced with bamboos to prevent pigs spoiling the food crops grown inside. Then small plots were setup inside the fenced area and planted with food crop. Empty fruit bunch from the mill was added to the plots before food crops were planted especially for the banana plots. Block information is shown in Table 1.

Table 1. Trial 257, Block information

Trial number	**257**	Soil Type	On raised coral
Block owner	Siri	Drainage	Good
Block No.	2655	Topography	Flat
Location	Lakurumau	Altitude	m asl
Division		Previous Land-use	Food gardens
Planting Density	(a)		
	(b)	Supervisor in charge	Paul Simin
Pattern	Triangular		
Date planted	(a)		
	(b)		
Trial started	March 2008		
Planting material	Dami D x P		
Progeny	Mixed Dami DxP		
Recording Started	2010 (Food crops)		

MEASUREMENTS IN 2010.
The harvested food crops from the plots were weighed and sub-samples were taken to determine the dry weights and to be sent for analysis. Soil samples were also taken from the plots and will be sent for analysis.

SUMMARY
Work is in progress and data collection has commenced.

Sustainability Project (SMCN/2009/013) (RSPO 1.1, 4.2, 4.3, 4.4, 4.8, 5.1, 5.6, 8.1)

The ACIAR-funded project 'Sustainable management of soil and water resources for oil palm production systems in Papua New Guinea' (SMCN-2009-013) officially commenced in January 2010 and is scheduled to run until December 2013. Sub-contracts were arranged in February 2010 and a draft web site was established at https://docs.google.com/View?id=dcsqhb9f_3dwn5ddmd. Activities in 2010 are described below under some general headings and under each of the project 'Objectives'.

Objective 1. To develop indicators of soil health

Soil organic matter

Soil organic matter research was carried out under the 'SCAN' (Silicon, Carbon and Nitrogen, see Object 3), 'Replant', and 'Allometrics' (see Object 2) experiments. SCAN soil samples were taken and sent to James Cook University (JCU) for C isotope analysis, which will be carried out in 2011. Soil samples from the SCAN experiment were sent to AgResearch in NZ for microbial characterisation in 2011. An incubation experiment was set up to quantify the rate of decomposition of pools of soil organic matter. The soil samples were taken in Hoskins and Popondetta and the incubation commenced at JCU in May 2010 (Figure 1). It will continue until the end of the project.

Figure 1. Soil sampling at under oil palm in one of the Morokea VOP blocks

Soil pH

Trial 324 was identified as a site for measuring rate of soil acidification under different management. pH meters were purchased, and sampling and analysis will be carried out in 2011.

Soil erosion

Potential approaches were discussed but no field activities were carried out.

Objective 2. To develop indicators of nutrient balances

Allometrics experiment.

A protocol was developed and sampling commenced to determine relationships between easily measured parameters (for use as inputs to indicators) and the amounts of biomass, C and nutrients in palms. While allometric relationships have been determined in the past, they have not been checked for current planting material, and they do not cover all the relationships needed to determine nutrient balances.

Three sites (plantations) of different palm ages were selected for allometric sampling: Haella plantation, Numondo and Bebere plantations which had palms at the ages of 6, 10 and 20 after planting. Four palms were selected in each plantation to be utilized for various sampling work. The 4 palms were GPSed and other information for these palms was recorded.

Core samples were extracted from the trunk tissues of the four palms using a corer (Figure 2). These have been processed and ready for dispatch.

Figure 2. Trunk sampling using a corer

Canopy measurements and sampling were completed in all 3 plantations (Figure 3) and data have been sent to objective leader while processed leaf tissues samples will be sent for analysis in 2011. Trunk measurements and sampling will be carried out in 2011.

Figure 3. Measuring rachis segments and weighing of a full rachis with all leaflets removed

Soil cores were taken to quantify root biomass (Figures 4 and 5). Cores were taken from various depths (0-2 metres) from 34 sampling points spread across all the five different management zones. Cores were taken back to the office where roots were extracted by sieving the soil (Figure 6), with fresh and dry weights recorded. So far we have completed soil coring in the 6 year old palms at Haella and all the roots samples from these palms have been processed and ready for dispatch. Fresh/dry weight data for these samples have been emailed to CSIRO. We are now doing core sampling in the 20 year old palms at Bebere. We have observed more roots in the soil cores taken from the 20 year old palms than the 6 year old palms at Haella.

Figure 4. Sampling points for soil coring

Figure 5. Using pulley to winch out core


Figure 6. Soil sieving for oil palm root extraction

Nutrient loss measurements
To determine the amount of nutrients leached from fertilised areas a lysimeter was trialled. A Full-stop® device was installed in one of the smallholder demonstration trials in Sarakolok to measure how far water infiltrates through the soil after rain (Figure 7). Since its installation, the apparatus has not been working consistently and new techniques are being looked into.

Figure 7. Testing the Full stop®

Replant experiment
A site was identified in Milne Bay for sampling and analysing palms and soils before and after replant, to determine C and nutrient balances during this period. A practice sampling was done on a couple of palms in the block and it is planned for actual sampling in 2011.

Nitrogen fixation
The nitrogen fixation part of the project comprises a Masters project which Rachel Pipai is currently undertaking at the University of Adelaide, withfield studies in PNG. Legume and other plant samples were collected from oil palm fields in Kimbe, Bialla and Popondetta for natural ^{15}N natural abundance determination. The samples from Popondetta have been sent for analysis while those from WNB will be sent in 2011. The field trials for biomass determination are planned for 2011.

Objective 3. To develop indicators of C sequestration

SCAN experiment (Silicon, Carbon and Nitrogen)
This experiment is designed to provide data on cycling of C and nutrients, and soil acidification. Fifteen sites have been sampled in Popondetta and two sites in Hoskins. Each of the 10 sites in Popondetta consists of an oil palm block (planting dates ranging from 1985 to 2009) that were established on grassland, an adjacent grassland sub-site and an adjacent forest sub-site. Each of the two Hoskins sites consists of a smallholder oil palm block that was established on ex-forest, and an

adjacent forest sub-site. Soil samples were taken in 2010 using pits down to 1.5 m depth, with several replicates (Figure 8). Bulk density was measured and samples were sent to JCU for analysis of C isotopes, nutrients and pH, all of which will be carried out in 2011. In addition, soil C analysis of oil palm blocks that have been under oil palm for a range of generations will be undertaken in 2011.

Figure 8. Soil pit with distinct layers at Morokea VOP

Objective 4. To develop indicators of aquatic ecosystem health

Four tasks were conducted during the period May to November 2010.

1. A detailed background literature review was undertaken that succeeded in identifying a variety of background information sources, including one previous study of the fresh water fish fauna of Kimbe Bay (Jenkins A (2000) The freshwater-estuarine fish fauna of the Kimbe Bay region, West New Britain, Papua New Guinea. Unpublished Technical Report, Wetlands International, Canberra).
2. Initial study site selection was conducted during which 126 potential study sites were selected in the Kimbe Bay/Bialla areas and 54 sites in the Milne Bay/Mullins Harbour areas.
3. Initial impact evaluations were conducted for each study site to support final selection of sites to represent the full available range of natural and impact conditions.
4. Based on the first 3 components field study designs were developed.

Initial impact evaluations suggested 6 major potential sources of impact:

- Mill waste water (visually discoloured) has a potential for impact on receiving streams.
- Gravel extraction from streams (for road construction) is poorly managed from an environmental standpoint, periodically blocking flows and producing intense bursts of highly turbid waters. These events are likely to be destabilising to fauna evolved to the very clear water conditions seen in undisturbed streams
- Fertiliser is spread right to stream banks and this provides the potential for quantities of extraneous nutrients entering waterways
- Increased human population pressure leads to intensification of a range of practices that probably had little impact when populations were low but now may have substantial impacts on stream organisms. Prominent among these are village washing and waste disposal, which has the potential to cause substantial eutrophication, and over fishing due the pressure of providing enough protein for increasing populations.
- Bank erosion due to the loss of large, deep rooted bank side vegetation because of clearing for oil palm and clearing to provide areas for gardening.
- Loss of riparian vegetation. This has a number of disadvantageous impacts; (a) loss of bank side shading which is critical because overhanging vegetation is one of the main controls on water temperature in tropical streams, (b) alteration of supply of insects and fruit as food inputs to aquatic systems, (c) loss of snag generating potential, which is critical to maintain stream hydrology and provide refuges for aquatic animals.

Two tasks were conducted during the period December 2010 to May 2011:

1. Assessment of the impact of effluent discharge from Hargy mill into the sea. The results of this work are still being analysed.
2. Specific site evaluation for suitability of sampling protocols in the Dagi R., Kimbe Bay.

Major field studies are scheduled for late May 2011 at Kimbe & Bialla.

Objective 5: To develop a crop system model that enables prediction of management effects on soil health, C sequestration, greenhouse gas emissions and nutrient balances

The PNGOPRA agronomy data bases and weather data were provided for the development of a crop system model for oil palm using APSIM (Agricultural Production Systems Simulator).

Objective 6: To test and implement an integrated monitoring & recommendation package, and build institutional capability to maintain it.

Pilot teams were put together in Hoskins and Popondetta, and meetings were held (May 2010) to discuss the planned activities of the pilot teams. Meetings were held in Kimbe and in Popondetta with the selected growers. In Popondetta, the five selected blocks were included in the smallholder leaf tissue sampling and socio-economic surveys in 2010. Various field days were carried out throughout the country and sustainability issues were discussed during these field days. In Popondetta, 22 mini and 1 major field days were carried out during which agronomy, HIV-AIDS, Gender and Sustainability issues were discussed.

International meetings and travel

- 18-20/01/2010, Townsville. Planning meeting (Project staff)
- In March and April, several meetings were attempted with the whole project team over the internet, but no satisfactory means of including everyone was established.
- In May a meeting with other groups developing sustainability indicators was arranged, but the meeting was cancelled by the organiser, J-P Caliman (CIRAD/SINAR MAS), due to other imperatives within the Sinar Mas group.
- 10/05/2010, Mosa. NBPOL briefing (Senior project staff and senior NBPOL staff)
- 11/05/2011, Nahavio. Hoskins Pilot team meeting (Project staff and pilot teams)
- 12/05/2011, Walindi. Inception meeting (Project staff, ACIAR representatives and other interested parties)
- 17/05/2011, Bialla. Hargy briefing (Senior project staff and senior NBPOL staff)
- 20/05/2011, Popondetta. Higaturu Oil Palms briefing and Popondetta Pilot team meeting.

Outputs and other information

ACIAR Technical report published

Nelson PN, Webb MJ, Orrell I, van Rees H, Banabas M, Berthelsen S, Sheaves M, Bakani F, Pukam O, Hoare M, Griffiths W, King G, Carberry P, Pipai R, McNeill A, Meekers P, Lord S, Butler J, Pattison T, Armour J and Dewhurst C. 2010. Environmental sustainability of oil palm cultivation in Papua New Guinea. ACIAR, Canberra.

Presentations

16/8/2010, Cairns. Public lecture on oil palm and the environment (Nelson)

Other

Drafted definition of fragile and marginal soils for RSPO NIWG.

Collaboration with Wageningen University, the Netherlands (RSPO 4.2, 4.3, 8.1)

A new model of oil palm growth and production has been developed at Wageningen University, the Netherlands. In the testing phase of the model data of PNGOPRA have been used. The aim of the PALMSIM model is to represent in a simple way the most important processes governing potential and resources limited growth of oil palm and bunch production. This dynamic model has been developed with the objective of keeping the complexity low in the description of the key growth processes, but to capture the most important dynamic aspects of a developing oil palm stand. It simulates palm growth and bunch production, as well as yield components. The results showed that the potential model is indeed simulating the upper boundary of what is currently measured in oil palm plantations in sites across South East Asia and one site in Latin America, as to be expected from a potential growth model. Furthermore, it could do this with one single parameterization, which shows that the description of the processes in the model is quite robust across quite different sites. The model could be applied easily to all of these sites, which shows that the aim of developing a relatively simple model that can be used rapidly in different locations has been achieved. Simulation of limiting elements (nutrients and water) was a more difficult exercise, especially for the nutrients. In the end all of the datasets only showed effects of K limitations, which we subsequently incorporated into the model. However, further research should be performed to improve and test further across locations the current implementations of the effects of :

- nutrient limitations on yield and yield components
- water stress on yield and yield components
- interactions between water stress and nutrient limitations on yield and yield components

These model developments would allow us to start testing in detail the actual yield prediction capacity of the model and to compare it to current, more empirical approaches.

2. ENTOMOLOGY RESEARCH

HEAD OF SECTION: CHARLES DEWHURST

SUMMARY

2011 was characterised by a large increase in reported infestations, which was predicted as likely to occur in the previous (2009) report. OPIC Divisional Managers continued to provide samples of pest taxa and "sexava" eggs from smallholder blocks that were being harvested from areas agreed for sampling during the weekly pest management meetings. This material is now systematically dissected to enable us to improve our understanding of embryonic development and the development of field populations. The number of treatment teams varied throughout the year and infestation control lagged behind new reports, however it is understood that this will change in 2011. Close liaison is also maintained with Plantation Managers who also provide specimens for confirmation, but these samples are more erratic.

Staff numbers increased during 2010 with the appointment of two executive staff, and the re-deployment of one executive staff member to Kula Group at Higaturu Centre. A lab technician was also employed at Dami, and a recorder was employed and sent to New Ireland for pest related work. Strong collaboration with local and overseas research personnel continued. HoE visited Washington in February for the project, Basic Research to Enable Agricultural Development (BREAD), a Gates Foundation project, to investigate alternative methods for control of pests. There was no response received from The Department of Environment and Conservation (DEC) in Port Moresby for requests dealing with this project nor for Queen Alexandra Birdwing Butterfly project and NAQIA did not take the Notifiable Pest Status further for gazettal, although a draft has been sighted. The collaborative ACIAR Zophiuma project ended in August; however the staff member working on his MPhil. Degree will continue his studies until mid 2011.

OIL PALM PEST REPORTS (RSPO 4.5, 8.1)

One hundred and thirty-eight (138) pest reports were received from plantations and smallholders, (73 from plantations and 65 from smallholders, including 3 from Solomon Islands) during the year (Fig.1). This was an increase from 2009, with a total of 74 for all areas of PNG (Fig.2). This represented an overall increase of 64 reports, up 42%. During 2010, there was only one pest report received from mainland PNG, from Mamba Estate (Kula Group), where reports of a newly recorded weevil were investigated (see below). The very heavy rains that fell during the latter part of 2009 and early 2010 are likely to be responsible for encouraging the build up of populations of sexava, although there were no obvious associated peaks (Fig.6). Wet periods benefit sexava population development while at the same time hindering the effective use of TTI for their control.

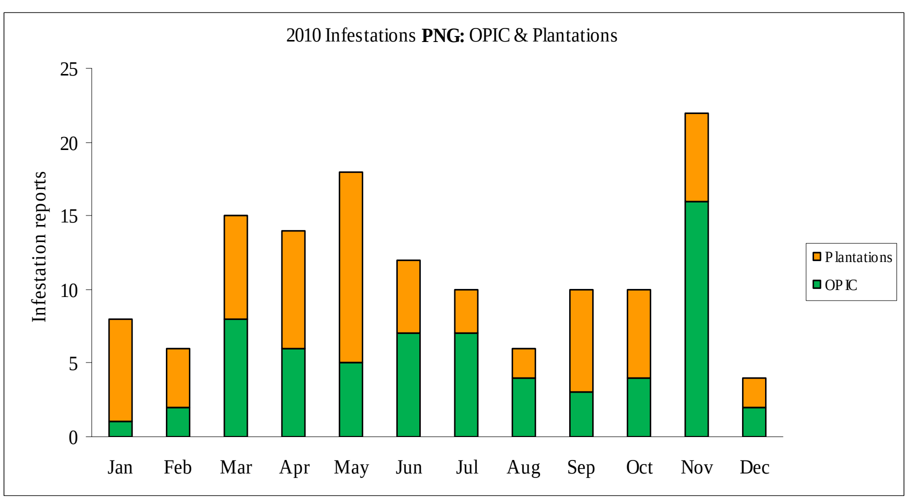

Figure 1. Pest infestation reports for 2010: PNG (plantations and smallholders).

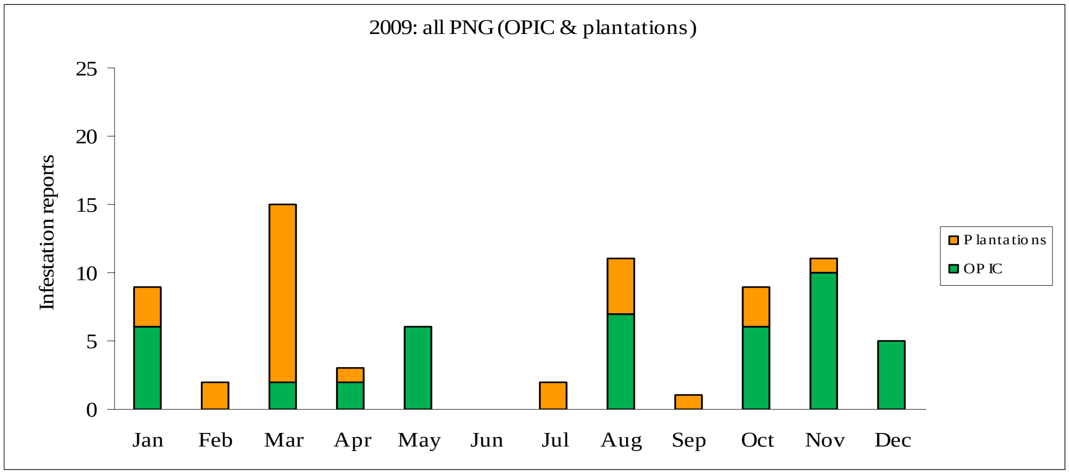

Figure 2. For comparison: Pest infestation reports: PNG 2009 (all plantations and smallholders).

Mainland PNG,
There was a single pest report of a previously unrecognised Curculionidae (weevil) from the Kula Group Mamba Estate (see below).

New Ireland
During 2010, infestation reports increased considerably, and there were 5 reports from smallholders and 18 reports from plantations (Fig.3). Interestingly there were also months when no reports were received (February, June August and October). A visit was made to NI by HoE in October 2010, and extensive field surveys were made of most of the Estates. Follow-up monitoring by TSD and PNGOPRA staff identified plantations where there were populations that required treatment. It was noteworthy that OPIC was now becoming more active in reporting infestations. It is hoped that the increased vigilance will result in a fall in infestations over the next years. At the end of the year, a new staff member was posted to NI to assist with the work over there and be responsible for the regular surveys, and the laboratory studies that will be required. The outside of the lab was repaired after being hit by a fruit truck.

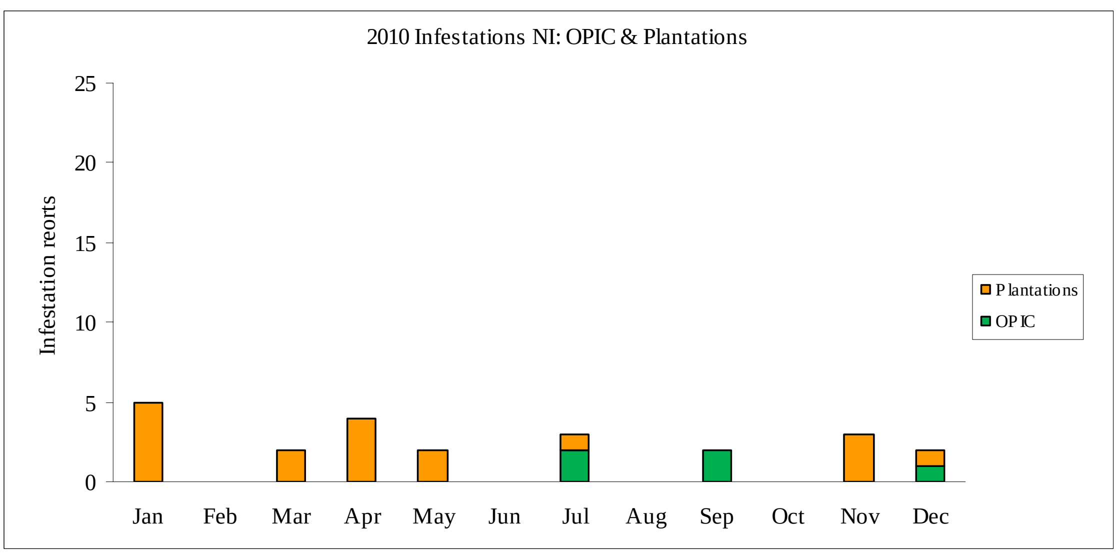

Figure 3. Infestations reported from New Ireland.

West New Britain
Infestation reports received from West New Britain (WNB) increased from the previous year (68 in 2009 to 111 reports in 2010, an increase of 39% (Fig.4). Of the reports, 60 were from smallholder growers and 51 from plantations.

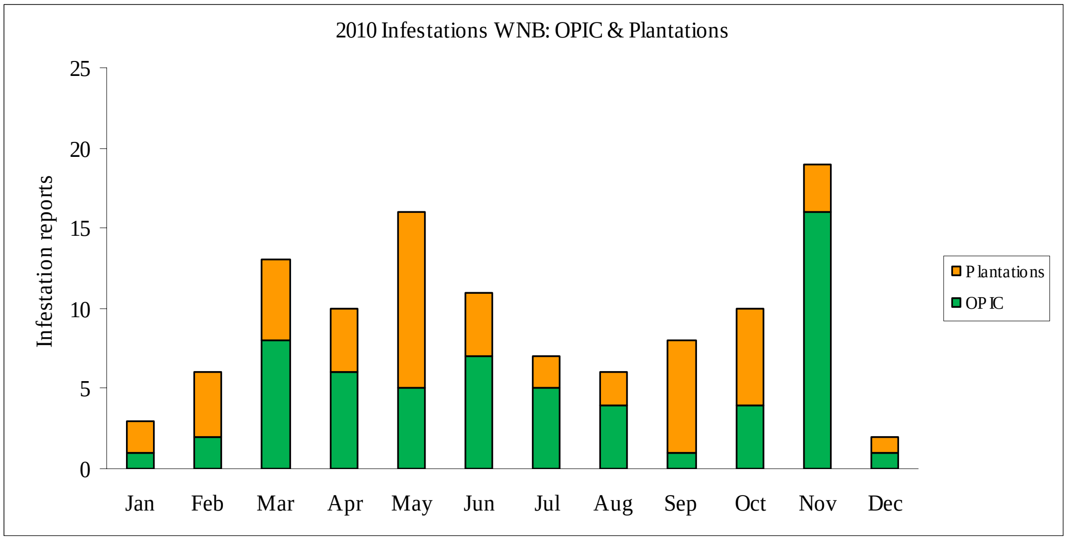

Figure 4. Infestations in West New Britain 2010 (OPIC and Plantations).

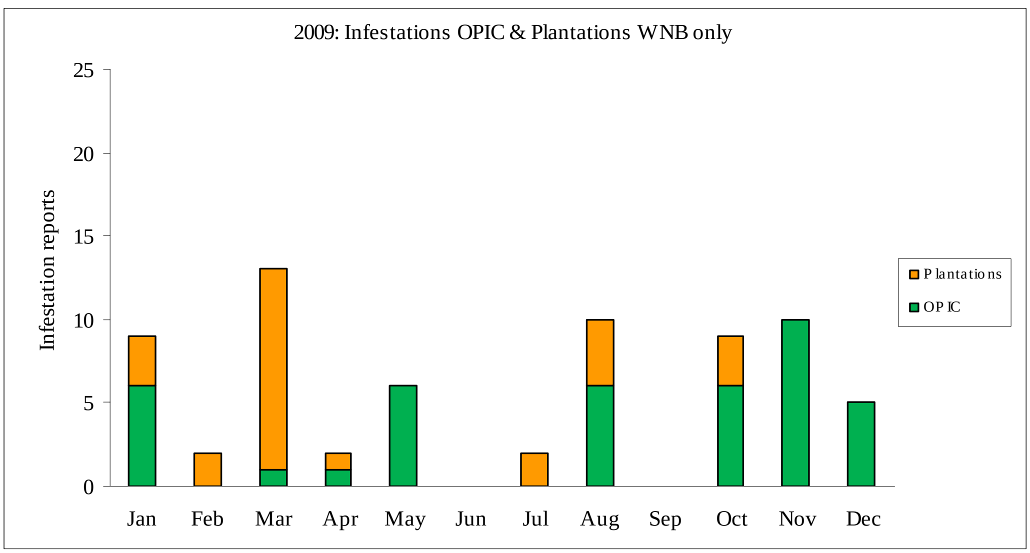

Figure 5. For comparison: Infestations in West New Britain 2009 (OPIC and Plantations).

On West New Britain (WNB) there were two obvious periods of increased reports represented as bimodal peaks between March and May, and again in November (Fig.4), but with reports during every month of the year, in contrast with events during 2009 where there were no reports during June and September (Fig.5). This reduction in reports does not of course mean that there was a reduction of activity; however it does indicate a drop in reported activity during those periods. Continued breeding activity during the year with sufficient rainfall resulted in the increased number of reports, however as in previous years, there was a noticeable trough of activity in the middle of the year which may also be related to the reduced rainfall during the middle of the year as reported from Dami Research Station and Navo Estate (Hargy Oil Palms), both of which are in the main areas of pest activity in West New Britain (Fig.6).

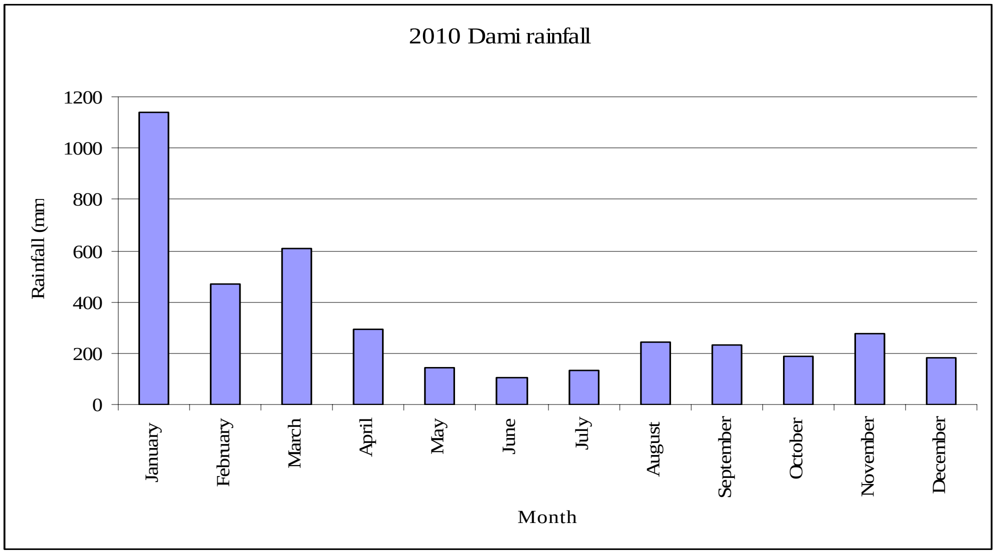

Figure 6. Rainfall at Dami Research Station.

There is no obvious correlation between rain days and infestation levels, although it can be seen that there was a three month lag followed by an increase of infestations after a period of 12 or more rain days in a month e.g. March, May, and November (Fig.7).

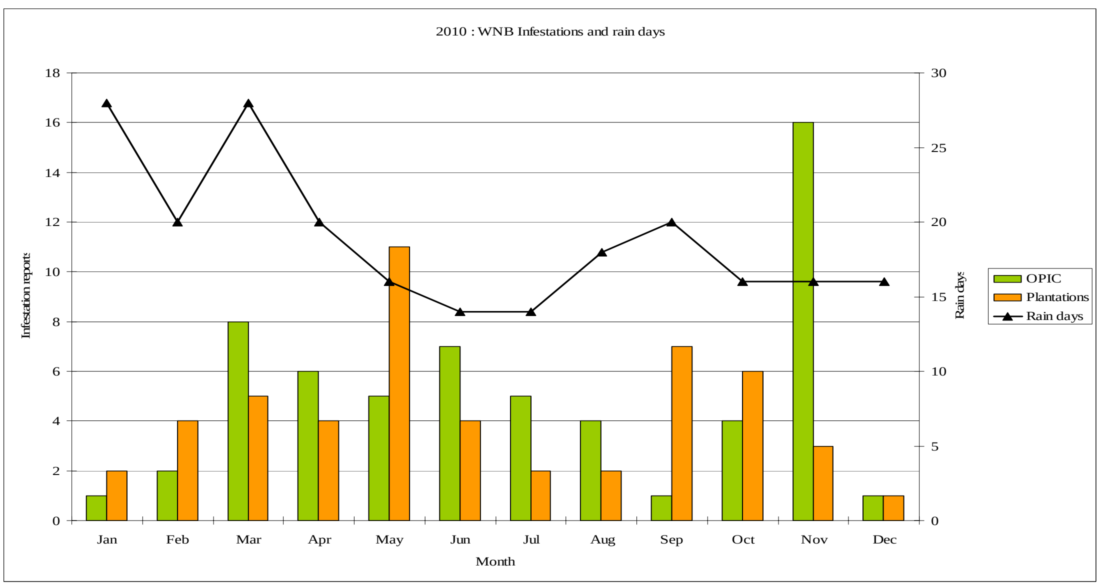

Figure 7. Pest reports with Rain days from Dami Research Station.

PestRecs and TTI levels in 2010 (RSPO 4.5, 4.6, 8.1)

As plantation staff and smallholder growers have been made more aware of the need for rapid reporting, through training, field visits and field days, reports from other categories (Moderate and Severe) should continue to be reduced with time (Table 1). All reported infestations are visited and PestRec issued. Analysis of the reported infestation levels show that the majority are now reported when damage is assessed by PNGOPRA as Light. Approximately 48% of infestations reported (both smallholders and plantations) were assessed as Light damage, 35% with moderate levels of damage and 16% with severe damage levels (Table 1 and Fig.8). Although it was encouraging that most reports were visited when damage was light, there is still a great deal of room for improvement, especially among plantations where almost 50% (26/42 reports) were reported when damage was already severe (Table 1).

Table 1. Damage levels as reported to entomology.

	Light	Moderate	Severe	Other*	
OPIC: PNG	62	51	14	0	
Plantation: PNG	62	41	26	1	
Plantation: SI	1	2	2	0	
Total	125	94	42	1	n=262
	47.70%	35.80%	16%	0.38%	

(* refers to two reports of weevil, *Sparganobasis* from Mamba Estate, Kula Group).

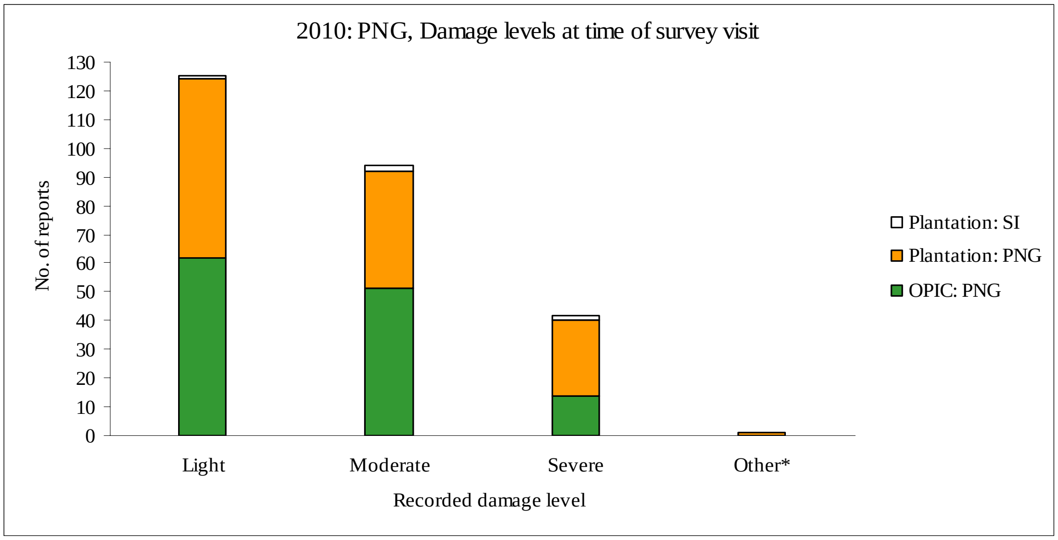

Figure 8. PNG PestRecs and severity. (**other refers to the recently reported weevil, Sparganobasis subcruciata, which was not treated*).

During the year, not all TTI requirements were completed, with many areas that were due for second treatments not completed within the time period of 16 weeks. This meant that further repeat surveys and TTI will be required during 2011 to cover those areas. Reasons for these delays were due to operational inadequacies and inclement weather conditions in the early part of the year. No recommendations for third treatment were made in 2010 (Fig.9). Almost 81% of infestations were recommended for a first treatment, while only 15% were recommended for a second treatment (Table 2).

Table 2: Number and types of treatments undertaken from within PNG in 2010.

	Recommendation					
Type of PestRec	**Treatment number**			Monitoring	Handpick	Other*
	#1	#2	#3			
OPIC: PNG	52	5	0	27	1	0
Plantation: PNG	52	15	0	35	1	2
Plantation: SI	0	0	0	2	3	0
Total	104	20	0	64	5	2

Total TTI	124	
Total control	129	
% Treatment #	80.60%	15.50%

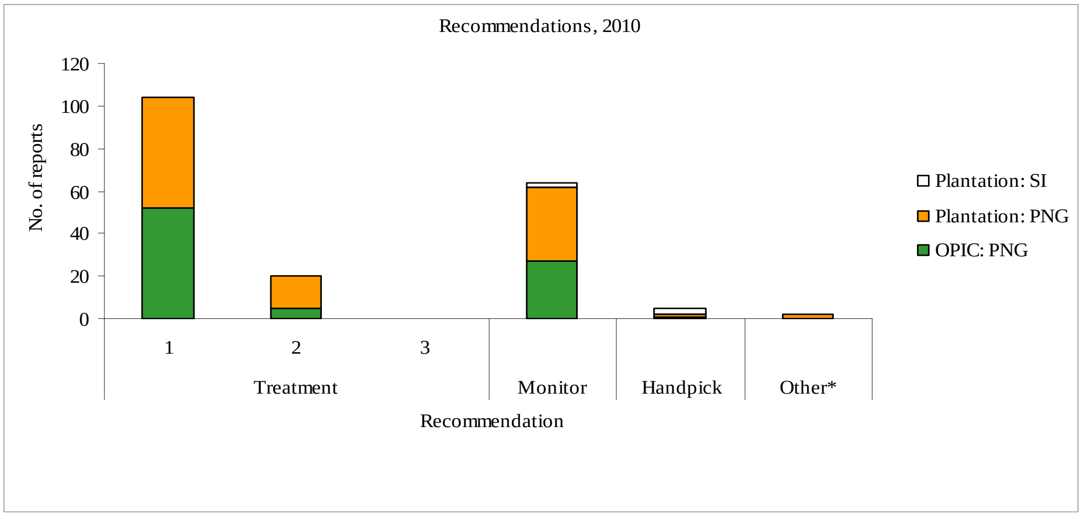

Figure 9. PNG and SI, plantations and OPIC (smallholders): recommendation options [* refers to *S.subcruciata* that was not treated].

Pest frequency and distribution. (RSPO 4.5, 8.1)
In 2010, because of the higher frequency of reports, *S.defoliaria*, *S.decoratus* and *E.calcarata* again dominated reports, although there was a shift in abundance with more "sexava" reports originating from plantations in 2010 than in 2009 (Fig.10 and Fig.11). This may be an effect of greater awareness among plantation staff, although with the regular field days during 2010, growers will also have an increased awareness (see below). It can be seen that infestations of *S.gracilis* from NI (as mentioned) also increased dramatically, while almost all infestation reports originated from WNB (Fig.12).

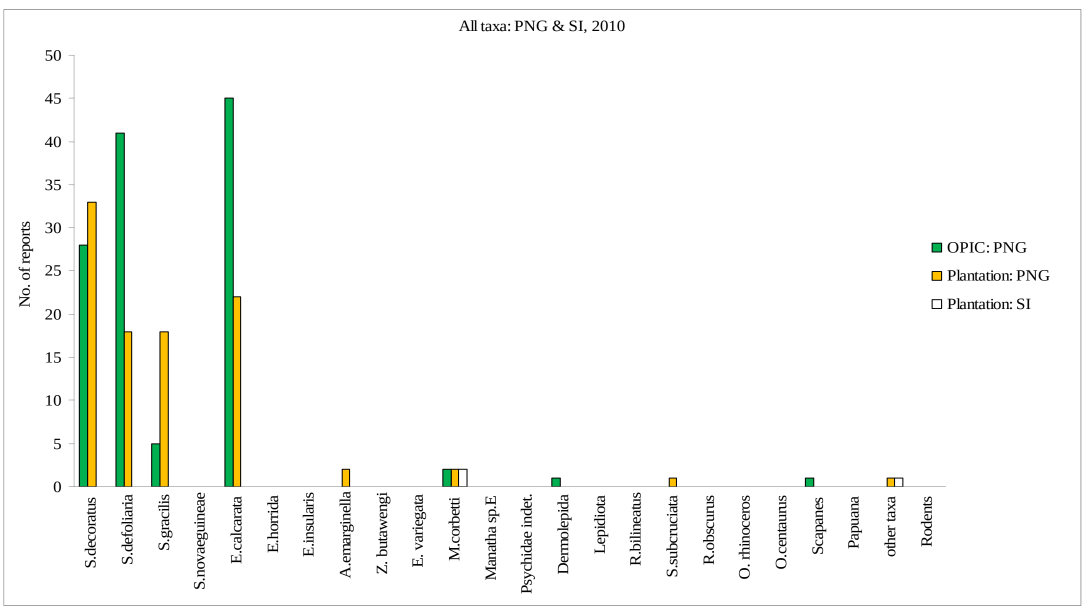

Figure 10. Pest taxa reported in 2010: PNG and Solomon Islands from plantations and smallholders (through OPIC).

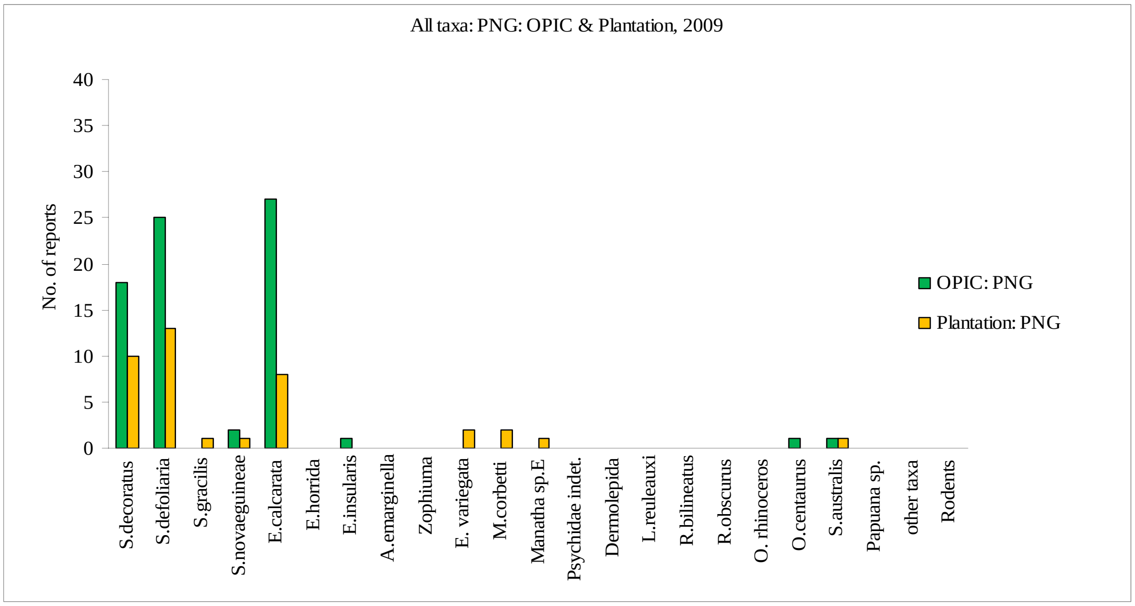

Figure 11. Pest taxa reported 2009: PNG from plantations and smallholders (through OPIC).

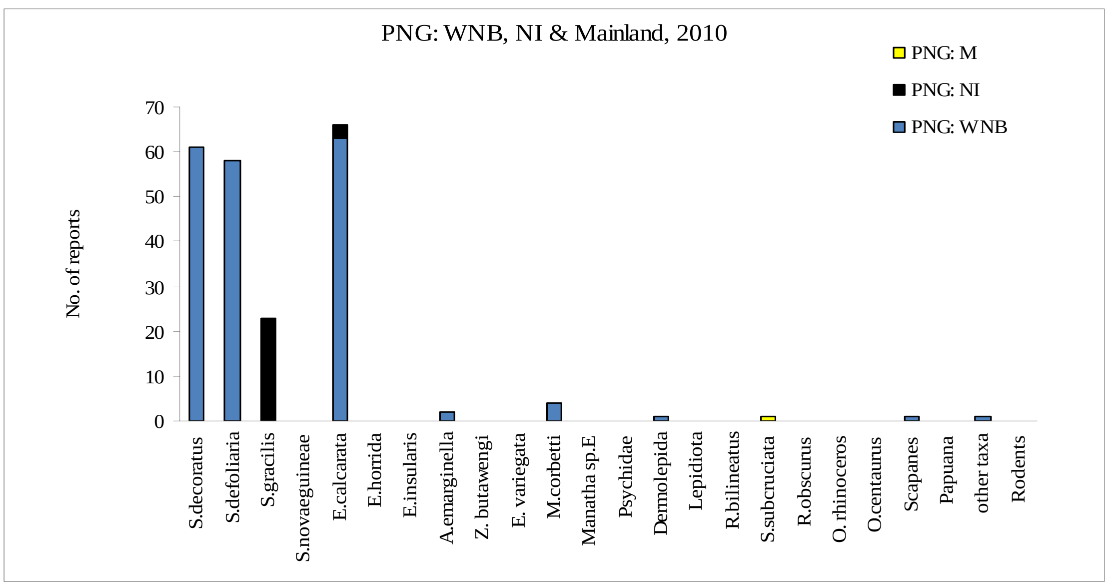

Figure 12. Pest taxa reported: WNB, NI and mainland (M) from plantations and smallholders (through OPIC). Not including Solomon Islands (SI).

Pest Treatment (RSPO 4.5, 4.6, 8.1)

Targeted Trunk Injection (TTI).

During 2010, TTI was lagging behind in some areas recommended for treatment, due mainly to the inclement weather conditions, staffing and logistics. Smallholder Affairs Dept (SHA) underwent restructuring in late 2010.

An OPRAtive Word on plugging the injection holes was published during the year (Technical Note 16, see References).

Areas treated during 2010.

During the year, working with colleagues in OPRS, attempts were made to tighten up on the reporting of areas treated to improve the accuracy of information. 7,471 hectares were treated by TTI during 2010. Approximately 764.5ha of the total areas were also recommended for 2nd treatment, giving a total of 6,707ha treated from 24 plantations (Table 3). This represents some 950,500 palms that were treated, a marked increase from 2009. There is however still the requirement of some of the details of treated areas to be clarified (Table 3), especially from OPIC Bialla Project.

Table 3. Plantations treated in 2010 (NBPOL WNB) (in conjunction with OPRS).

Division	Area for TTI (Ha)	Report Date
Bebere 1	48	18/2/10
Bebere 1	48	18/2/10
Bebere 1	80.2	18/2/10
Bebere 2	75	8/6/10
Togulo 1	93	8/6/10
Togulo 1	114	8/6/10
Togulo 1	72	8/6/10
Togulo 1	95	8/6/10
Dami 2	130	8/4/10
Dami 2	9	8/4/10
Dami 2	20	8/4/10
Dami 2	30	5/5/10
Volupai 1	81.8	12/4/10
Volupai 1	81.8	22/8/10
Volupai 1	40	22/8/10
Volupai 2	38	5/2/10
Volupai 2	61	5/2/10
Volupai 2	140	5/2/10
Volupai 2	18	5/2/10
Volupai 2	165	9/3/10
Volupai 2	179	9/3/10
Volupai 2	66	9/3/10
Volupai 2	38	8/6/10
Volupai 2	206	8/6/10
Volupai 2	130	22/7/10
Volupai 2	90	22/7/10
Lolokuru 1	84	12/4/10
Bilomi 1	44	9/3/10
Numundo 1	89	9/3/10
Numundo 1	49	9/3/10
Numundo 1	87	9/3/10
Numundo 1	62	9/3/10
Numundo 1	60	9/3/10
Numundo 1	72	9/3/10
Numundo 1	59	9/3/10
Numundo 2	25	8/6/10
Numundo 2	22	8/6/10
Haella 1	40	13/3/10
Haella 1	20	6/8/10
Haella 1	74	13/3/10
Haella 1	82	6/8/10
Haella 1	68	6/8/10
Haella 1	84	6/8/10
Haella 1	57	13/3/10
Haella 1	57	6/8/10

Division	Area for TTI (Ha)	Report Date
Haella 2	5	13/3/10
Haella 2	9	6/4/10
Haella 2	19	6/4/10
Haella 2	14	6/4/10
Haella 2	50	6/8/10
Garu 2	33	20/1/10
Garu 2	67	20/1/10
Garu 2	67	20/1/10
Daliavu 1	113	9/3/10
Daliavu 1	49	9/3/10
Daliavu 1	38	9/3/10
Daliavu 1	16	9/3/10
Daliavu 1	73	9/3/10
Daliavu 1	85	9/3/10
Daliavu 1	91	9/3/10
Daliavu 1	94	9/3/10
Daliavu 1	87	9/3/10
Daliavu 1	10	9/3/10
Daliavu 1	90	9/3/10
Daliavu 1	65	9/3/10
Daliavu 1	26	9/3/10
Daliavu 1	107	9/3/10
Bilomi 1	59	22/10/10
Bilomi 1	111	18/10/10
Karausu 1	89	29/10/10
Karausu 1	40	29/10/10
Karausu 1	84	29/10/10
Karausu 1	72	29/10/10
Karausu 1	100	29/10/10
Karausu 2	110	29/10/10
Karausu 3	94	22/10/10
Karausu 3	105	22/10/10
Volupai 2	190	2/11/10
Volupai 2	206	2/11/10
Volupai 2	235	2/11/10
Volupai 2	184	2/11/10
Volupai 2	179	2/11/10
Volupai 2	66	2/11/10
Dami 2	149	4/10/10
Dami 2	95	4/10/10
Dami 2	99	4/10/10
Kumbango	132	28/12/10
Kumbango	128	28/12/10
Togulo 1	132	12/11/10
Togulo 1	53	12/11/10
Karatu 1	89	4/10/10
Karatu 1	40	4/10/10

Division	Area for TTI (Ha)	Report Date
Karatu 1	84	4/10/10
Karatu 1	100	4/10/10
Karatu 1	72	4/10/10
Karatu 2	47	4/10/10
Garu 2	109	4/10/10
Garu 2	75	4/10/10
Garu 2	75	4/10/10
Haella 4	103	28/12/10
Sapuri 1	91.9	2/11/10
Sapuri 1	119.8	2/11/10
Sapuri 2	89.3	2/11/10

Summaries	
Total area for TTI (ha)	**7,471**
Total Oil Palms (TTI)	**950,437**
Total Methamidophos (litres)	**9,504**

Table 4. Areas treated (ha) in Bialla Project during 2010.

Lavu	Sege	Mu-umata	Mu-umata ME and Gamupa	**Total ha. treated**
July	July	July	August	
11.6	3.88	175.71	29.61	**220.80**

(Original data: OPIC, Bialla). Bialla Project (Source: P Taramurray, Hargy Oil Palms Ltd.).

Results for areas treated by Smallholder Affairs (SHA) from West New Britain in 2010 were not available in a useable form at the time of writing, although the raw data were available and are currently being entered onto our database. Similarly the majority of the data for the areas treated from the Bialla Project (OPIC) were unavailable at the time of writing (Table 4), however Mu-umata (Bialla, WNB) required a large input from TTI. Both sets of data will be included in the 2011 Annual Report.

The data (Tables 5 and 6) show that Hargy infestations treated in 2010 were less than those treated in 2009 and Table 7 shows all Plantations and smallholder areas recommended for TTI during 2010.

Table 5. Hectares of oil palm treated by Hargy Oil Palms in 2010, compared with 2009.

2009	2010	Reduced ha treated over previous year
1,440	1,224.0	216.0

(Adapted from original data: Peter Taramurray Hargy Oil Palms).

Table 6. Hargy Oil Palms, Navo Estate areas treated with TTI.

Field Number	Ha TTI	Month of activity for TTI
1	16.8	Dec
3	228.9	Apr,May,Oct,Nov
4	255.7	Mar,Apr,Oct,Nov,Dec
5	183.2	Jan,Feb
6	270.8	May,July
7	198.3	Mar,Aug,Oct,Nov,Dec
8	16.8	Mar
9	53.5	Dec
Total ha TTI	**1,224**	

Table 7. Summary from PID list of infestations in PNG during 2010

PestRec #	Locality	Division/ Group	Report received by PNGOPRA	Date of visit	Days after report received at OPRA	Date report issued by PNGOPRA	Days from visit to report issued
0310	Galai 1	Buvussi	11-Jan-10	14-Jan-10	3	20-Jan-10	6
0410	Garu Plantation	Numundo	13-Jan-10	15-Jan-10	2	20-Jan-10	5
0510	Lamerika Plantation	Madak Estate	08-Jan-10	30-Jan-10	22	09-Feb-10	10
0610	Volupai Plantation	Mosa	29-Jan-10	30-Jan-10	1	06-Feb-10	7
0710	Bebere Plantation	Mosa	04-Feb-10	17-Feb-10	13	19-Feb-10	2
0810	Valoka	Siki	03-Feb-10	05-Feb-10	2	11-Feb-10	6
0910**	Soubu Plantation	*should be 2009*					
1010	Suma Plantation	Madak Estate	25-Jan-10	25-Jan-10	0	09-Feb-10	15
1110	Piera Plantation	Noatsi Estate	25-Jan-10	25-Jan-10	0	09-Feb-10	15
1210	Kapsu Plantation	Kara Estate	28-Jan-10	28-Jan-10	0	09-Feb-10	12
1310	Wanup Plantation	Kara Estate	28-Jan-10	28-Jan-10	0	09-Feb-10	12
1410	Daliavu Plantation	Numundo	23-Feb-10	25-Feb-10	2	09-Mar-10	12
1510	Volupai Plantation	Mosa	24-Feb-10	25-Feb-10	1	09-Mar-10	12

Table 7. cont.

PestRec #	Locality	Division/ Group	Report received by PNGOPRA	Date of visit	Days after report received at OPRA	Date report issued by PNGOPRA	Days from visit to report issued
1610	Galai 1	Buvussi	25-Feb-10	02-Mar-10	5	09-Mar-10	7
1710	Bilomi Plantation	Kapiura	26-Feb-10	04-Mar-10	6	09-Mar-10	5
1810	Banaule	Kavui	03-Mar-10	03-Mar-10	0	09-Mar-10	6
1910	Bilomi Plantation	Kapiura	04-Mar-10	04-Mar-10	0	09-Mar-10	5
2010	Siki	Siki	01-Mar-10	09-Mar-10	8	13-Mar-10	4
2110	Numundo Plantation	Numundo	04-Mar-10	04-Mar-10	0	09-Mar-10	5
2210	Haella Plantation	Numundo	10-Mar-10	11-Mar-10	1	13-Mar-10	2
2310	Rikau	Siki	10-Mar-10	11-Mar-10	1	16-Mar-10	5
2410	Koimumu	Siki	08-Mar-10	13-Mar-10	5	24-Mar-10	11
2510	Sarakolok	Nahavio	15-Mar-10	16-Mar-10	1	24-Mar-10	8
2610	Soi LSS	Meramera	17-Mar-10	17-Mar-10	0	24-Mar-10	7
2710	Sale/Sege LSS	Cenaka	12-Mar-10	18-Mar-10	6	24-Mar-10	6
2810	Kabil Plantation	Noatsi Estate	02-Mar-10	15-Mar-10	13	27-Mar-10	12
2910**	Kimadan Plantation	Madak Estate	02-Mar-10	15-Mar-10	13	27-Mar-10	12
3010	Haella Plantation	Numundo	31-Mar-10	31-Mar-10	0	06-Apr-10	6
3110	Mai	Kavui	29-Mar-10	07-Apr-10	9	08-Apr-10	1
3210	Waisisi Plantation	Mosa	06-Apr-10	07-Apr-10	1	08-Apr-10	1
3310	Lotomgam Plantation	Mosa	06-Apr-10	09-Apr-10	3	12-Apr-10	3
3410	Lolokuru Plantation	Mosa	26-Mar-10	09-Apr-10	14	12-Apr-10	3
3510	Galai 2	Buvussi	12-Apr-10	14-Apr-10	2	15-Apr-10	1
3610	Ubai	Salelubu	12-Apr-10	21-Apr-10	9	22-Apr-10	1
3710	Poli Plantation	Noatsi Estate	19-Apr-10	14-Jul-10	86	16-Jul-10	2
3810	Kandori	Nahaviio	22-Apr-10	26-Apr-10	4	28-May-10	32
3910	Bebere Plantation	Mosa	22-Apr-10	24-Apr-10	2	30-Apr-10	6
4010	Kilu	Nahavio	22-Apr-10	26-Apr-10	4	28-May-10	32
4110	Buvussi	Buvussi	26-Apr-10	04-May-10	8	05-May-10	1
4210**	Libba Plantation	Noatsi Estate	19-Apr-10	14-Jul-10	86	16-Jul-10	2
4310	Maranawai Plantation	Nalik West Estate	01-May-10	06-Jun-10	36	10-Jun-10	4
4410	Tiauru LSS	Maututu	28-Apr-10	28-Apr-10	0	07-May-10	9
4510	Waisisi Plantation	Mosa	03-May-10	04-May-10	1	05-May-10	1
4610**	Tiauru						
4710	Noau VOP	Meramera	05-May-10	06-May-10	1	29-Jun-10	54
4810	Mu Umata Estate	Meramera	05-May-10	06-May-10	1	29-Jun-10	54
4910	Novunabea Estate	Meramera	05-May-10	06-May-10	1	29-Jun-10	54
5010	Alaba Estate	Meramera	05-May-10	06-May-10	1	29-Jun-10	54
5110	Magalona Estate	Meramera	05-May-10	06-May-10	1	29-Jun-10	54
5210	Gamupa Estate	Meramera	05-May-10	06-May-10	1	29-Jun-10	54
5310	Kelangalel VOP	Meramera	05-May-10	06-May-10	1	29-Jun-10	54
5410**	Noau						
5510	Gaongo	Kavui	10-May-10	13-May-10	3	20-May-10	7
5610	Ngalimbiu Plantation	GPPOL	19-Apr-10	16-May-10	27	19-May-10	3
5710	Tetere Plantation	GPPOL	19-Apr-10	16-May-10	27	19-May-10	3
5810**	Valoka	Siki	20-May-10	20-May-10	0	23-May-10	3
5910	Buvussi	Buvussi	20-May-10	21-May-10	1	23-May-10	2
6010	Navo Plantation	SIPEF	28-Apr-10	29-Apr-10	1	23-May-10	24
6110	Ngalimbiu Plantation	GPPOL	19-Apr-10	16-May-10	27	23-May-10	7

Table 7. cont.

PestRec #	Locality	Division/ Group	Report received by PNGOPRA	Date of visit	Days after report received at OPRA	Date report issued by PNGOPRA	Days from visit to report issued
6210	Numundo Plantation	Mosa	24-May-10	27-May-10	3	08-Jun-10	12
6310	Kumbango Plantation	Mosa	25-May-10	27-May-10	2	08-Jun-10	12
6410	Bebere Plantation	Mosa	26-May-10	27-May-10	1	08-Jun-10	12
6510	Numundo Plantation	Mosa	25-May-10	06-Jun-10	12	08-Jun-10	2
6610	Togulo Plantation	Mosa	01-Jun-10	02-Jun-10	1	08-Jun-10	6
6710	Sarakolok	Nahavio	02-Jun-10	04-Jun-10	2	08-Jun-10	4
6810	Hark	Nahavio	02-Jun-10	04-Jun-10	2	08-Jun-10	4
6910	Volupai Plantation	Mosa	24-May-10	25-May-10	1	08-Jun-10	14
7010	Bebere Plantation	Mosa	03-Jun-10	04-Jun-10	1	08-Jun-10	4
7110	Kavui	Kavui	07-Jun-10	09-Jun-10	2	10-Jun-10	1
7210	Dalom Plantation	Madak Estate	01-May-10	06-Jun-10	36	03-Jul-10	27
7310	Malassi LSS	Cenaka	11-Jun-10	04-Aug-10	54	26-Aug-10	22
7410	Haella Plantation	Numundo	19-Jun-10	21-Jun-10	2	25-Jun-10	4
7510	Koimumu	Siki	21-Jun-10	23-Jun-10	2	25-Jun-10	2
7610	Gavaiva	Siki	21-Jun-10	23-Jun-10	2	25-Jun-10	2
7710	Kumbango Plantation	Mosa	25-Jun-10	29-Jun-10	4	02-Jul-10	3
7810	Gaongo	Kavui	28-Jun-10	01-Jul-10	3	05-Jul-10	4
7910	Sarakolok	Nahavio	01-Jul-10	15-Jul-10	14	26-Jul-10	11
8010	Soi LSS	Meramera	01-Jul-10	01-Jul-10	0	26-Jul-10	25
8110	Lotomgam Plantation	Mosa	16-Jul-10	17-Jul-10	1	22-Jul-10	5
8210	Volupai Plantation	Mosa	17-Jul-10	17-Jul-10	0	22-Jul-10	5
8310	Ganeboku	Nahavio	15-Jul-10	05-Aug-10	21	27-Aug-10	22
8410	Panamafei	North	17-Jul-10	17-Jul-10	0	21-Jul-10	4
8510	Panamafei	North	17-Jul-10	17-Jul-10	0	21-Jul-10	4
8610	Baia Plantation	Kara Estate	14-Jul-10	14-Jul-10	0	21-Jul-10	7
8710	Kapore	Kavui	16-Jul-10	16-Jul-10	0	22-Jul-10	6
8810	Haella Plantation	Numundo	02-Aug-10	05-Aug-10	3	06-Aug-10	1
8910	Ubai	Salelubu	21-Jul-10	04-Aug-10	14	27-Aug-10	23
9010	Mosa	Kavui	06-Aug-10	10-Aug-10	4	27-Aug-10	17
9110	Bebere Plantation	Mosa	12-Aug-10	26-Aug-10	14	01-Sep-10	6
9210	Buluma 1	Kavui	12-Aug-10	26-Aug-10	14	01-Sep-10	6
9310	Hak	Nahavio	25-Aug-10	26-Aug-10	1	01-Sep-10	6
9410	Karato Plantation	Numundo	26-Aug-10	01-Sep-10	6	06-Sep-10	5
9510	Galai 1	Buvussi	06-Sep-10	09-Nov-10	64	12-Nov-10	3
9610	Panamafei	North	26-Sep-10	28-Sep-10	2	12-Oct-10	14
9710	Panamafei	North	26-Sep-10	28-Sep-10	2	12-Oct-10	14
9810	Garu Plantation	Numundo	10-Sep-10	29-Sep-10	19	04-Oct-10	5
9910	Soubu Plantation	Noatsi Estate	19-Apr-10	14-Jul-10	86	12-Oct-10	90
10010**	Libba Plantation	Noatsi Estate	19-Apr-10	14-Jul-10	86	07-Oct-10	85
10110	Haella Plantation	Numundo	15-Sep-10	15-Sep-10	0	22-Sep-10	7
10210	Kavui	Kavui	08-Oct-10	25-Nov-10	48	28-Dec-10	33
10310	Waisisi Plantation	Mosa	23-Sep-10	28-Sep-10	5	04-Oct-10	6
10410	Kaurausu	Kapiura	30-Sep-10	01-Oct-10	1	04-Oct-10	3
10510	Bilomi Plantation	Kapiura	12-Sep-10	19-Oct-10	37	22-Oct-10	3
10610	Kautu Plantation	Kapiura	12-Sep-10	19-Oct-10	37	22-Oct-10	3
10710	Kumali	Nahavio	04-Oct-10	28-Oct-10	24	29-Oct-10	1

Table 7. cont.

PestRec #	Locality	Division/ Group	Report received by PNGOPRA	Date of visit	Days after report received at OPRA	Date report issued by PNGOPRA	Days from visit to report issued
10810	Togulo Plantation	Mosa	21-Sep-10	12-Nov-10	52	12-Nov-10	0
10910	Volupai Plantation	Mosa	05-Oct-10	08-Oct-10	3	12-Oct-10	4
11010	Mamba Plantation	Kula Group	22-Jun-10	28-Sep-10	98	14-Oct-10	16
11110	Numundo Plantation	Numundo	20-Oct-10	27-Oct-10	7	28-Oct-10	1
11210	Waisisi	Siki	22-Oct-10	04-Nov-10	13	12-Nov-10	8
11310	Rikau	Siki	22-Oct-10	04-Nov-10	13	08-Nov-10	4
11410	Daliavu Plantation	Numundo	21-Oct-10	22-Oct-10	1	25-Oct-10	3
11510	Daliavu Plantation	Numundo	21-Oct-10	22-Oct-10	1	25-Oct-10	3
11610	Kaurausu Plantation	Kapiura	22-Oct-10	27-Oct-10	5	29-Oct-10	2
11710	Sapuri Plantation	Numundo	25-Oct-10	30-Oct-10	5	02-Nov-10	3
11810	Tamba LSS	Nahavio	03-Nov-10	03-Nov-10	0	12-Nov-10	9
11910	Sabaltepun VOP	Salelubu	08-Nov-10	09-Nov-10	1	23-Nov-10	14
12010	Bereme VOP	Salelubu	08-Nov-10	09-Nov-10	1	23-Nov-10	14
12110	Kabil Plantation	Noatsi Estate	20-Nov-10	20-Nov-10	0	23-Nov-10	3
12210	Kafkaf Plantation	Noatsi Estate	20-Nov-10	20-Nov-10	0	23-Nov-10	3
12310	Piera Plantation	Noatsi Estate	20-Nov-10	20-Nov-10	0	23-Nov-10	3
12410	Navo Plantation	SIPEF	24-Nov-10	24-Nov-10	0	10-Dec-10	16
12510	Bubu VOP	Maututu	20-Nov-10	24-Nov-10	4	10-Dec-10	16
12610	Nanatabu VOP	Meramera	20-Nov-10	24-Nov-10	4	10-Dec-10	16
12710	Likoranga VOP	Meramera	20-Nov-10	24-Nov-10	4	10-Dec-10	16
12810	Kabaia LSS	Meramera	20-Nov-10	02-Dec-10	12	10-Dec-10	8
12910**	Magalona	Meramera	20-Nov-10	02-Dec-10	12	10-Dec-10	8
13010	Gamupa VOP	Meramera	20-Nov-10	02-Dec-10	12	10-Dec-10	8
13110	Tauke VOP	Meramera	20-Nov-10	02-Dec-10	12	10-Dec-10	8
13210	Kelangalel VOP	Meramera	20-Nov-10	02-Dec-10	12	10-Dec-10	8
13310	Tiauru LSS	Maututu	20-Nov-10	03-Dec-10	13	10-Dec-10	7
13410	Sale LSS	Cenaka	20-Nov-10	03-Dec-10	13	10-Dec-10	7
13510	Malassi LSS	Cenaka	20-Nov-10	03-Dec-10	13	10-Dec-10	7
13610	Sule VOP	Cenaka	20-Nov-10	03-Dec-10	13	10-Dec-10	7
13710	Kaiamu VOP	Cenaka	20-Nov-10	03-Dec-10	13	10-Dec-10	7
13810	Sege LSS	Cenaka	20-Nov-10	03-Dec-10	13	10-Dec-10	7
13910	Haella/Tili Plantation	Numundo	16-Nov-10	18-Dec-10	32	28-Dec-10	10
14010	Kumbango Plantation	Mosa	15-Dec-10	21-Dec-10	6	28-Dec-10	7
14110	Banaule VOP	Kavui	17-Dec-10	22-Dec-10	5	28-Dec-10	6
14210	Lamerika Plantation	Madak Estate	29-Dec-10	29-Dec-10	0	04-Jan-11	6
14310	Panamafei	North	December	29-Dec-10	0	04-Jan-11	6

We continue to improve the time taken between when reports from the field of possible infestations are received and when field survey visits are made (currently averaging 8 days). A new staff member was recruited at the end of 2010 for New Ireland to improve our inputs there and to bring surveys into line with our expectation of 4-5 working days. PestRec output which is currently standing at an average of 11 days is also expected to fall to the target of 3/4 working days.

Mainland PNG

There was no TTI control of insect pests undertaken against oil palm pests this year.

New Ireland province

In 2010, 24 PestRecs were sent out following field visits to infestations, however only 14 required TTI involving some 1,719.20ha within 4 Estates covering 14 plantations (Table 8). For smallholders at Panamafei, 2.09ha were treated during the year (Table 9). This year smallholders, through a good relationship between the company and OPIC were taking steps to monitor closely activities within the smallholder areas. Plantations through increased awareness were also following more closely monitoring and reporting routines, and hence more areas were reported and subsequently treated.

Table 8. 2010 New Ireland areas treated (ha).

Estate	Plantation	Date recommended	Date Started	Date Completed	Duration	Area Treated
Kara	Kapsu	9-Feb-10	9-Apr-10	29-Apr-10	20	133.30
Kara	Wanup	9-Feb-10	29-Apr-10	6-May-10	7	27.63
Madak	Dalom	9-Feb-10	7-Jul-10	7-Jul-10	0	18.03
Madak	Lamerika	9-Feb-10	2-Mar-10	8-Apr-10	37	158.20
Madak	Suma	9-Feb-10	7-Jul-10	15-Jul-10	8	66.40
Noatsi	Piere	9-Feb-10	4-Jun-10	23-Jun-10	19	98.00
Noatsi	Soubu	9-Feb-10	1-Feb-10	1-Mar-10	28	176.60
Madak	Kimadan	27-Mar-10	24-Jun-10	7-Jul-10	13	178.06
Noatsi	Kabil	27-Mar-10	10-May-10	25-May-10	15	78.67
Nalik West	Maranawai	10-Jun-10	16-Jul-10	19-Jul-10	3	56.30
Noatsi	Poli	16-Jun-10	20-Jul-10	31-Jul-10	11	103.10
Kara	Baia	21-Jul-10	2-Aug-10	3-Sep-10	32	252.80
Noatsi	Libba	7-Oct-10	19-Oct-10	17-Nov-10	29	167.02
Noatsi	Kafkaf	23-Nov-10	2-Dec-10	18-Dec-10	16	205.09
						1,719.20

Table 9. 2010 New Ireland smallholder TTI undertaken (ha).

Small Holder	Location	Area Treated	Date Started	Date Completed
	Panamafei	0.75	06/08/2010	06/08/2010
	Panamafei	0.81	06/08/2010	06/08/2010
	Panamafei	0.53	18/10/2010	18/10/2010
		2.09		

Rainfall (RSPO 4.5, 8.1)

Although any correlation between rainfall/rain days and the development of subsequent infestations requires detailed analysis, the association between rainfall and infestations are still far from clear. Sexava thrives under wet conditions, and requires “free” water which it avidly imbibes and we have shown that eggs can survive submersion under water for up to 30 days under lab conditions. We do not have such data for the other major pest, *Eurycantha calcarata.* Heavy rain hinders control using TTI which inadvertently encourages sexava by leaving them unattended!

West New Britain Province

At Dami, there were only two months where there were less than 15 rain days per month (Fig.7). Rainfall at Hargy and Navo also increased somewhat during 2009/2010, while during the early part of the year, the number of rain days above 15 per month remained at almost half those recorded during 2009 and 2010 whereas there were three months only in 2008 (Fig.13).

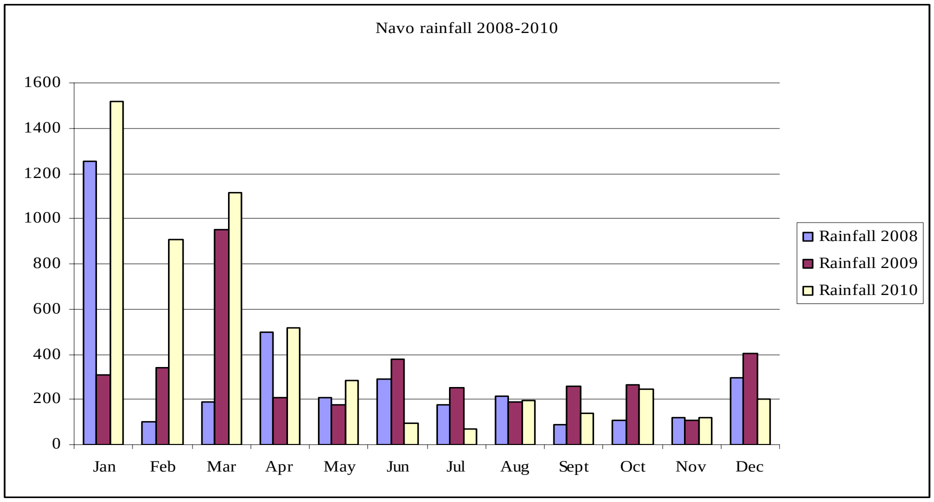

Figure 13. 2008-2010**:** Hargy Oil Palms, Navo Estate rainfall. 2008-2010. (Adapted from original data Hargy Oil Palms Ltd.).

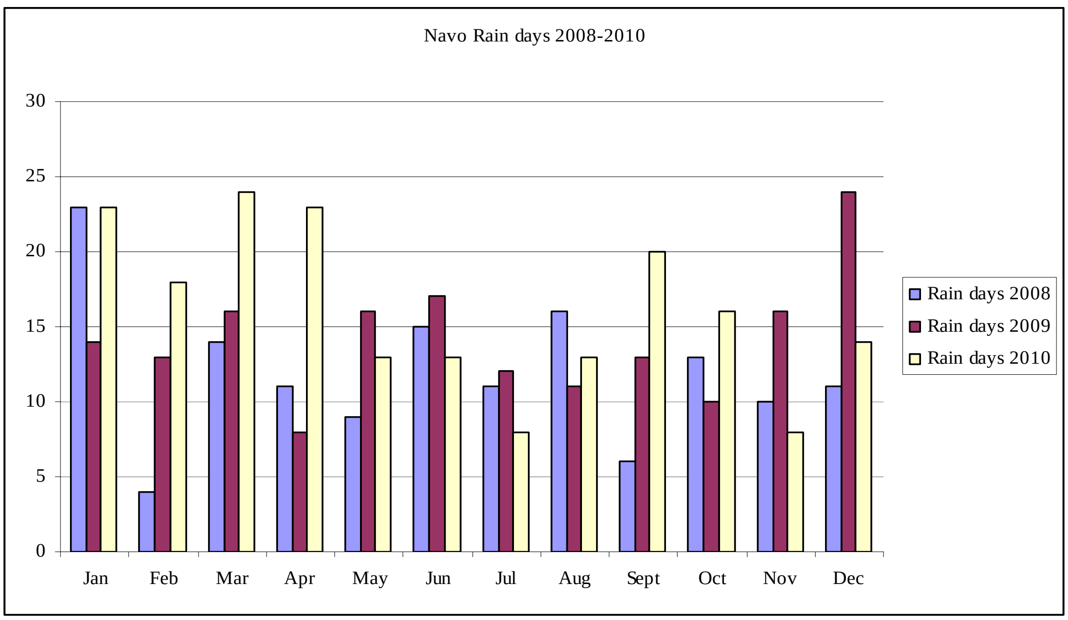

Figure 14. 2008-2010: Hargy Oil Palms, Navo Estate rain days 2008-2010. (Adapted from original data: Hargy Oil Palms Ltd.).

Oro Province

In Northern (Oro) Province, Higaturu Oil Palms, at Ambogo Estate and Mamba Estates, rainfall peaked three times during the year, with only two months having more than 15 days of rainfall. At Ambogo Estate, the overall rainfall is much higher and every month except February received more than 15 rain days (Fig.15). This high rainfall at Mamba Estate (Fig.16), coupled with the deep frond bases developed from high planting densities and organic detritus build-up, may have resulted in bacterial rot, which is assumed to be a factor encouraging the weevil *S.subcruciata*. However this hypothesis is still to be confirmed.

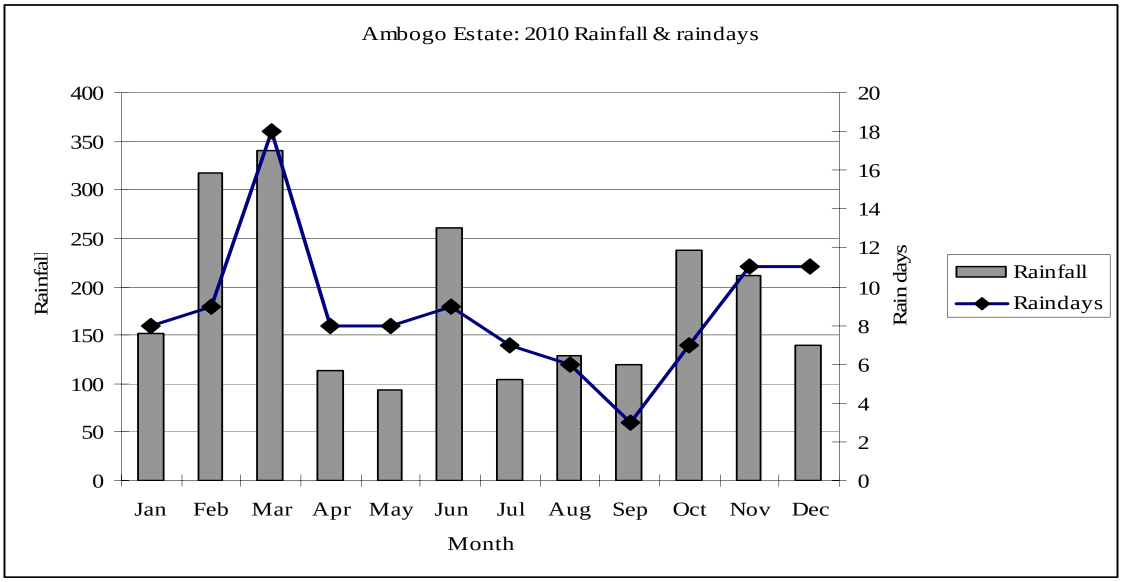

Figure 15. Rainfall and rain days from Ambogo Estate, Northern (Oro) Province 2010. (Adapted from original data: M Banabas).

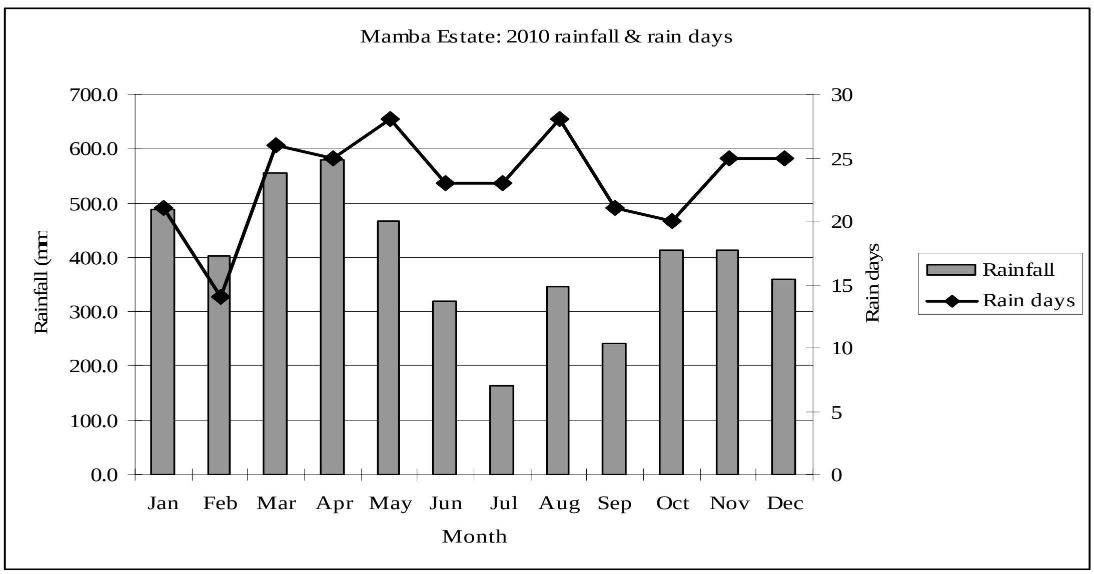

Figure 16. Rainfall recorded from Mamba Estate, Northern (Oro) Province 2010. (Adapted from original data: M Banabas).

New Ireland Province

Rainfall and rain day data for New Ireland were only available from Lakurumau during 2010, nevertheless, apart from some dry periods in June and December, there were 7 months when there was rainfall recorded for at least half the month (Fig. 17).

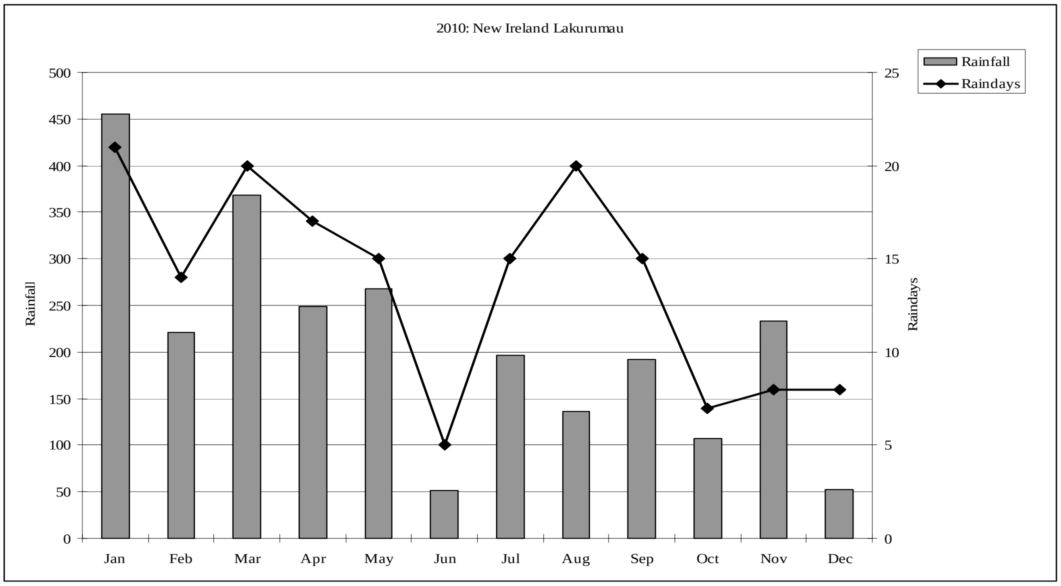

Figure 17. Rainfall and rain days recorded from Lakurumau during 2010. (Adapted from original data: CTP-TSD).

APPLIED RESEARCH

Insecticide trials (David Putulan). **(RSPO 4.5, 4.6, 8.1)**
Although a recommendation for further work on the use of Dimehypo (Bisultap) was made in the draft report, the final document is not yet available. The results (which will be presented as percentage deaths) show that this insecticide is suitable for the control of sexava, but at a higher dose that is currently used for methamidophos. For Dimehypo 18%, 40ml of the insecticide is required, as opposed to the 10ml of methamidophos (Fig.18).

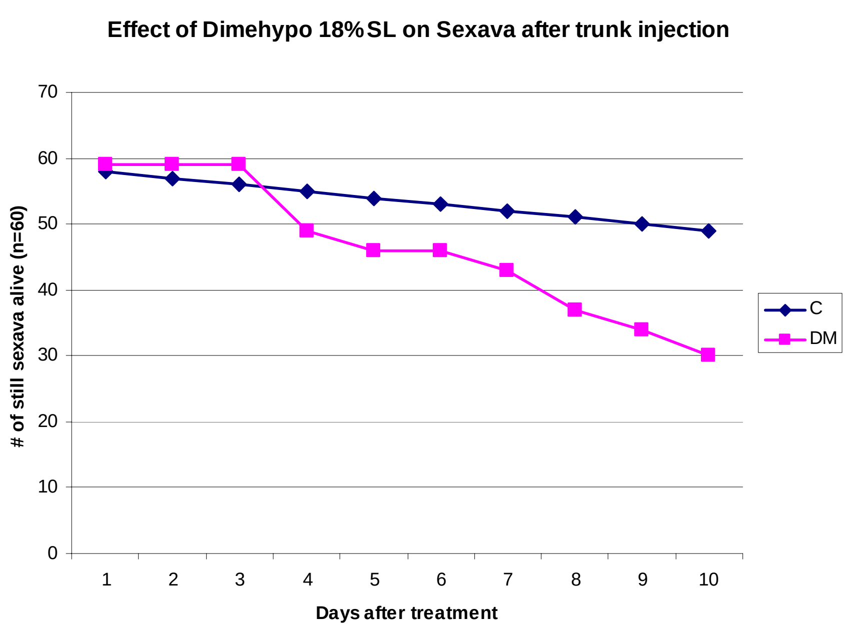

Figure 18. Effect of Dimehypo on sexava mortality. [C=Untreated control, DM=Dimehypo].

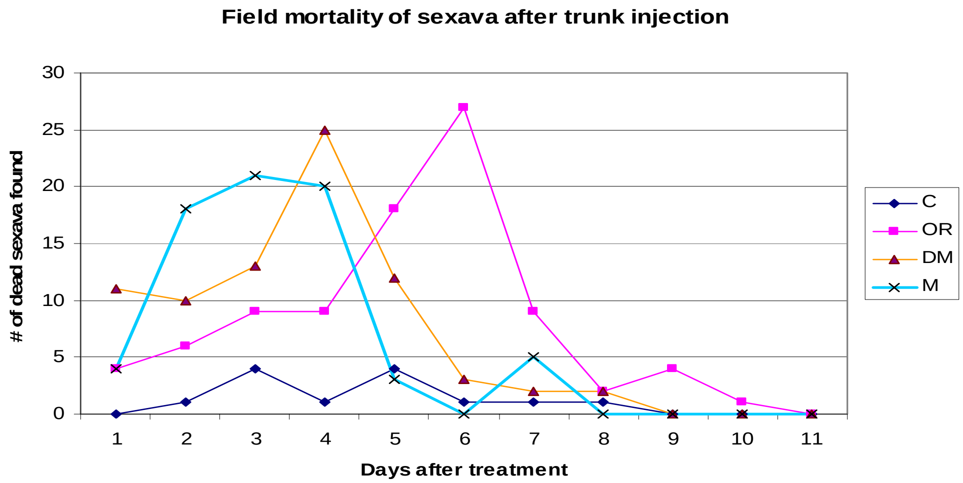

Figure 19. The effect of Dimehypo (DM) on sexava mortality. C=Untreated control, OR=Orthene, M=methamidophos.

The data collected on this insecticide showed clearly the efficacy of the insecticide, steps are required to ascertain whether it can be imported into PNG for use in TTI. A cost benefit analysis was not carried out.

Insecticide movement within a TTI treated oil palm (DP).
A very important observation was made however, that in spite of TTI being carried out on only one side of a palm, the insecticide spread throughout all fronds throughout the palm. It is for this reason that the injection height is recommended.

Rearing of "sexava" and stick insects (SS, SK, **EK**)**. (RSPO 4.5, 8.1)**
In spite of field collections of adult sexava and intensive laboratory rearing we are still not producing a steady or sufficient supply of insects that are required for parasitoid rearing and other experimental work. Stock numbers still regularly have to be supplemented through field "hunting" trips. We are investigating the key mortality factors and at what stage or stages mortality has a major effect on population dynamics.

Initial results indicate that there is high mortality at the egg stage and during the final moult into the adult stage. Successful rearing of nymphs in cages is crucial for increasing the number of "sexava" without hunting for them in the field. Work on rearing nymphs is ongoing. During 2009, the cages were partly covered with black plastic to increase humidity; however it was found that the cages became very hot, so the plastic was removed and a sago frond roof ("Morata") was raised above the cages to keep them cooler (Fig.20). Foodplant material is sprayed twice daily to maintain available moisture and humidity.

Figure 20. Part of Dami entomology section insectary with raised roof and sago frond thatching.

To further improve sexava diet, banana leaf was added as a food source. Nevertheless, in spite of predictions made last year, numbers of insects reared has not improved significantly, although nymph emergence and survival data are providing useful key factor data which will be analysed once there are sufficient data. Current tentative indications show that survival under laboratory rearing conditions in 2010 was very variable between both species (*S.defoliaria* and *S.decoratus*) with the number of *S.decoratus* nymphs surviving to adult at 5.5% (838 eggs, 46 adults), and *S.defoliaria* at 32.4% (145 eggs producing 47 adults). Continual attacks by ants and rats and lizards in the outside cages (Fig.20) are a serious cause of nymph and adult mortality, especially when they are moulting.

Sexava survival and reproduction (T Manjobie**) (RSPO 4.5, 8.1)**

Introduction
Understanding the reproductive patterns and survival of individual sexava species is an essential part of our work with this pest. A programme probing into all aspects of the ecology of the insect is underway. With the appointment of a staff member with this responsibility, we are now able (insect stock permitting) to undertake detailed life history studies, which will enable us to make improvements in the management of these insects. Two small scale detailed rearing studies were undertaken: Trials 1 and 2: February-April and August –November 2010

Terminology
Eggs = total number of eggs laid by each female in the specified trial.
POP = Pre-Oviposition Period (days), between fledging and oviposition.
ELP = The length of the egg laying period (days).
Life = Number of days the female survived from fledging until death.
PEL = Post Egg Laying survival (days until death).

Methods
Two trials were done to investigate the fecundity and survival of individual adults of laboratory reared sexava species, *S.defoliaria* and *S.decoratus*. The trials were conducted at two different times of the year (between February and April and between July and November). The total number of female sexava used was 25, (15 *S.decoratus* and 10 *S.defoliaria*). 10 recently fledged adult *S.decoratus* and 5 *S.defoliaria* that were freshly fledged and mated (indicated by the presence of a spermatophore in *S.defoliaria* only) were used. There were insufficient last instars of *S.defoliaria* available in the insectary for use once fledged, which was the reason for using only 5 insects.

The Tables (below) show results obtained from both species from somewhat limited data, as sample size was very small (10 *S.decoratus* and 5 *S.defoliaria*), but the results were markedly different; nevertheless they do provide an insight into the wide range of longevity and fecundity and live weights shown by these insects. These data do not however indicate how many actual oviposition sessions took place or whether the process was continuous (W Page, pers.comm.). This important aspect will be clarified during 2011 investigations.

Results
Tables 10, 11 and 12 refer.

- The Pre Oviposition Period (POP, defined as the time between fledging and laying eggs), varied between the two species, with a mean POP of between 69-71 days in *S.decoratus* and only 6-12 days in *S.defoliaria* (Table 10).
- The Egg Laying Period (ELP) was similar for both species in both trials (Table 10).
- *S.decoratus* produced 81 eggs, in Trial 1 (Feb-April), but less than half the number (34) in Trial 2 (July-Nov) (Table 10). These differences will require clarification through study of larger samples. Oviposition differences will require fuller investigation as indicated below.
- *S.decoratus* survived considerably longer than *S.defoliaria* in both trials and in the individual insect investigations (Table 10). Once oviposition was complete in the two Trials, females of both

species died in a matter of days with *S.defoliaria* dying much more rapidly than *S.decoratus* (Table 10).

- Overall survival rates in one trial (Table 12) were comparable although S.defoliaria survival differed appreciably between trial dates. (Table 10).
- *S.decoratus* fledging in February survived for about 89 days (*Life*), [52-139, n=10].
- *S.decoratus* fledging in July survived for 97 days (*Life*), [63-136, n=10].
- *S.defoliaria* fledging in February survived for about 51 days (*Life*), [20-71, n=5].
- *S.defoliaria* fledging in July survived for 41days (*Life*), [15-78, n=5].
- Increased egg production by *S.decoratus* is to be expected as the parthenogenetic *S.decoratus* adult females are somewhat heavier (mean 5.75g) than *S.defoliaria* (5.41g) (Table 11), and they may be able to hold up the oviposition process when there are no available males (W Page, pers.comm.).

Table 10. Adult survival and fecundity at two different times of the year, for *S.decoratus* and *S.defoliaria* females in the laboratory.

	TRIAL 1 (February – April 2010					TRIAL 2 (July – November 2010)				
	Eggs	**POP**	**ELP**	**Life**	**PEL**	**Eggs**	**POP**	**ELP**	**Life**	**PEL**
S. decoratus (means, n=10)	81	69	46	89	8	34	71	25	97	5
S. defoliaria ***(means, n=5)***	66	6	40	51	4	37	12	27	41	2

POP = Pre-Oviposition Period, ELP = Egg Laying Period, PEL = Post Egg Laying survival, Life= fledging to death

Table 11. Live weights & colour morphs of adult "sexava" from outside lab cages (live insects-gm).

ex Dami lab stock from Bialla.			16 March '11		
Segestidea defoliaria			***Segestes decoratus***		
Sex	**Colour**	**Weight (g)**	**Sex**	**Colour**	**Weight (g)**
Female	Brown	6.40	Female	Brown	7.20
Female	Green	5.06	Female	Brown	4.67
Female	Green	4.79	Female	Brown	6.26
Female	Green	5.53	Female	Brown	5.75
Female	Green	5.29	Female	Brown	6.18
	mean	**5.41**	Female	Brown	5.61
	sd	0.62	Female	Brown	4.07
			Female	Brown	5.79
Male	Brown	3.51	Female	Brown	6.35
Male	Brown	3.03	Female	Brown	4.29
Male	Brown	3.06	Female	Green	5.19
Male	Brown	4.03	Female	Green	6.55
Male	Brown	3.03	Female	Green	4.78
Male	Green	3.50	Female	Green	5.16
Male	Green	3.18	Female	Green	6.07
Male	Green	3.22	Female	Green	5.90
Male	Green	3.42	Female	Green	5.12
Male	Green	3.43	Female	Green	6.87
Male	Green	3.15	Female	Green	6.27
Male	Green	2.54	Female	Green	6.94
Male	Green	3.03			
Male	Green	2.99		mean	**5.75**
Male	Green	3.64		sd	0.88
	mean	**3.25**			
	sd	0.35			

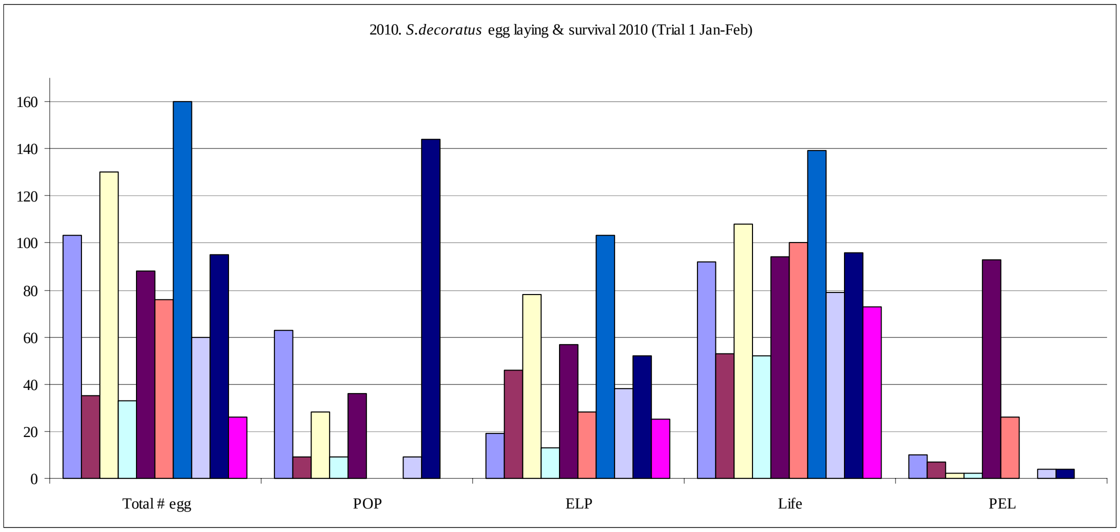

Figure 21. *S.decoratus*: Trial 1. Feb-April. Egg laying and survival of females (using 10 insects)
POP = Pre-Oviposition Period, ELP = Egg Laying Period, PEL = Post Egg Laying survival

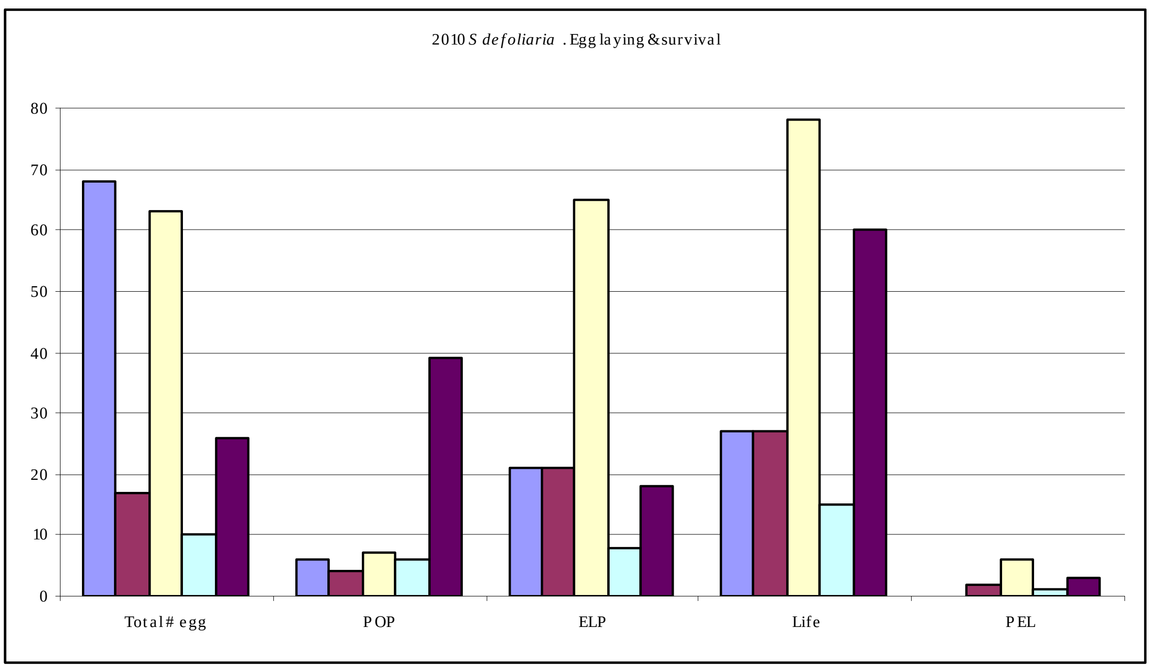

Figure 22. *S.defoliaria*: Trial 1. Feb-April. Egg laying and survival of females (using 5 insects)
POP = Pre-Oviposition Period, ELP = Egg Laying Period, PEL = Post Egg Laying survival

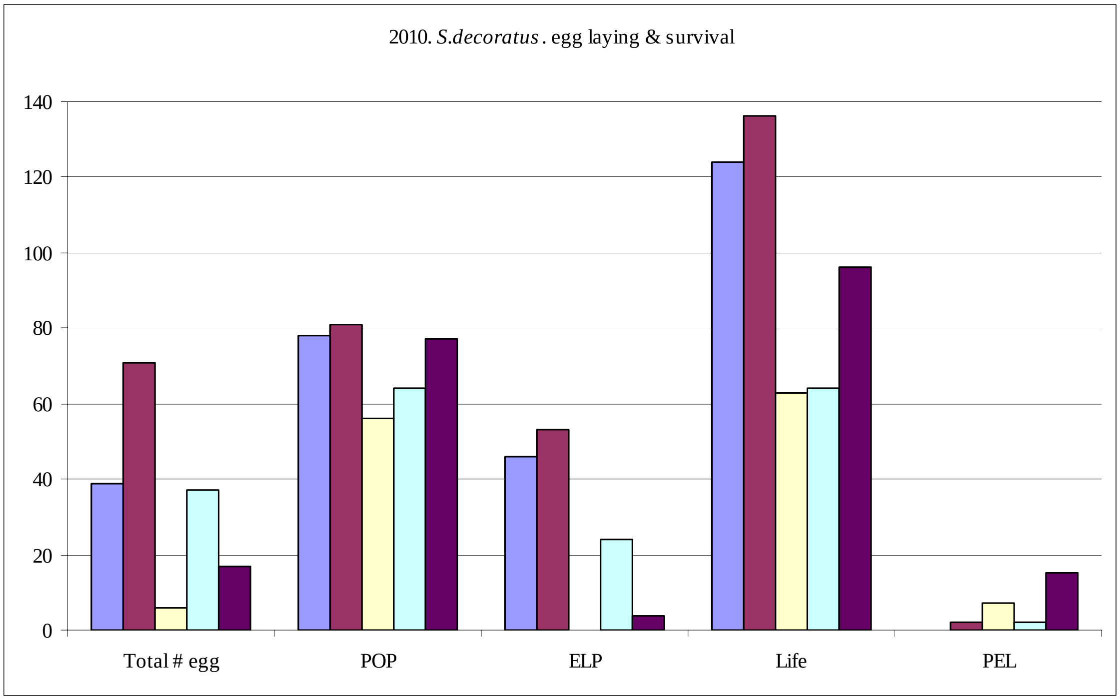

Figure 23. *S.decoratus*. Trial 2 July-November. Egg laying and Survival of females (using 5 insects).
POP = Pre-Oviposition Period, ELP = Egg Laying Period, PEL = Post Egg Laying survival

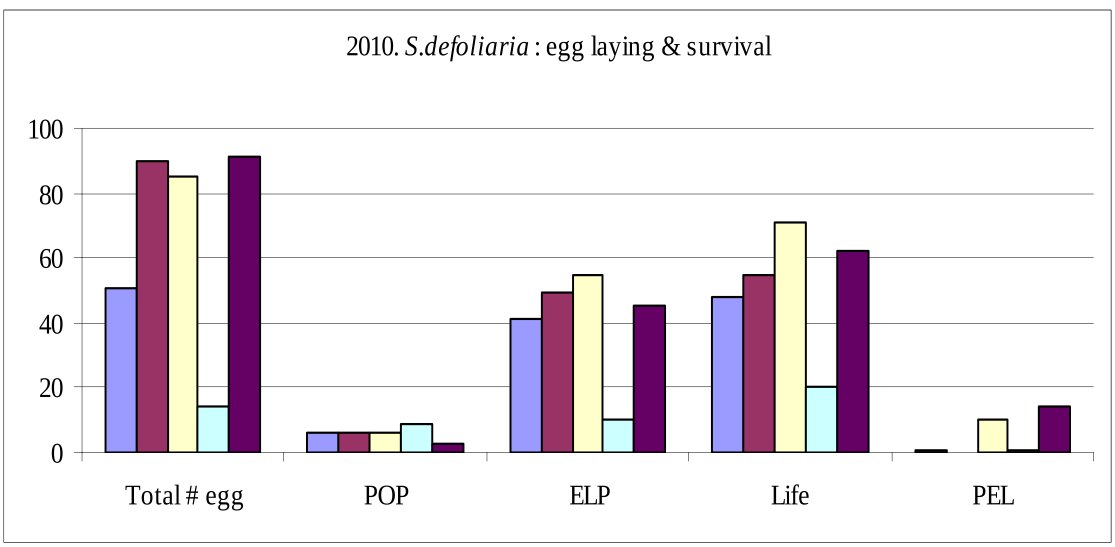

Figure 24. *S.defoliaria*. Trial 2, July-Nov. Egg laying and Survival of females (using 5 insects).
POP = Pre-Oviposition Period, ELP = Egg Laying Period, PEL = Post Egg Laying survival

Destructive Palm Sampling (DPS). (RSPO 4.5, 8.1)

Objective:
This project is to develop a clearer understanding of the distribution of pest insects within the oil palm canopy.

Method

Fifteen (15) oil palms were destructively sampled during 2010 from Dami plantation (1987 planting). Records of any stages of sexava, stick insects or bagworms found on the fronds were removed, recorded and entered into the database as used in the previous collections. Acting on professional advice, all data collected during previous years' sampling work from plantations were re-entered onto newly designed record sheets, and they will be added to the database and analysed during 2011 with assistance from A.Yalu (OPRS). The original record sheets although providing workable results were liable to misinterpretation (this was because fronds were cut from the base towards the spear and had therefore to be entered in that order, but the order reversed for analysis.

Economic monitoring (FFB production) (RSPO 4.5, 8.1)

Smallholder monitoring at Kavui (WNB) was continued during 2010, but data were erratic and unreliable (due to harvest date collection changes and many skip-harvest periods). In early 2011, we will decide if the data are of use, or if the recording should cease. Data from the severely damaged oil palms in a number of fields within MU 6B and 6C at Bebere Plantation (WNB) are being collected and will continue to be collected over a long period and analysed on an on-going basis at a field by field level, to provide additional real-time damage costs (productivity reduction as a result of defoliation).

An investigation into the economics of sexava damage based on a desk exercise of PNGOPRA Agronomy trials conducted from 1989 through to 2005 highlighted the enormous financial losses resulting from a failure to treat infestations before damage became severe. An OPRAtive Word (Technical Note 20) was published in December 2010 which estimated that the stripping of palms over 500Ha could cause a loss of around US$.8.8 million (K22.6 million) in Crude Palm Oil because of the recovery time of about five years.

Pest Information Database (PID) (RSPO 4.1, 4.5, 8.1)

Although the PID should have been fully operational by this year, personnel changes and demands from the IS section have delayed the final implementation of the Access based PID. PestRec outputs are retained and will be incorporated once the required repairs are completed. Currently the data are available on Excel spreadsheets. Copies of all PestRecs issued to Plantations within the NBPOL Group are also passed to Precision Agriculture OPRS. Copies of PestRecs issued for Hargy Oil Palms and OPIC Bialla are forwarded to Smallholder Affairs Co-ordinator at Hargy.

Methamidophos Usage Database (MUD). (RSPO 4.1, 4.5, 4.6, 8.1)

During 2010, only 19 records were received from plantations and SHA. No reports were sent out, as the database software issues had not been repaired by IS. The reports received were retained, and as soon as the database is corrected, these data will be entered and forwarded for use as requested.

Biological control of insect pests of oil palm (4.5, 8.1)

Work continued with the rearing and release of the egg parasitoids of "sexava". Although the facilities improved marginally with the modification of the downstairs part of the ento facility in 2010 the rearing process was still slow. Parasitoid release data are reported below.

Stichotrema dallatorreanum.

No *Stichotrema* releases were made during 2010, primarily because the holding cages at Navo Estate were not utilised as they had become unserviceable. The following information was received from Dr Kathirithamby on the molecular work being undertaken at Oxford University. "The genome assemblies of *Stichotrema dallatorreanum* and *Xenos vesparum* are now at the following URL: http://genome.arc.georgetown.edu/strepsiptera/. However the username and password are not for circulation, they are held with Entomology Section. *Xenos vesparum* was sequenced by Berkeley and we are awaiting the sequences of another strepsipteran to be uploaded. This site is managed by Chris Elsik of Georgetown University Washington, USA", and further information relating to this genome work will be released as it becomes available.

Sexava egg parasitoids. (4.5, 8.1)

Egg parasitoid rearing and releases in 2010 (Hekoi Sar)
Sexava egg parasitoids (*Leefmansia bicolor* Waterston and *Doirania leefmansi* Waterston) continued to be reared in the laboratory and released in both plantations and smallholder blocks during the year. There was an increase in release numbers for *L.bicolor* and a decrease in releases of *D.leefmansi* compared to the parasitoid releases in 2009 (Table 13). Numbers of *Doirania* released did follow the estimated release numbers in both the actual and estimated releases (Fig. 25) and cumulated releases (Fig.26). Using actual emergence figures 786,184 *L.bicolor* were released (Table 14) and 1,898,378 *D.leefmansi* were released at 117 sites (*L.bicolor* 56 sites and *D. leefmansi* 61 sites) covering only WNB and NI plantations and smallholder blocks (Table 15). Average monthly production was 158,000 for *Doirania* and 66,000 for *Leefmansia*, and there was an acceptable agreement between estimated and actual numbers released (Fig.27), while the cumulative figures were also comparable (Fig.28). Numbers of both species produced fell in April as judged by releases being less than 50% of maximum monthly production. This was because of a change in the counting methodology to improve accuracy of release numbers. We used the data from individual egg rearing trials to provide an average number of insects released, based on a sample of 10% of parasitized eggs retained to provide information on percentage parasitism. Individual host eggs were parasitized and the emergence data used to estimate adult parasitoid emergence. It was clear from these data that *Doirania* numbers produced from individual host eggs was very variable, whereas the adults of *L.bicolor* emerging from host eggs was more consistent.

Table 13. Comparisons of parasitoid releases 2009 and **2010**.

Parasitoid	2009	**2010**	**Variance**
L.bicolor	772,520	786,184	13,664 (increase)
D.leefmansi	1,995,059	1,898,378	-96,681 (decrease)

Table 14. *Leefmansia bicolor* release sites.

Date of release	Site of release	Releases/ month	OPIC/Plantation	No. of Host eggs released	% emergence of released eggs
25 January 2010	Banaule VOP block 015 - 0089	3	O	380	95
25 Janurary 2010	Banaule VOP block 015 - 0119		O	350	88
29 January 2010	Banaule VOP block 015 - 0089		O	400	80
13 February 2010	Kavui Section 11	6	O	440	88
17 February 2010	Poliamba plantation		P	216	90
17 February 2010	Bebere plantation Div. 2		P	430	86
18 February 2010	Dami plantation Div. 1 (Buluma field)		P	220	92
24 February 2010	Kavui LSS		O	360	90
26 February 2010	Dami plantation Div. 1 (Buluma field)		P	540	90
04 March 2010	Bilomi Div. 1 & Div. 2	5	P	550	92
10 March 2010	Siki Section 3		O	490	82
17 March 2010	Bialla: Noau		O	630	90
23 March 2010	Siki Section 4		O	540	90
26 March 2010	Buluma VOP		O	560	112
09 April 2010	Dami plantation (seed garden)	4	P	360	90
10 April 2010	Bialla, Navo Estate		P	450	90
26 April 2010	Nahavio Div 1		O	150	19
30 April 2010	Kavui Section 11		O	432	90
06 May 2010	Taukea VOP, Bialla	9	O	190	79
06 May 2010	Kilangale VOP, Bialla		O	260	72
06 May 2010	Gamupa VOP, Bialla		O	220	92
06 May 2010	Magalona VOP, Bialla		O	200	83
06 May 2010	Noau VOP, Bialla		O	160	67
13 May 2010	Poinini Ag.Tech.School		O	540	90
14 May 2010	Banaule Section 2 block 60		O	210	88
27 May 2010	Kumbango plantation Div. 1		P	290	81
31 May 2010	Banaule VOP Section 1 block 87		O	340	85
10 June 2010	Kumbango Div. 1, field 1121-01A Av 5	4	P	550	79
16 June 2010	Banaule VOP, block.010		O	180	90
23 June 2010	Koimumu VOP, block 0069		O	720	90
24 June 2010	Banaule VOP, block 089		O	470	94
07 July 2010	Kavui, Section 11	4	O	900	90
12 July 2010	Banaule VOP, block 0089		O	310	78
16 July 2010	Kapore Section 4 block. 342		O	820	91
28 July 2010	Kapore Section 4 block. 342		O	850	94
03 August 2010	Uasilau VOP	4	O	600	86
05 August 2010	Ganeboku VOP		O	770	96
12 August 2010	Kavui Section 11		O	620	89
24 August 2010	Mamota LSS S3		O	500	83
15 September 2010	Lolokuru Plantation	4	P	800	89
17 September 2010	Kavui Section 11		O	680	85
28 September 2010	Garu plantation , Ave. 10		P	400	80
29 September 2010	Banaule VOP Section 1 block '010		O	390	98
19 October 2010	Karausu plantatiion, field 11	4	P	850	94
20 October 2010	Kavui Section 11		O	370	93
21 October 2010	Togulo Div.1		P	520	87
25 October 2010	Karausu plantation, Ave 3 MU 9A		P	370	93
19 November 2010	Banaule Section 1 (Young palms)	4	O	1150	88
24 November 2010	Banaule Section 1 (young palms)		O	1000	83
26 November 2010	Banaule Section 1 block 015 - 010		O	820	91
29 November 2010	Dami plantation field 1		P	360	90
01 December 2010	Bialla - Kabaia & Magalona	5	O	810	90
06 December 2010	Dami plantation field 1		P	570	95
15 December 2010	Navarai plantation		P	630	90
22 December 2010	Dami plantation Div. 1 (Buluma field)		P	510	85
31 December 2010	Banaule VOP block 015 - 0119		O	650	81

Table 15. *D.leefmansi release sites.*

Date of release	Site of release	Releases/ month	OPIC/Plantation	No.of Host eggs released	% emergence of released eggs
25 January 2010	Suma plantation	6	P	114	95
25 January 2010	Soubu plantation		P	400	100
25 January 2010	Lamerika plantation		P	150	100
25 January 2010	Banaule VOP block 0089		O	370	93
25 January 2010	Banaule VOP block 0019		O	425	85
29 January 2010	Banaule VOP block 0089		O	430	86
13 February 2010	Kavui Section 2	6	O	470	94
17 February 2010	Poliamba		P	216	90
17 February 2010	Bebere Div. 2		P	500	100
18 February 2010	Dami plantation Div. 1 (Buluma field)		P	190	79
24 February 2010	Kavui LSS		O	360	90
26 February 2010	Dami plantation Div. 1 (Buluma field)		P	540	90
04 March 2010	Bilomi Div. 2	5	P	530	88
10 March 2010	Siki Section 3		O	450	75
17 March 2010	Bialla: Noau ME		O	180	30
23 March 2010	Siki Section 4		O	540	90
26 March 2010	Buluma VOP		O	450	90
09 April 2010	Dami plantation (Seed garden)	4	P	750	100
10 April 2010	Bialla Navo Estate		P	450	90
26 April 2010	Nahavio		O	100	13
30 April 2010	Kavui Section 11		O	324	90
06 May 2010	Taukea, Bialla VOP	9	O	200	83
06 May 2010	Kilangale VOP, Bialla		O	240	100
06 May 2010	Gamupa VOP, Bialla		O	390	81
06 May 2010	Magalona VOP, Bialla		O	220	92
06 May 2010	Noau VOP, Bialla		O	270	75
13 May 2010	Poinini Ag. Tech.School		O	610	85
14 May 2010	Banaule Section 2 Block 60		O	360	75
27 May 2010	Kumbango plantion Div. 1		P	270	75
31 May 2010	Banaule VOP Section 1 block 87		O	350	88
10 June 2010	Kumbango plantaion Div. 1 field 1121-01A	5	P	370	93
16 June 2010	Banaule VOP, block 0010		O	200	100
21 June 2010	Haella plantation, Div. 1, field 1321-05		P	1,200	100
23 June 2010	Koimumu VOP, block 0069		O	600	100
24 June 2010	Banaule VOP, block 089		O	360	90
07 July 2010	Kavui Section 11	5	O	360	90
12 July 2010	Banaule VOP, block. 0089		O	370	93
16 July 2010	Kapore Section 4 block 342		O	550	92
28 July 2010	Kapore Section 4 block 342		O	620	89
28 July 2010	Banaule VOP block. '0010		O	650	93
03 August 2010	Uasilau VOP	4	O	660	94
05 August 2010	Ganeboku VOP		O	690	99
12 August 2010	Kavui Section 11		O	570	95
24 August 2010	Mamota LSS Section3		O	450	75
15 September 2010	Lolokuru plantation	4	P	850	94
17 September 2010	Kavui Section 11		O	710	88
28 September 2010	Garu plantation: Ave 10		P	460	92
29 September 2010	Banaule VOP: Section 1 #'0010		O	370	93
19 October 2010	Karausu plantation, field 11	4	P	760	84
20 October 2010	Kavui Section 11		O	400	100
21 October 2010	Togulo plantation Div. 1		P	560	93
25 October 2010	Karausu plantation, Ave 3 MU 9A		P	300	75
19 November 2010	Banaule, Section 1 (Young palms)	4	O	650	93
24 November 2010	Banaule Section 1 (Young palms)		O	750	83
26 November 2010	Banaule Section 1 block'010		O	650	81
29 November 2010	Dami plantation field 1		P	430	86
01 December 2010	Bialla Kabaia & Magalona	5	O	1,250	83
06 December 2010	Dami plantation		P	450	75
15 December 2010	Navarai plantation		P	540	90
22 December 2010	Dami plantation Div. 1 (Buluma field)		P	490	82
31 December 2010	Banaule VOP block 015 - 0119		O	220	73

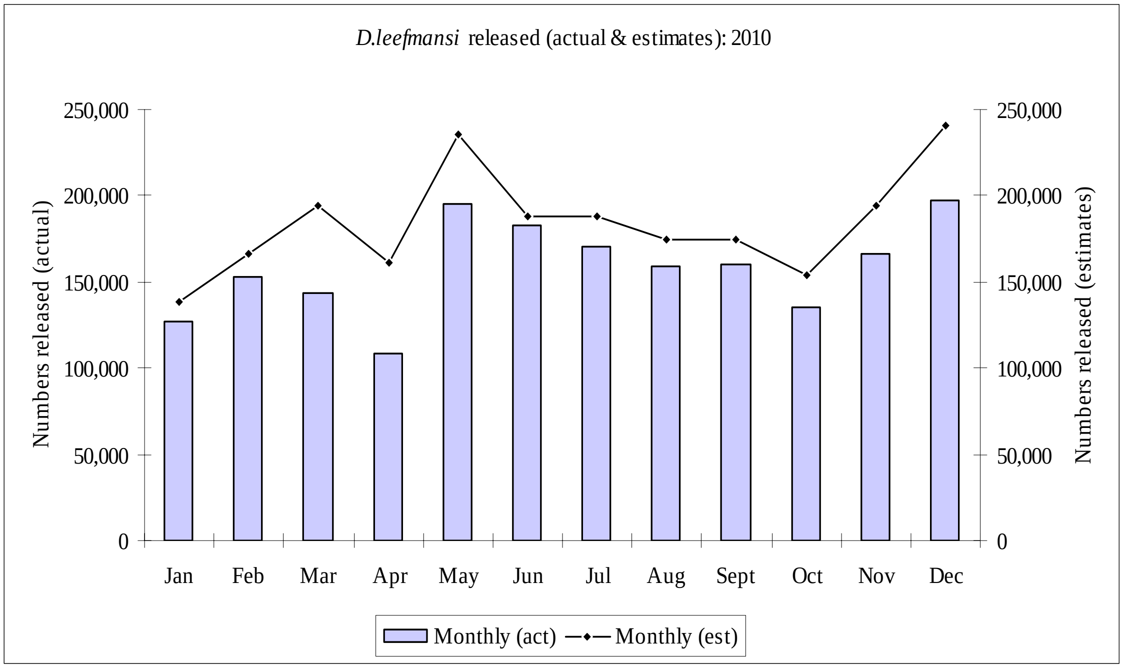

Figure 25. *D.leefmansi* monthly releases with estimated releases.

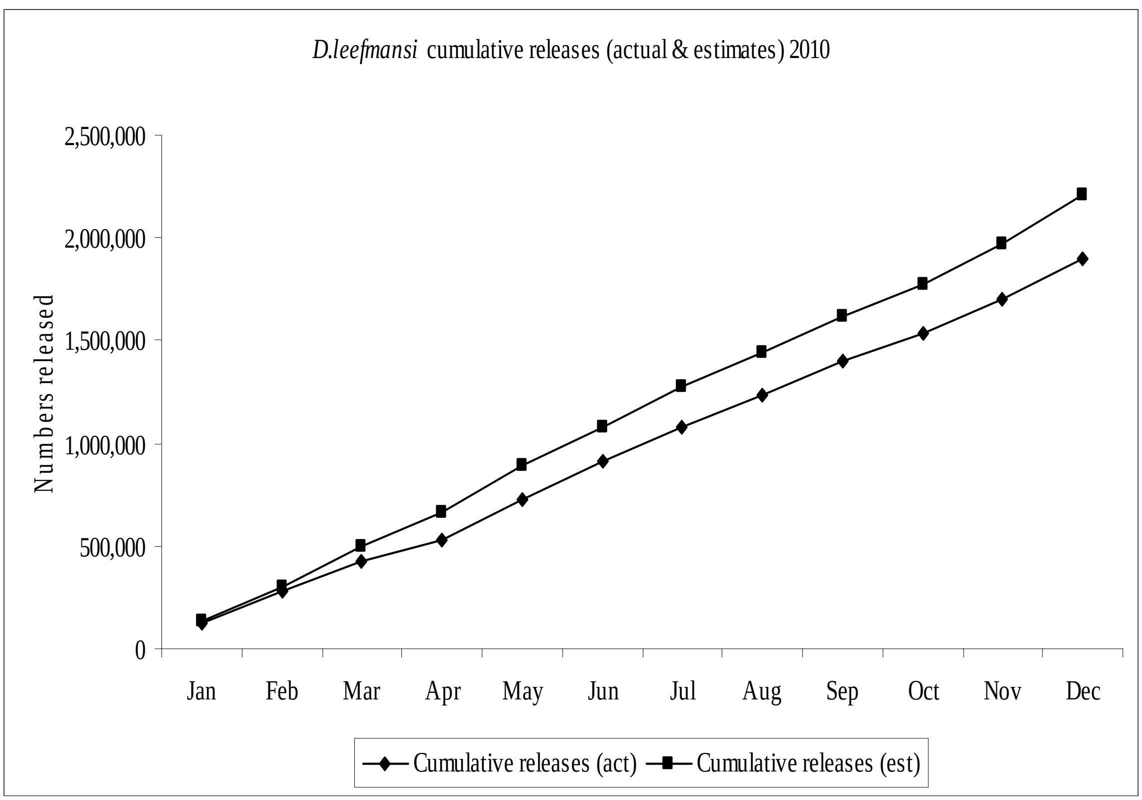

Figure 26. *D.leefmansi* cumulative monthly releases with estimated cumulative releases.

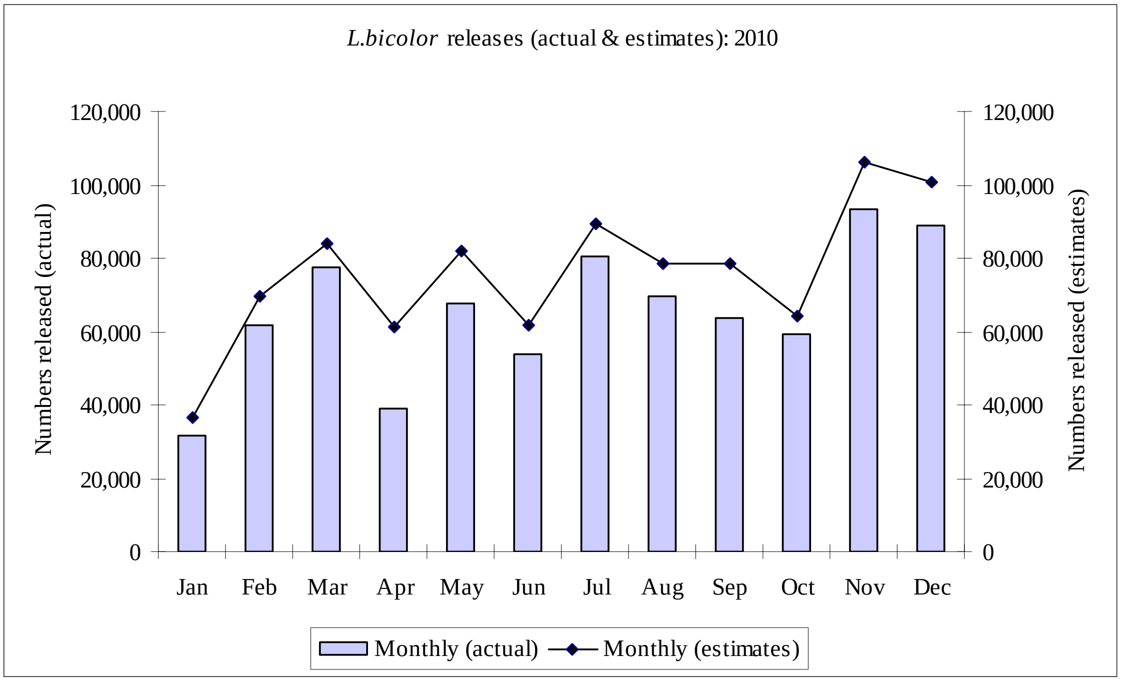

Figure 27. *L.bicolor* monthly releases with estimated releases.

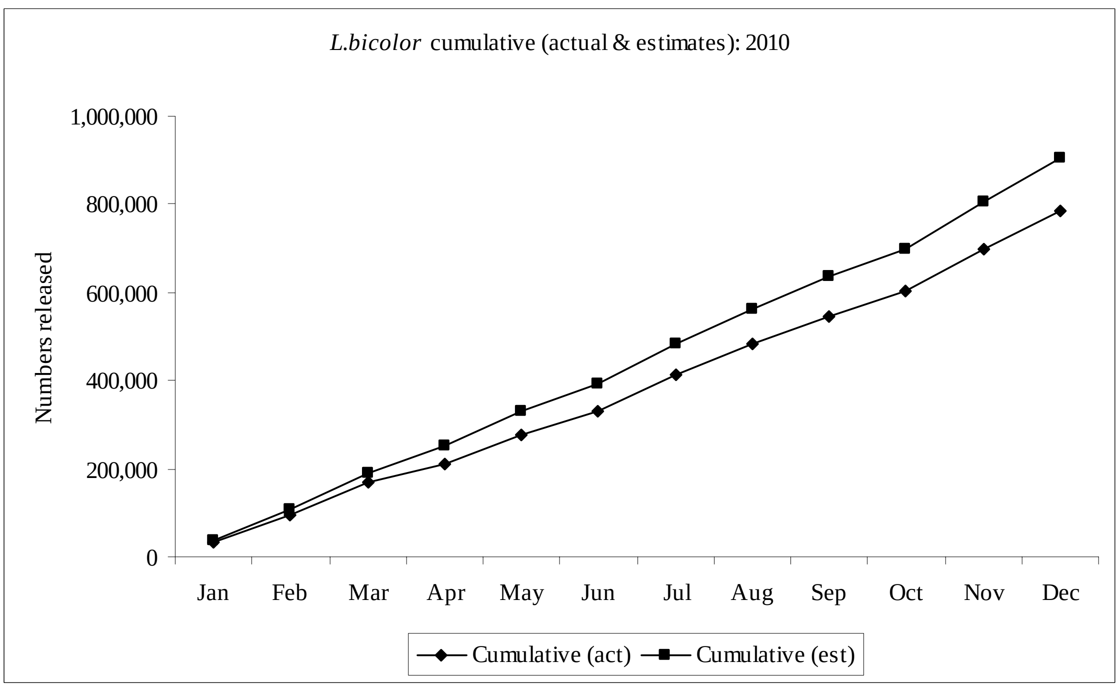

Figure 28. *L.bicolor* cumulative monthly releases with cumulative estimated releases.

Pollinating weevils (RSPO 8.1)

Elaeidobius monitoring in WNB.
Pollinating weevils were monitored monthly from ten sites in WNB and New Ireland during 2010, as illustrated below. The 3 sites on NI were only sampled for the first three months of the year because of staff availability. This situation was rectified at the end of the year, and monitoring of Maramakas, Lakurumau and Leinaru will commence again in 2011. On West New Britain, Lolokuru, Kumbango (until August), and Dami were regularly sampled, while Galewale, Kavui and Siki smallholder blocks sampled until the end of August (Table 16) Data sheets are retained and electronic copies are on entomology drive at PNGOPRA..

Following the SAC meeting, it was agreed that routine weevil monitoring from the majority of sites would cease, however for specific requests sampling would continue. We are therefore continuing to monitor weevil populations at Lolokuru Plantation in response to a request from OPRS and Dami. One smallholder block will also be monitored. The request for weevil monitoring at Lolokuru followed concern of low weevil numbers being responsible for the development of parthenocarpic fruit. Figure 29 shows that weevil numbers were well below what would be required during September, November-December in 5 of the six sites and only above what is currently deemed as acceptable in area S1 during November and December (there were no records for October). Area S6 reached acceptable levels in November 2010 at Lolokuru. Records were also maintained for Dami (Fig.30) and Kumbango where monitoring ceased in August (Fig.31). Interestingly from these figures, numbers during the same months were better at Lolokuru than those recorded for Dami (W Page, pers.comm.). As the monitoring and relationship with FFB productivity proceed, levels of *Elaeidobius* will be carefully followed during 2011 to pick up on the time lag between weevil activity and FFB production. Although an estimated figure of 200,000 weevils is the accepted minimum number of weevils required per hectare, figures were within a wide range to achieve a fruitset of about 60%, (Prior, 1993 *in* Annual Report PNGOPRA) 150,000-200,000 weevils/ha was a guide figure we used for these estimates. Spikelets sampled from Dami indicated weevil numbers between 150,000-200,000 in February, July, August, October and December, with a noticeable peak in August, while at Kumbango weevils numbers fell within this range in February, and between April and August at which time sampling ceased. Data recorded from the weevil samples include the presence/absence of phoretic mites and internal nematodes. All data are stored on the Entomology drive at PNGOPRA.

Table 16. Weevil (*E.kamerunicus*) monitoring and population estimates.

Date sampled	Location	No. /Ha based on 10 infl./Ha	Total No. spikelets	Date sampled	Location	No. /Ha based on 10 infl./Ha	Total No. spikelets
02-Jan-10	Leinaru	289672	237	04-Oct-10	Dami	140667	101
02-Jan-10	Maramakas	328351	265	10-Oct-10	Hoskins VOP	267694	215
08-Jan-10	Lakurumau	310748	276	06-Nov-10	Hoskins VOP	276219	63
14-Jan-10	Kumbango	128669	149	07-Nov-10	Dami	70232	166
14-Jan-10	Haella	60602	140	10-Nov-10	Lolokoru S1	227682	175
14-Jan-10	Kavui LSS	104940	120	10-Nov-10	Lolokoru S2	44699	56
15-Jan-10	Dami	95442	140	10-Nov-10	Lolokoru S3	83854	133
26-Jan-10	Siki LSS	18560	104	10-Nov-10	Lolokoru S4	136682	125
02-Feb-10	Maramakas	193462	274	10-Nov-10	Lolokoru S5	105512	74
12-Feb-10	Dami	194473	195	10-Nov-10	Lolokoru S6	200881	139
12-Feb-10	Lakurumau	167994	282	03-Dec-10	Lolokoru S1	246437	170
16-Feb-10	Leinaru	299101	219	03-Dec-10	Lolokoru S2	147657	126
18-Feb-10	Kumbango	183314	180	03-Dec-10	Lolokoru S3	169375	118
01-Mar-10	Dami	96914	120	03-Dec-10	Lolokoru S4	158518	205
01-Mar-10	Leinaru	169179	205	03-Dec-10	Lolokoru S5	142629	91
13-Mar-10	Maramakas	89031	263	03-Dec-10	Lolokoru S6	173603	145
15-Mar-10	Lakurumau	232177	212	10-Dec-10	Hoskins VOP	211869	106
29-Mar-10	Kumbango	74540	186	10-Dec-10	Dami	187555	161
14-Apr-10	Kumbango	225410	210				
16-Apr-10	Dami	92387	106				
07-May-10	Dami	90131	190				
13-May-10	Kumbango	227694	200				
07-Jun-10	Dami	27583	102				
09-Jun-10	Kumbango	220847	206				
01-Jul-10	Kumbango	203028	174				
01-Jul-10	Dami	170914	154				
02-Aug-10	Dami	249437	174				
13-Aug-10	Kumbango	176593	204				
06-Sep-10	Hoskins VOP	108363	98				
06-Sep-10	Dami	116053	102				
22-Sep-10	Lolokoru S1	120310	133				
22-Sep-10	Lolokoru S2	38720	100				
22-Sep-10	Lolokoru S6	135201	131				
22-Sep-10	Lolokoru S4	102681	109				
22-Sep-10	Lolokoru S3	123761	124				
23-Sep-10	Lolokoru S5	93133	131				

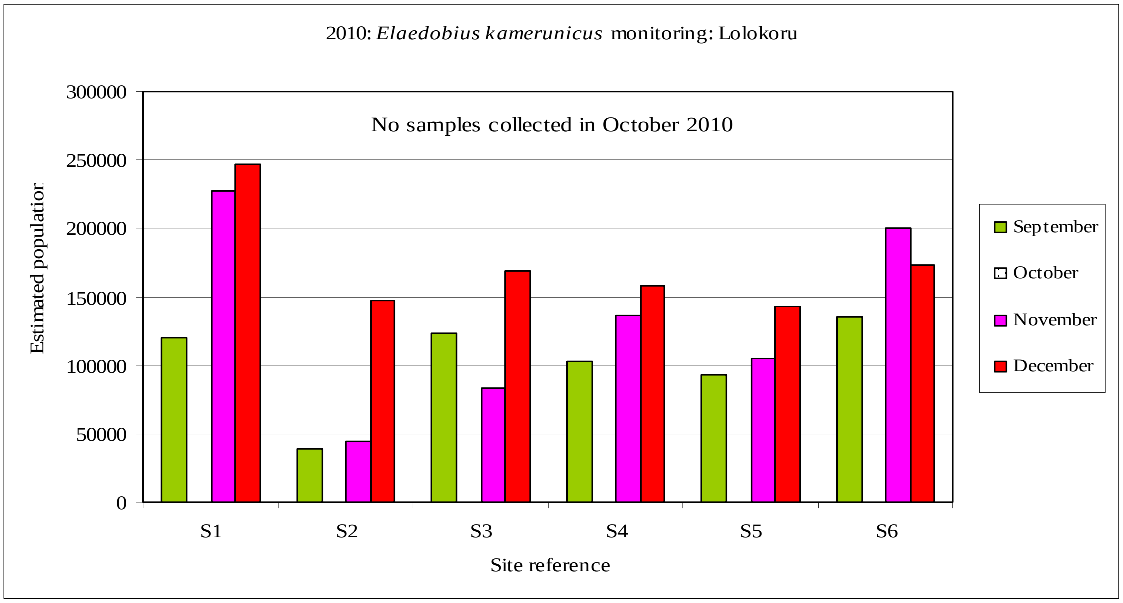

Figure 29. WNB, Lolokuru Plantation: *Elaeidobius* estimated population numbers from 6 sampling sites.

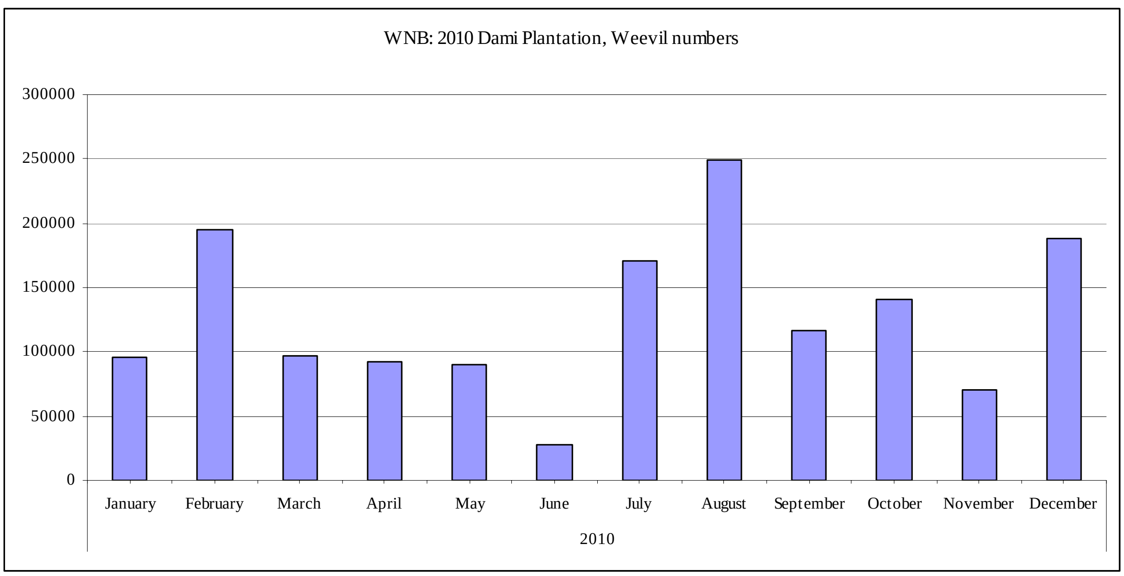

Figure 30. WNB, Dami Plantation: *Elaeidobius* estimated population.

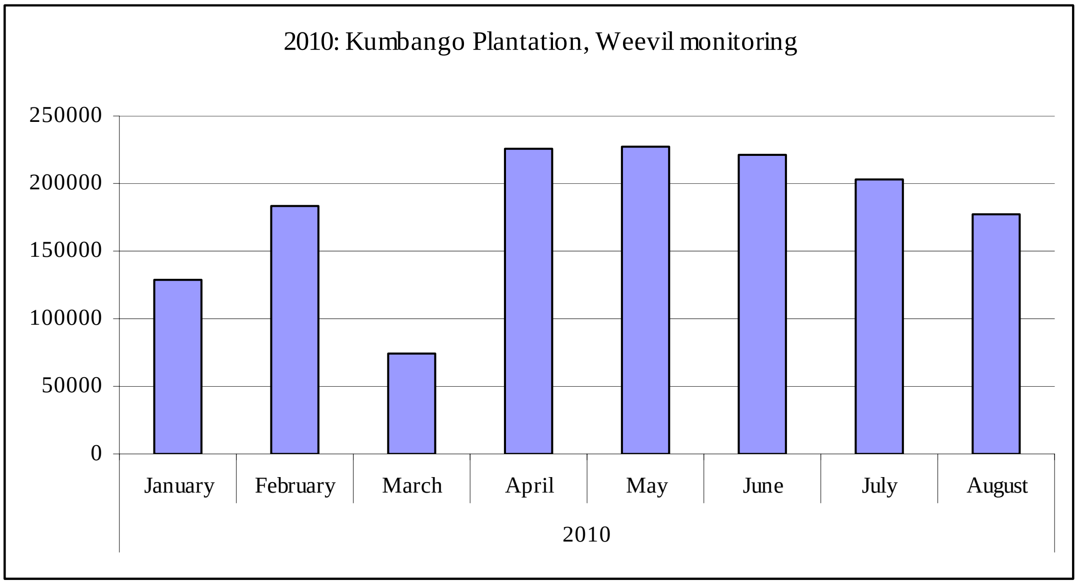

Figure 31. WNB, Kumbango Plantation: *Elaeidobius* estimated population. Sampling ended in August.

Ghana origin weevils.
Two releases were made at RAIL after three previous unsuccessful attempts to fly material over there. The environment is very dry there, however it is hoped that the weevils will survive and provide the genetic diversity to those weevils already present. Once approval from the Board is received, it is proposed to release weevil at all plantations in PNG managed by NBPOL, Hargy Oil Palms and smallholder grower blocks. Weevil rearing will continue until these requirements are met.

Phasmatidae (stick insects). **(RSPO 4.5, 8.1)**
Infestations of *E.calcarata* were regularly reported however on no occasion during the year were they the primary cause of a reported infestation. In reports received from smallholder growers, *E.calcarata* was in almost as many locations as *S.defoliaria*. *E.horrida* was not reported from any infestation, and no specimens were collected from mainland PNG either. No parasitoids of *Eurycantha calcarata* were reared during 2010.

Life history and feeding trials for Stick insect, Eurycantha insularis (Elizabeth Nyani-PNG University of Natural Resources and Environment).

A PNG-UNRE student worked with us for 6 weeks to investigate feeding requirements of *Eurycantha calcarata* and sexava. Her report, which will require further analysis although incomplete, does indicate tentatively that:

(i) Adult males *S.defoliaria* may consume: 1.11g of oil palm leaflet per day (n=5).
(ii) Adult female S.defoliaria may consume 1.46gm of oil palm leaflet per day (n=5).
(iii) Adult female *S.decoratus* may consume: 0.96g of oil palm leaflet per day (n=5), which does seem low.
(iv) Late instar nymphs of *E.calcarata* may consume 0.86gm for males and 0.98gm for females.

It is intended that these data will be completed and analysed by the student who has now returned to University.

Coleoptera (weevils, rhinoceros beetles and white grubs). **(RSPO 4.5, 8.1)**
Scarabaeidae, Melolonthinae: *Lepidiota reauleuxi:* no reports were received during 2010.
Scarabaeidae, Melolonthinae: *Papuana* sp. (*woodlarkiana/hubneri*): no reports were received during 2010.

Chafer beetle: (*Dermolepida* spp., Scarabaeidae, Melolonthinae): there were no reports of damaging levels of this complex of beetles during 2010, although specimens of this genus are often found on the leaflets of oil palm.

Curculionidae: *Rhabdoscelus obscurus* and *Rhynchophorus bilineatus:* no species of *Rhabdoscelus* has yet been recorded as a pest of oil palm in PNG, however adults of *R.obscurus* weevil were found in appreciable numbers on freshly cut oil palm fronds and cut trunks in association with a smaller species (as yet not identified) from Mamba Estate, Higaturu Oil Palms, Northern Province (Kula Group) (Fig.32).

Figure 32. *R. .obscurus* and an unidentified (smaller) species of weevil on cut frond-base, Mamba Estate, Higaturu Oil Palms October 2010.

Additional specimens of *R.. obscurus* were sent to Dr Chris Lyall at the Natural History Museum, London, UK who is investigating the DNA and speciation within the genus which is very widespread throughout the Pacific region, and reported as a pest of oil palm in Indonesia (see Annual report 2009). There has not been any advancement on this work but it is hoped that progress will be made in 2011.

Rhynchophorus bilineatus (Black Palm Weevil).
This weevil has not been reported as causing any damage during 2010.

A few specimens of *Rhynchophorus bilineatus* were also found as larvae, pupae (in cocoons), and adults at Mamba Estate, Higaturu Oil Palms, Northern Province. The specimens were retained for the reference collection (Fig.33)

Figure 33. *R. bilineatus – female (l), male(r).*

Sparganobasis subcruciata
Although this weevil is known from coconut (S.Laup personal communication, 2011), there has been little work done, and nothing published since the early days. This weevil was recorded as a coconut pest (from Madang), but the records and damage observed in Mamba Estate, Northern Province are the first records from oil palm (Fig.34). The first draft of a manuscript has been prepared and the abstract is attached as Annex 1 (below). Larvae were subsequently found at Giligili Plantation, Milne Bay Estates (from a palm felled due to Ganoderma, C.Pilotti, personal communication). The weevil is strongly attracted to the decay smell given off from Ganoderma or rot in frond bases of palms, as a result of chemicals released either by the bacterium, *Thielaviopsis paradoxa* or

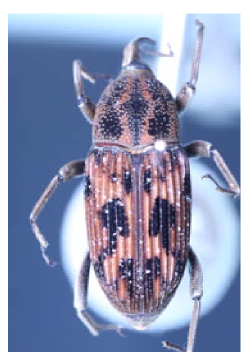

Figure 34. *S.subcruciata.*

the smell given off by a secondary yeast infection. The chemicals produced by *T. paradoxa* activity are, most likely ethyl or methyl Acetates or Butyrates (esters), and from the yeasts, acetic acid or other carboxylic acids, produced by a breakdown of Oil palm tissues.

Other bacteria were also identified which give off the strong sweet smell that cannot be ruled out as an attractant (C. Pilotti, personal communication).
Specimens of the weevil have been provided to the National Insect collection Kila Kila Port Moresby, Natural History Museum, London, CSIRO Ecosystem Sciences and are also retained in the PNGOPRA reference collection.

Oryctes rhinoceros (Asian Rhinoceros Beetle): there were no reports of this insect received during 2010.

O.centaurus (Larger Rhinoceros Beetle).
Routine monitoring of this insect continued at bimonthly intervals although somewhat erratically, at Higaturu, however results are not available at this time. No further specimens were sent to The Natural Resources Institute in Kent, UK to look for pheromones as insect numbers available have fallen. It is felt that now the palms at Ambogo have now grown out of the stage when they may be attacked by the beetle.

Scapanes australis ssp. *grossepunctatus* (Three-horned rhinoceros beetle): no reports were received during 2010.

Lepidoptera (RSPO 4.5, 8.1)
Lymantriidae (Tussock moths): a single report was received from GPPOL during 2010, however TTI was not recommended. This moth has still to be reared through to the adult stage.

Oecophoridae (Xylorictidae), (Oil Palm Webworm): there were no reports of the Oil Palm Webworm (*Acria* sp nr. *emarginella*) received during the year, however there was a query raised from India where this insect was reported. A response was made to the enquiry advising that the insect could not have introduced through seeds sent by NBPOL due to the packaging process and the fact that seeds are just germinated.

Psychidae (Bagworms): there were two reports of rough bagworm (*M.corbetti*) from Solomon Islands (GPPOL) received and recommended for TTI and hand picking during 2010. No reports of bagworm (*Mahasena* or *Manatha*) were received from the Kula Group plantations. Routine monitoring of the populations present at Ambogo continued throughout 2010. The collaborative study on bagworm taxonomy had moved only very slowly during 2010, due to a lack of communication from the collaborating author.

Hemiptera: Finschhafen Disorder (RSPO 4.5, 8.1)
Note: at the time of writing this report (early 2011), ***Zophiuma lobulata*** has been found to be a synonym of ***Zophiuma butawengi*** and the latter name is used in this section except when quoting old reports/papers. The change of name is as a consequence of the PNGOPRA/ACIAR project on Finschhafen Disorder (see Annex 1).

The ACIAR supported collaborative project with Charles Sturt University, Orange, Australia entitled, "*Integrated pest management for Finschhafen Disorder of Oil palm in Papua New* Guinea [CP/2006/063] was completed and a final report was prepared and submitted to ACIAR. Two peer-reviewed manuscripts were submitted during the year; however they will not be published until 2011. One paper "*Insect pests and insect-vectored diseases of palms-a review*", was published at the end of 2009 in The Australian Journal of Entomology (see references) by Gitau, Gurr, Dewhurst, Fletcher and Mitchell. *Z.pupillata* was studied, and a re-description produced entitled "*A review of the* *planthopper genus* Zophiuma *with first description of the male* Z.pupillata*"* was sent to the peer reviewed Australian Journal of Entomology and will be published in early 2011.

No further donor funding to support operational research on the lab rearing and inundative mass release of parasitoids materialised. (See also section on M.Phil. student studies on entomofungi). The final project report is summarised in Annex 1 (below) and the full report is lodged on the Entomology drive (Reports/ACIAR 53pp).

Other Outputs:
Two poster presentations were made. Other papers are in various stages of preparation for publication in peer reviewed journals, and will be made available upon request as they are published.

Mycopathogens of *Z. butawengi*: M.Phil study, Deane Woruba (RSPO 4.5, 8.1)

Figure 35. Z. *butawengi* attacked by entomophagous fungus (Photo: PNGOPRA).

Deane Woruba, recipient of the ACIAR John Allwright Fellowship in 2008 commenced his Master of Philosophy studies in July 2009 at Charles Sturt University (CSU), Orange, New South Wales, Australia. Deane is involved in the ACAIR Project CP/2006/063: *Integrated pest management of Finschhafen Disorder of oil palm in Papua New Guinea (PNG)* and he is investigating the potential for the use of entomopathogenic fungi in controlling *Zophiuma butawengi*, the causal organism for Finschhafen Disorder.

From successful field collections of *Z. butawengi* entomopathogenic fungi from locations in West New Britain (WNB) and Milne Bay (MB) provinces in February 2010, three (3) entomopathogens were identified; *Metarhizium flavoviride* var. *minus*, *Hirsutella citriformis* and *Paecilomyces marquandii*. These three pathogens were then used in laboratory-based bioassay on *Z. butawengi* nymphs. This work was done at the PNGOPRA entomology laboratory in Dami, WNB and fungal isolations work was done at the PNGOPRA Plant pathology laboratory in Hagita, MB.
Findings from this research have been written up and are about to be submitted for publication and below is an abstract from this paper:

Abstract
Oil palm Elaeis guineensis Jacq. *is an important cash crop in Papua New Guinea. Production is currently under threat from Finschhafen Disorder caused by the planthopper* Zophiuma butawengi, *a native pest of coconut palm. The need for an environmentally friendly strategy to manage* Z. butawengi *is vital since the industry is committed to sustainable palm oil production. One option is the development of a biological control agent using entomopathogenic organisms that could be applied in response to outbreaks of the pest, thereby reducing impact of* Z. butawengi*. From field collections, three entomopathogens,* Metarhizium flavoviride *var.* minus, Paecilomyces marquandii *and* Hirsutella citriformis*, were identified from* Z. butawengi *cadavers. This is the first record of identified entomopathogenic fungi of Z.* butawengi*. In a laboratory-based bioassay, the*

entomopathogens were tested on Z. butawengi *nymphs at three concentrations of* $1x10^{-4}$, $1x10^{-5}$ *and* $1x10^{-6}$. *Water and nil treatment were applied as control.* M. flavoviride *var.* minus *killed insects most rapidly, followed by* H. citriformis *and* P. marquandii. M. flavoviride *var.* minus *showed promise as a candidate for further development as a biological control agent for* Z. butawengi.

From a literature review conducted for the thesis, a review paper is being written up with the running title: *Entomopathogenic fungi of planthoppers.*

Other pests (RSPO 4.5, 8.1)
Achatina fulica: there were no reports of the Giant African Snail during 2010.

Rats and other vertebrates: no reports of rats were received during 2010.

Weed pests (RSPO 4.5, 8.1)
Mikania micrantha, Mile-a-minute vine (ACIAR project CP/2004/064).
We continue to work in close collaboration with colleagues at NARI Kerevat, and infected material is sent to us at Dami for release in WNB. A paper is in preparation and will be submitted to the APS-IPPC conference in Hawaii in August 2011.

Abstract
Mikania micrantha *Kunth (Asteraceae) or mile a minute is a Neotropical plant species, now found in 15 lowland provinces in PNG and all major islands of Fiji. The weed invades plantations and cropping areas, thereby reducing productivity and threatening food security. As part of an Australian Government funded biocontrol program, the rust fungus* Puccinia spegazzinii *was imported into PNG and Fiji in 2008. Life cycle studies were conducted and eight inoculation techniques were evaluated to determine the most efficient method to culture the rust. A variety of field release techniques were trialled and field monitoring by monthly sampling at three sites, using random quadrats was conducted to determine the effect of the rust on populations of mikania. Elsewhere, other release sites were revisited to determine establishment and spread of the rust.* P. spegazzinii *is a microcyclic and autocieous rust, with a life cycle of 18-22 days. The most efficient inoculation method with high levels of infection were obtained when 3-4 week old plants grown in polycups were placed under infected plants in an inoculation chamber for 48 hours at 26±1°C. The rust fungus has been released in over 500 sites in 15 provinces in PNG and over 80 sites on four islands in Fiji. In PNG, the rust has established at nearly 100 sites, spreading up to 40 km from some sites, while in Fiji, it has established at over 20 sites on two islands. Laboratory studies and detailed field monitoring has shown that* P. spegazzinii *can reduce the growth and percent plant cover of mikania and has the potential to control mikania in many parts of both countries.*

Sida rhombifolia, Broomstick: releases of Chrysomelid beetles, (*Calligrapha pantherina*) from RAIL, were made during 2010, and a culture under shade was set up at Dami to enable cropping and release to be undertaken as required.

Pistia stratiotes, Water lettuce: the biological control weevil (*Neohydronomus affinis* Hustache) culture virtually died out during the year, and the work has only involved trying to maintain the culture.

Eichornia crassipes, Water hyacinth: water hyacinth is attacked by weevils of a different genus, *Neochetina bruchi* (Coleoptera: Curculionidae)-the Chevroned Water hyacinth beetle. Host material is collected from waterways in WNB and infested plants are returned on an *ad hoc* basis.

Queen Alexandra Birdwing butterfly (*Ornithoptera alexandrae*). (RSPO 5.2, 8.1)

Figure 36. The original female QABB shot by A S Meek in 1906 at Biagi near the Mambare River, Northern Province, PNG. (Photo: courtesy J. Tennent).

Collaborative work with OPRS (Tissue culture laboratory) continued with emphasis on improving propagation techniques based on multiplication of Pararistolochia vine of known origin and of food plant material. Results show that there is a strong possibility that there is a very narrow host plant preference at level of specific vine genotypes. The use of tissue cultured material taken from seeds was not pursued, after it was shown that the removal of the endogenous fungus from within the tissues, which killed off developing seedlings, would become a major research project in itself. We (Dr D Smith and CFD) therefore continue to concentrate on using known origin vine cuttings and are continuing to develop methodologies that can be used simply under nursery conditions to propagate the vine for habitat enhancement.

Smallholder Agricultural Development Project (SADP). (RSPO 4.4, 8.1)

Environmental Monitoring

PNGOPRA will be developing and trialling a system of stream monitoring using freshwater arthropods as bio-indicators. A detailed list of equipment requirements for this project has been prepared, and will be sent off once the project approval has been granted. The implementation of this project has been delayed by logistics within the donor system. There is a concern that with the advent of this project, there will be a lack of space to undertake the work and steps have been taken to obtain funding, through SADP, to extend and repair the current entomology building to cater for this important project.

Reference and reprint (EndNote) development (1) and insect reference collections (2). (RSPO 8.1)

Publication/Reprint collection

Although it was reported last year that 761 reprints were added to EndNote, this figure was incorrect as many had been duplicated. The current figure at end December 2010 is 492.

Specimen collection

Additional insect material was added to our reference collection, and one cabinet was prepared to accept only pest material. The need for additional space will soon become apparent and oil palm pest and associated taxa are collected.

Training and field days. (RSPO 1.1, 4.8, 8.1)

The field days organised by OPIC were well attended during the year, and entomology staff participated in all except one meeting. Field days held in the Hoskins Project area were more readily accessible than those held by the Bialla Project where we were only able to attend a single field day. The majority of Bialla field days were cancelled by the Project Manager. It is primarily a logistical difficulty that prevents our regular attendance at the Bialla meetings. An updated Entomology activities brochure was produced as a hand-out during meetings, training courses and to visitors.

Table 5. OPIC field days (including those attended by entomology staff).

Date	Division	Area/Location	Estimated number of growers	Number of attendees	Number of Ento support staff attending	Comment
13-Apr-10	Buvussi	Buvussi	120	46	2	
20-Apr-10	Buvussi	Galai 1	80	86	4	
27-Apr-10	Buvussi	Galai 2	100	57	3	
04-May-10	Kavui	Kavui	200	59	3	
11-May-10	Kavui	Kapore	200	57	3	
18-May-10	Kavui	Gaungo/Mai	200			
25-May-10	Kavui	Kaus	200	59	5	
08-Jun-10	Siki	Hoskins Secondary School	120	72	4	
15-Jun-10	Siki	Siki LSS	120			
05-Oct-10	Siki	Makasili		140	2	Excluding children
12-Oct-10	Siki	Makasili		?	1	No count
29-Jun-10	Siki	Rikau	100	46	2	
06-Jul-10	Nahavio	Dagi	60	44	1	
13-Jul-10	Nahavio	Morokea	200	34	2	
20-Jul-10	Nahavio	Rerengi	100			Cancelled
27-Jul-10	Nahavio	Liapo	80			Not attended
03-Aug-10	Salelubu	Umu	100	52	3	
04-Aug-10	Bialla	Lalopu		148	2	
17-Aug-10	Salelubu	Silanga	200	130	3	OPIC Bialla
17-Aug-10	Salelubu	Mamota 1-4	150		4	
18-Aug-10	Bialla	Soi (OPIC Bialla)		218	3	
24-Aug-10	Salelubu	Sebal/Malele/Bereme	150			OPIC Bialla
07-Sep-10	Siki	Lavege	?	0	2	
14-Sep-10	Nahavio	Balabolo		45	2	
21-Sep-10	Buvussi	Bubu	100	31	3	

IPM Working Group held at Hargy Oil Palms offices.
No IPM Working Group (IPMWG) meeting were held during 2010.

Extension: Radio Programmes. (RSPO 1.1, 4.8, 8.1)
Three radio programmes were completed for Radio West New Britain during 2010.

OPRAtive Word (RSPO 1.1, 4.8, 8.1)
Two OPRAtive Words were published during 2010 (see references).

Quarantine related issues. (RSPO 5.1, 8.1)

Seed Production Unit (SPU)
Routine monitoring of traps was erratic during the year due to major refurbishment of the seed production facility, however on the occasions when material was checked, no taxa of quarantine concern were identified. Routine monitoring will continue once refurbishment has been completed.
Certification
PNGOPRA PEQ (Post Entry Quarantine) facility was re-assessed by NAQIA, and approval given for its use as a quarantine laboratory by NAQIA (PEQC4). During the year, a single sample was received from NAQIA requiring identification. A report was prepared and sent to NAQIA.

Pest Lists (RSPO 4.5, 8.1)
The spreadsheet of oil palm associated arthropods and vertebrates, including those that may become possible threats to oil palm, was set up and is updated on a regular basis. There are still outstanding additions to be made, and the importance of this list is clear with the new players entering the oil palm industry in PNG. To date some 197 different species have been identified. Many of which are not recognised as pests but for which mention has been made in the literature, even if vaguely. There is a

large amount of information on many of the Homoptera (scale and mealy bugs) which has not been included, as they are still so complicated taxonomically. The information will be added to as and when new information in forthcoming.

Visitors to Entomology Section in 2010

More than 40 official visitors were addressed by entomology staff during 2010. Visitors were from the following organisations:

NBPOL, NARI World Bank OPIC
Kula Group
ACIAR, Fiji
NAQIA, POM
Divine Word University, Madang
Hargy Oil Palms, Bialla
Natural History Museum, London, UK
University of Queensland
James Cook University ACIAR, Canberra
BioSecurity, Queensland

References.

Lepesme, P 1947. Les Insectes des Palmiers. Paris (1947), pp 807.

OPRAtive Word –Technical Note 16. *An alternative method for palm plugging during targeted trunk injection (TTI): Saving costs-observations using old palm nuts*. Deane Woruba and Charles Dewhurst.

OPRAtive Word – Technical Note 20. *Sexava:the cost of no control*. Bill Page and Charles Dewhurst.

Prospects for parasitoid-based biocontrol of *Z. lobulata* (Hemiptera: Lophopidae), the cause of Finschhafen Disorder of Oil Palm in Papua New Guinea. Catherine Gitau, Geoff Gurr, Charles Dewhurst, Murray Fletcher, Andrew Mitchell. *AES 41st AGM and Scientific Conference, 26-29 September 2010, Perth, Australia.*

Tettigoniidae pests of Oil Palm in Papua New Guinea (2009). Charles Dewhurst. 10th International Congress of Orthopterology, Antalya, Turkey (poster presentation).

Entomopathogenic fungi of Zophiuma butawengi *(Hemiptera: Lophopidae), a planthopper pest of oil palm in Papua New Guinea, and prospects for biological control.*
D.N. Woruba, M.J. Priest, C.F. Dewhurst, C.W. Gitau, M.J. Fletcher, A. Cowling and G.M. Gurr. *(in preparation).*

The biology, culturing, field release and monitoring of the rust fungus Puccinia spegazzinii, *de Toni (Pucciniales: Pucciniaceae), a classical biocontrol of* Mikania micrantha Kunth *(Asteraceae) in Papua New Guinea and Fiji*
Day, M. D., , Kawi, A.P, Fidelis, J., Tunabuna, A. Orapa, W., Swamy, B., Ratutini, J, Saul-Maora, J., Dewhurst, C.F. (*awaiting Journal approval*).

In preparation

Description and biological parameters of Ooencyrtus isabellae Guerrieri & Noyes sp. nov. Hymenoptera, Chalcidoidea, Encyrtidae), a biocontrol agent of Zophiuma butawengi (Heller) (= Z. lobulata Ghauri)(Hemiptera, Fulgoromorpha, Lophopidae) in Papua New Guinea
Emilio Guerrieri, Catherine W. Gitau, Murray Fletcher, John S. Noyes, Charles Dewhurst, Geoff Gurr

Catherine Gitau, Geoff Gurr, Charles Dewhurst, Murray Fletcher, Andrew Mitchell (Zootaxa *in press*). A review of the planthopper genus *Zophiuma* Fennah (Hemiptera: Fulgoromorpha: Lophopidae), with first description of the male of *Z.pupillata* Stal.

ANNEX 1.
[Note: at the time of writing the final report *Zophiuma butawengi* was known as *Z.lobulata*]

Integrated Pest Management for Finschhafen Disorder of Oil palm in Papua New Guinea [CP/2006/063].

Summary from Final Project Report. (Full report is on the Entomology drive).

The objective of this project was to protect the viability of oil palm industry in Papua New Guinea by enhancing the social and economic benefits that emanate from production in plantations and smallholdings. The main work concerned Finschhafen disorder (FD), a problem first reported from coconut palms near Finschhafen, Morobe Province, Papua New Guinea (PNG) in 1960. FD is now a threat to palm oil production. Research conducted in the 1980's implicated a native PNG planthopper *Z. lobulata* Ghauri (Hemiptera: Lophopidae). Methods used in previous studies pre-dated the availability of molecular biology tools that enable detection of possible plant pathogens. In this project, these tools were used to screen plant and insect material for a variety of pathogens known to be vectored in other crops by a group of insects to which *Z. lobulata* belongs. Transmission experiments in large cages and small sleeves were also used to study FD causality.

In the last year, the Postdoctoral Fellow (Dr Catherine Gitau) visited PNG once to conduct experiments and work with Mr. Charles Dewhurst, Head of Entomology at PNG Oil Palm Research Association. Molecular biology and taxonomic expertise have been contributed by Drs Andrew Mitchell, Australian Museum and Murray Fletcher, NSW Department of Primary Industries.

The first objective of this project was to develop a comprehensive biological understanding of the causes of FD. The second objective was to develop preliminary control measures for FD.

On the first objective, bibliographic information on FD and *Z. lobulata* as well as similar disorders and pests of palms was sourced from various scientific databases and an electronic library was compiled using the EndNote bibliographic software package. Copies of all relevant publications have been collected and complemented by a significant volume of personal communication material that has been obtained from liaison with palm health researchers around the world. All of this information was synthesised into a comprehensive review article that was published in the Australian Journal of Entomology.

The identity of *Z. lobulata* was confirmed by comparing specimens collected from mainland PNG and West New Britain and those associated with coconut, oil palms as well as betel nut. The confirmation used the formal description made by Ghauri (1966). Results showed consistency in *Z. lobulata* male genitalia of all the specimens examined. Molecular methods using the CO1 gene showed the same consistency. We therefore conclude that there is no evidence for additional or cryptic species and only one species is associated with FD. From opportunistic collections, a congeneric planthopper to *Z. lobulata* namely *Z. pupillata* (Stål) was collected from coconut and sugarcane in mainland PNG. The two were compared using morphological taxonomy and CO1 bar-coding and results showed distinct differentiation between the species.

However, a most fascinating and significant outcome from this project is the finding that of the five described species of the New Guinean genus *Zophiuma* Fennah (Hemiptera: Fulgoromorpha: Lophopidae), *Z. lobulata* Ghauri is a synonym of *Zophiuma butawengi* (Heller) and *Zophiuma guineae* (Lallemand) is a synonym of *Zophiuma pupillata* (Stål). The third species of the genus, Z. *doreyensis*

Distant, is known only from the male holotype. After examination of the male genitalia of all available specimens, *Zophiuma* was returned back to three species after the addition of the two species from the genus *Hellerides* by Liang (1995). We found out that the best known species is associated with FD on coconut and oil palms and it is unfortunate that the rules of priority require that this species has a change of name from *Z. lobulata* to *Z. butawengi*. All references to *Z. lobulata* previously published essentially apply to *Z. butawengi*. An article on this work is near completion and will be submitted to the Australian Journal of Entomology.

Comprehensive screening for possible microbial pathogens in *Z. lobulata* and oil palm material was conducted. Insect and plant material were thoroughly screened using current molecular biology tools for phytoplasmas and bacteria-like organisms (BLOs) as these pathogens were commonly cited in literature as being transmitted by Hemiptera. Saliva samples that were collected in 5% sucrose solution were also screened for pathogens. The saliva was collected by presenting sucrose solution contained in an Eppendorf tube which was covered with a semi permeable membrane, to the planthoppers for feeding.

Large insect-proof cages (1.8mx1.8mx2.5m) were constructed and used in a study that aimed at elucidating the role of *Z. lobulata* in FD. *Z. lobulata* that were raised from eggs in the laboratory and those collected from the field were released into the cages in an additive process over a period of 11 months. Both the lab-reared and field-collected *Z. lobulata* induced FD symptoms to healthy coconut and oil palms. Small sleeve experiments were further set up to corroborate the large cage experiments. Results showed that FD is caused by a direct feeding effect by *Z. lobulata* rather than transmission of a pathogen.

Field work was aimed at identifying natural enemies of *Z. lobulata* that could be used as biocontrol agents. The field surveys resulted in the collection of several taxa of parasitic wasps belonging to the family Mymaridae and Encyrtidae. These were the common parasitoids of *Z. lobulata* egg masses on West New Britain and Milne Bay in PNG mainland. Samples of the Mymaridae were sent to Canada and UK for identification and revealed that they are new species. Description of the species is currently underway.

Samples of *Z. lobulata* were found killed by entomopathogens. Deane Woruba, a staff member from PNGOPRA received the ACIAR John Allwright Fellowship in 2008 and commenced his Masters studies in July 2009 at Charles Sturt University (CSU), Orange, New South Wales (NSW). Deane is investigating the potential for entomopathogenic fungi in controlling *Z. lobulata*. Dr. Michael Priest, the Senior Plant Pathologist at Orange Agriculture Institute, Industry and Investment NSW joined the team and is now co-supervising Deane's project. Currently, samples collected are undergoing morphological identification. So far, saprophytic fungi have been isolated, two known entomopathogenic genus have been identified namely: *Metarhizium* and *Paecilomyces* and a third entomopathogenic fungi genus, Hirsutella, is believed to be observed on field collections but laboratory cultures are yet to confirm if this genus is present in PNG.

To develop preliminary control methods for FD, a variety of coloured sticky traps was evaluated in the field in order to assess trapping as a monitoring tool for *Z. lobulata*. Results did not reveal significant differences in attractiveness, based on colour. Moreover the numbers of *Z. lobulata* adults and nymphs captured were very low. Future experiments using trap and kill approaches using fungi will perhaps be considered when results on entomopathogens are completed. However, monthly monitoring of *Z. lobulata* numbers and FD symptoms on betel nut, coconut and oil palm was conducted between January 2008 and February 2009 and from March 2009 to February 2010 on a small holder oil palm blocks in West New Britain. Laboratory experiments evaluating the influence of nectar rich ground cover plants on the lifespan of mymarid and encyrtid parasitoids were conducted.
Results suggest that direct visualisation of *Z. lobulata* egg masses may be a viable monitoring tool, and that adults lived longer when they had access to honey compared with those that were fed on flowers and water alone.

3. PLANT PATHOLOGY RESEARCH

HEAD OF SECTION: CARMEL PILOTTI

THE EPIDEMIOLOGY OF BASAL STEM ROT (RSPO 4.1, 4.5, 8.1)

Introduction

The progress of the BSR epidemic in Milne Bay has been followed since the first recordings of the disease in 1995. Ideally, disease progress should be followed through until replant so that a reliable model can be generated to develop tools for disease management in future plantings. Some errors in predictions are anticipated since control methods have been implemented throughout the period of data collection and this will need to be considered when developing models. In addition, the inconsistency of disease spread in different geographical areas most likely will not permit a universal model to be applied.

Methodology

Survey data presented here has been obtained from Milne Bay Estates Ltd., Poliamba Ltd., Higaturu Oil Palms Ltd. and New Britain Palm Oil Ltd. All data has been corrected where possible and only disease incidence data detected in the 2010 surveys. Ganoderma survey data for Blocks 7501, 6404, 6503, 6504, 7213 and 7214 and Fields E4 and E5 were collected by OPRA personnel in biannual (Milne Bay) or quarterly (West New Britain) surveys.

Disease progress in first generation oil palms

Milne Bay Surveys

The total disease incidence for 2010 expressed as the number of diseased palms per hectare for all Divisions in Milne Bay is shown in Fig. 1. The range of infections in 2010 was between 0.5 to 6.1palms/ha.The highest disease incidences were recorded for Giligili and Naura Divisions with 6.1 and 6 palms/ha respectively in 2010. Corresponding percentage disease levels are shown in Fig. 2. Audits have not been completed and the data presented is as provided by TSDs.

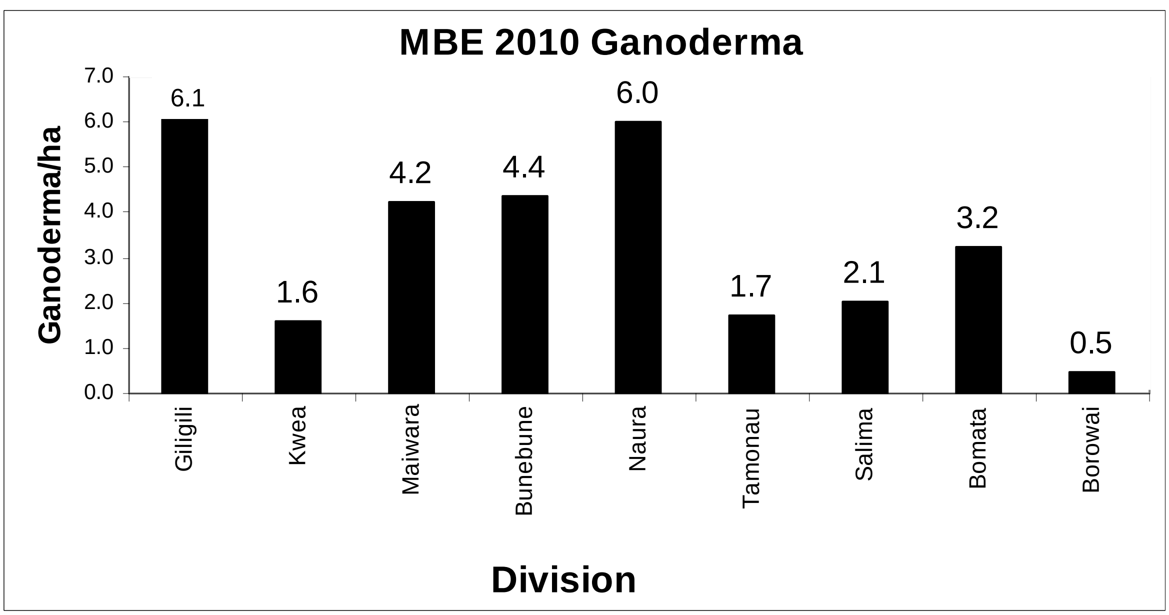

Figure 1. Number of diseased palms (per ha) detected in selected Divisions in Milne Bay in 2010.

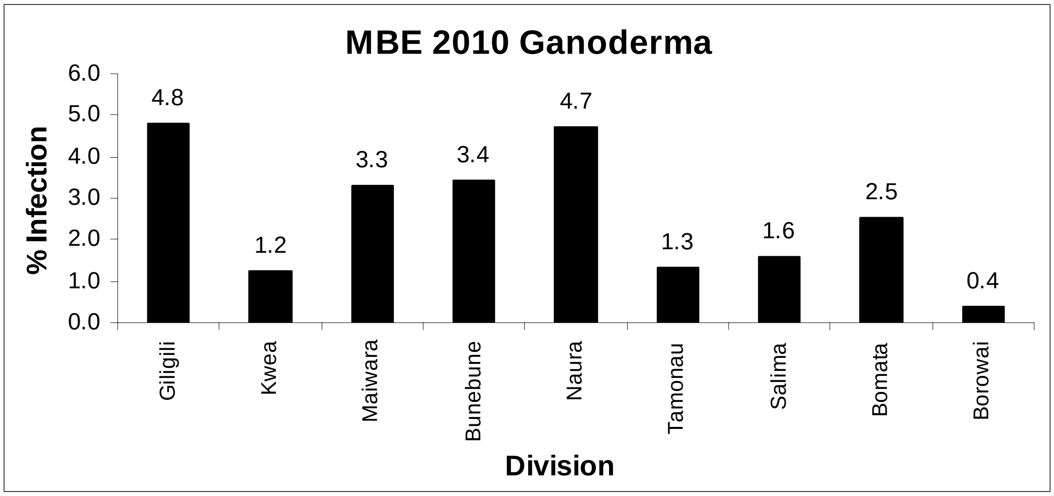

Figure 2. Disease incidence data (expressed as percentage of total palms) for selected Divisions in Milne Bay in 2010.

Disease progress curves for palms planted in 1986, 1987 and 1988in Milne Bay are shown in Fig. 3. Disease progress in these older plantings has been continuing in a non-linear fashion since about 2005 and the average level of infection in 25 year old palms is now 26.7% a significant increase of over 5% from 2009.

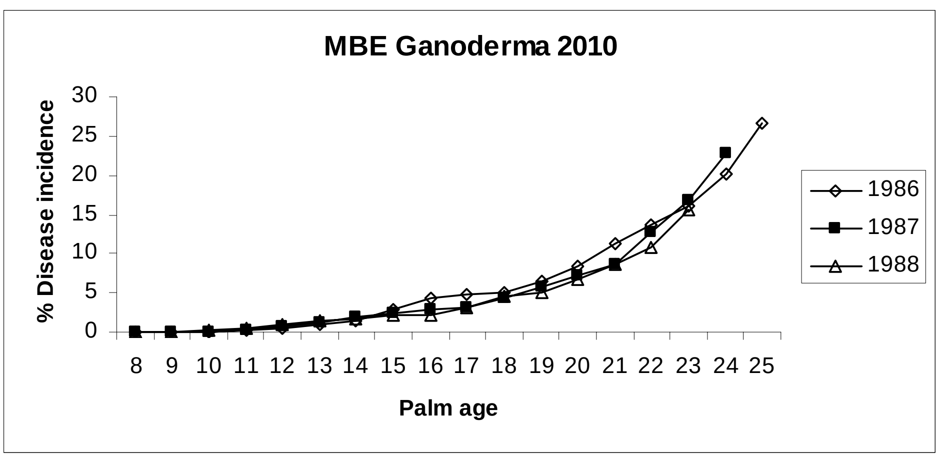

Figure 3. Cumulative disease incidence (1995-2010) for palms planted in 1986 and 1987 in Milne Bay.

Disease progress in Ganoderma study blocks

Disease incidence in Blocks 7213, 7214, 7501, 6404, 6503 and 6504 in 2010 are shown in Fig. 4. A reduction in disease levels from 2009 was observed for all blocks except Blocks 7213 and 6503 where non-significant increases were seen. Block 7214 recorded the highest incidence in 2010 with 3.02% down slightly from that recorded in 2009. The lowest disease rate was observed for Block 7213.

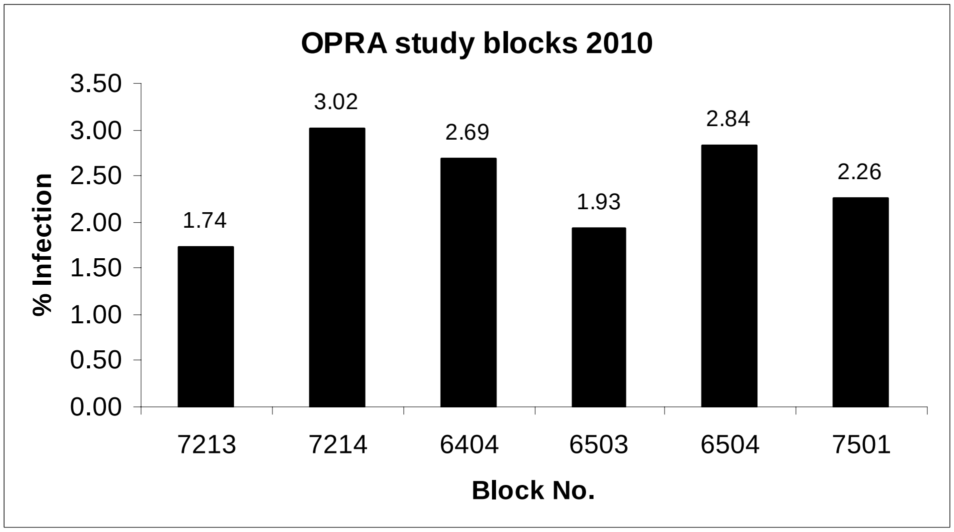

Figure 4. Incidences of Ganoderma in OPRA study blocks in Milne Bay in 2010.

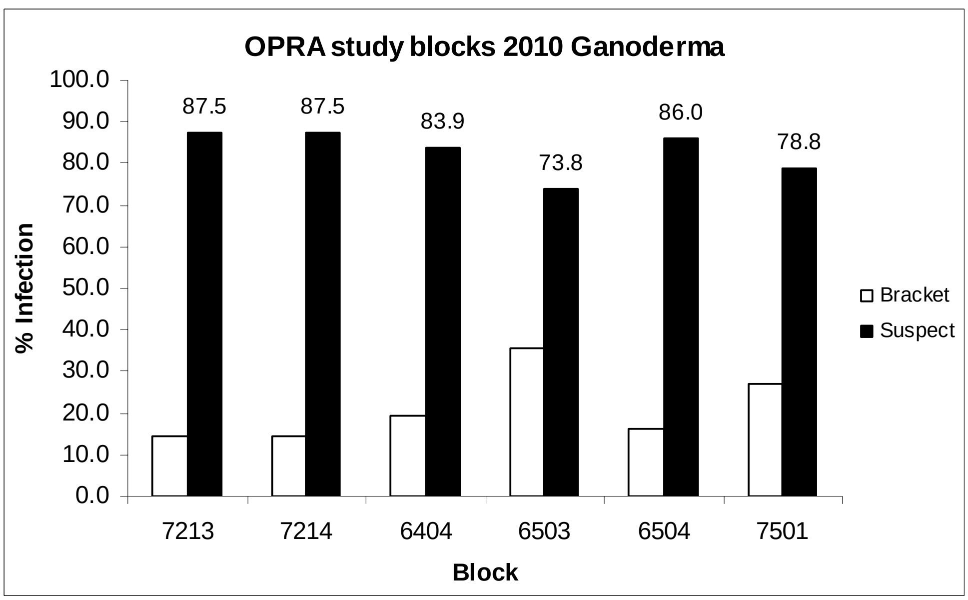

Figure 5. Ganoderma disease incidences in the six study blocks in Milne Bay showing the numbers of suspected and confirmed Ganoderma palms.

The percentage of suspect palms continues to increase in each of the blocks (Fig. 5). An elevated wet season may have contributed to the increase in the number of suspect palms in most of the blocks in 2010.

Updated disease progress curves (DPC) for these six blocks are shown in Fig. 6. Block 6504 has the highest disease levels with 30.9% and Block 7213 has the lowest incidence of 15.7%. Incidences of Ganoderma in the remaining blocks are in the range 19.5-20.6%. Block 7501 was replanted in 2010 and therefore disease incidence is underestimated for the year and Blocks 6503 and 6504 are due for replant in 2011.

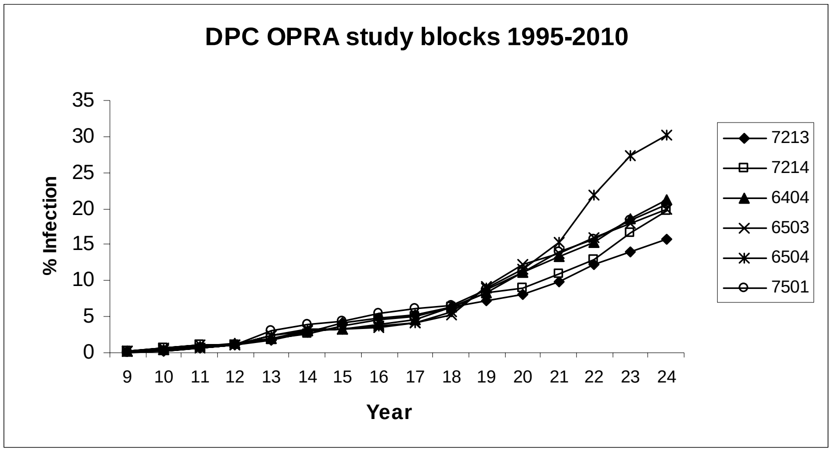

Figure 6. Disease progress curves from 1995 to 2010 for the six blocks selected for study in Milne Bay.

The DPC for Block 7213 approximate best to a linear curve whilst that of Block 6503 is sigmoidal, indicating large differences in disease rates between these blocks.

Smallholder Surveys – Milne Bay

Ganoderma surveys were completed in a number of smallholder (VOP) blocks in Milne Bay in 2010. Not all blocks were accessible due to poor upkeep and deteriorating road networks but all zones were visited and 30-100% of blocks in each zone were surveyed (Table 1). Blocks not surveyed will be revisited in 2011 as roads are upgraded.

Table 1. Number and area of smallholder surveys completed in Milne Bay in 2010.

AREA	TOTAL #BLOCKS	# BLOCKS SURVEYED	# IMMATU-RE	# INACCES-SIBLE	# BLOCKS NOT SURVEYED	TOTAL HA	#HA SURVEYED	% BLOCKS SURVEYED
Kerakera	25	15	2	0	8	63	40	60.0
Rabe	34	31	2	1	0	74	69	91.2
Waema	37	20	17	0	0	83	45	54.1
Kekerina	37	27	14	0	2	62	43	73.0
CIS	6	6	0	0	0	23	23	100.0
Gabugabuna	34	14	14	0	10	49	34	41.2
Yaneyanene	44	20	14	2	8	100	50	45.5
Lautewatewa	29	11	17	0	0	61	32	37.9
Delama	19	11	6	0	2	51	27	57.9
Diudiu	11	10	1	0	0	20	18	90.9
Lauhaba	23	21	0	0	2	63	58	91.3
Kapurika	25	20	0	0	5	76	65	80.0
Naura/Baraga	39	32	7	1	6	112	101	82.1
Kilakilana	28	17	7	0	3	57	39	60.7
Marayanene	22	7	7	1	7	52	28	31.8
Maiwara	7	0	7	0	0	0	0	0.0
Gumine	28	11	1	0	16	50	18	39.3
Ata'ata	38	15	7	6	10	83	35	39.5
Figo	32	15	15	1	1	95	51	46.9
Iwame/Dailogi	24	16	3	0	5	51	40	66.7
Mila	33	25	3	1	4	73	61	75.8
Wela/Bwauna	10	10	0	0	0	18	18	100.0
Ipouli	43	27	15	1	0	92	59	62.8
Borowai	67	21	46	0	0	113	32	31.3
Tamonau	39	26	2	1	10	91	68	66.7
Siasiada	57	39	4	0	14	111	89	68.4
TOTAL	791		NB: IMMATURE BLOCKS <10YRS					

The levels of infection in some blocks were very high but the majority of those recorded were suspect palms and their status could be attributed to other factors besides disease such as poor nutrition and water-logging (Table 2). The number of palms with confirmed Ganoderma (brackets) was relatively low however the large number of suspect palms needs to be investigated.

Table 2. Ganoderma-infected palms recorded in smallholder blocks in Milne Bay in 2010.

AREA	*TOTAL GANODERMA	BRACKET PALMS	SUSPECT PALMS	AREA SURVEYED	INFECTION PER HA	% INFECTION
Kerakera	1075	18	1057	40	26.9	21.0
Rabe	246	25	170	69	3.6	2.8
Waema	264	34	230	45	5.9	4.6
Kekerina	465	28	389	43	10.8	8.4
CIS	226	6	208	23	9.8	7.7
Gabugabuna	1067	39	1028	34	31.4	24.5
Yaneyanene	216	2	214	50	4.3	3.4
Lautewatewa	394	92	291	32	12.3	9.6
Delama	200	5	198	27	7.4	5.8
Diudiu	19	17	1	18	1.1	0.8
Lauhaba	483	6	466	58	8.3	6.5
Kapurika	659	678	1	65	10.1	7.9
Naura/Baraga	907	2	904	101	9.0	7.0
Kilakilana	215	0	215	39	5.5	4.3
Marayanene	136	1	135	28	4.9	3.8
Gumine	77	2	75	18	4.3	3.3
Ata'ata	125	0	125	35	3.6	2.8
Figo	241	0	241	51	4.7	3.7
Iwame/Dailogi	136	0	136	40	3.4	2.7
Mila	267	0	267	61	4.4	3.4
Wela/Bwauna	69	0	69	18	3.8	3.0
Ipouli	143	10	133	59	2.4	1.9
Borowai	322	3	319	32	10.1	7.9
Tamonau	518	3	515	68	7.6	6.0
Siasiada	182	19	163	89	2.0	1.6
	*DATA EXCLUDES STERILE PALMS					

New Ireland Surveys

Ganoderma infection levels recorded for each estate at Poliamba in 2010 are shown in Fig. 7. Noatsi Estate continues to record the highest levels of disease however in 2010 disease levels had decreased significantly from 5.7% in 2009 to 2.3%. This is significantly lower than most blocks in Milne Bay. Disease levels in all other Estates except Nalik East also decreased in 2010 from 2009 (Fig. 8).

The number of palms with brackets compared to suspect palms continues to be significantly higher at Poliamba than in Milne Bay as shown in Fig. 9. This is especially evident in Noatsi and Nalik East Estates. This may be due to a number of reasons including a more aggressive strain of Ganoderma and therefore, extra vigilance is required in order to minimise the amount of inoculum in blocks with high levels of basal stem rot.

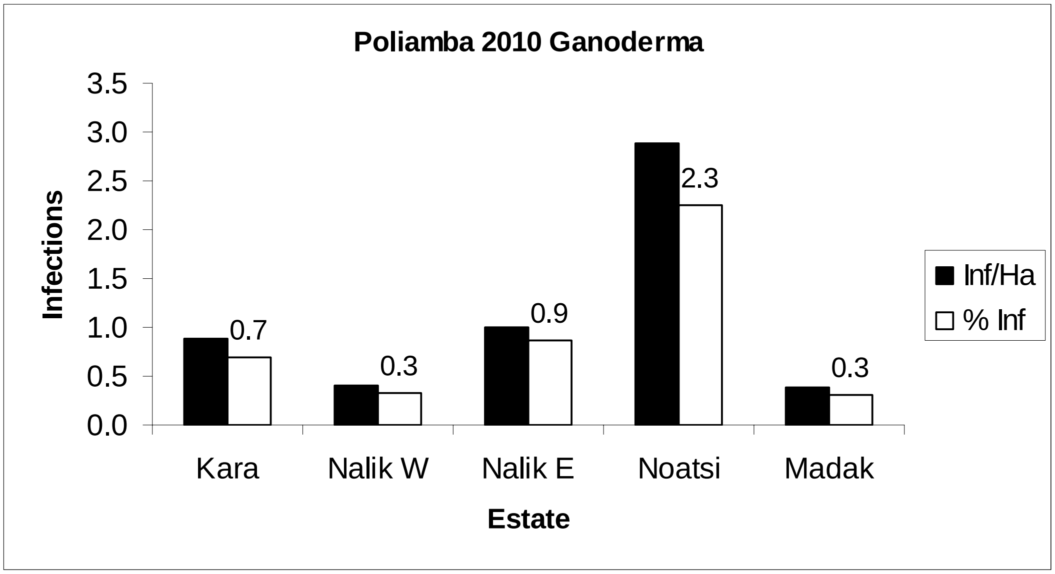

Figure 7. Ganoderma infection levels for all Estates at Poliamba Ltd., New Ireland in 2010 expressed as the number of diseased palms per hectare (black bars) and percentage of total original palm count (white bars).

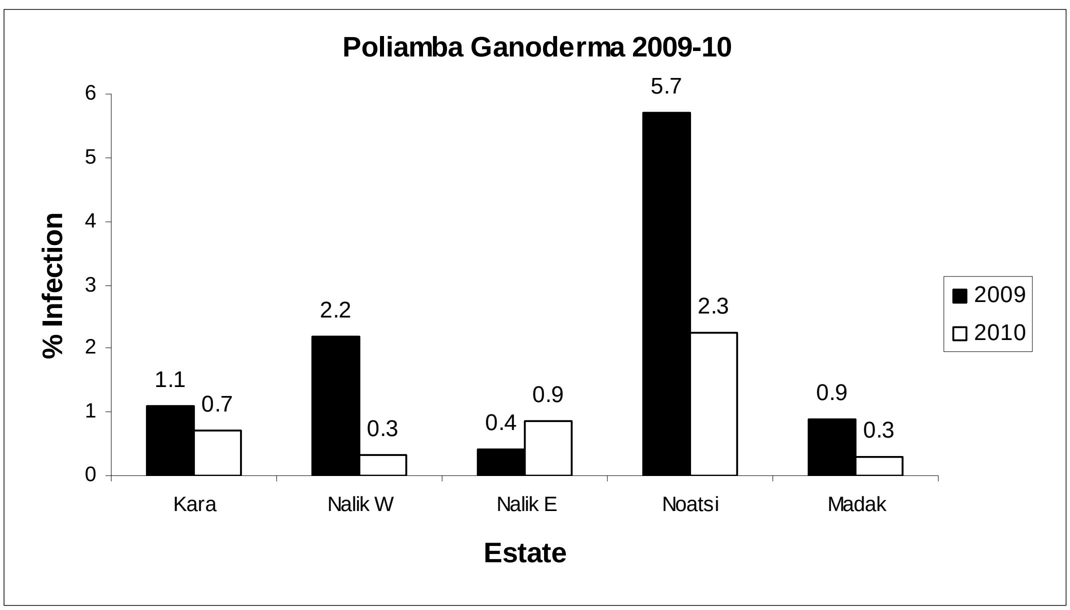

Figure 8. Ganoderma infection levels at Poliamba Ltd., New Ireland for the period 2009-2010.

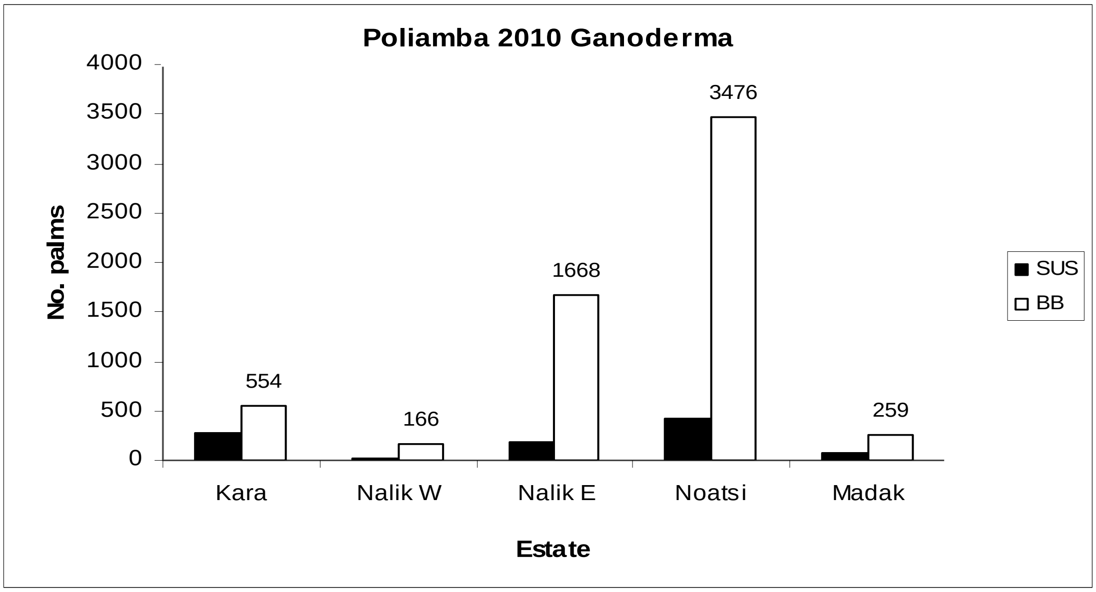

Figure 9. Numbers of bracket and suspect palms detected at each Estate at Poliamba Ltd., New Ireland in 2010.

Ganoderma levels in individual blocks in each of the Estates are shown in Figs. 10 to 14. Nalik West and Madak recorded the lowest levels of Ganoderma in 2010 with the highest recorded infections below 2%. Blocks in Noatsi and Nalik East Estates recorded higher levels of Ganoderma with Block AD0320 in Noatsi recording nearly 12 infected palms per hectare (Fig. 12). This may be a carry-over from removals in 2009 not being completed.

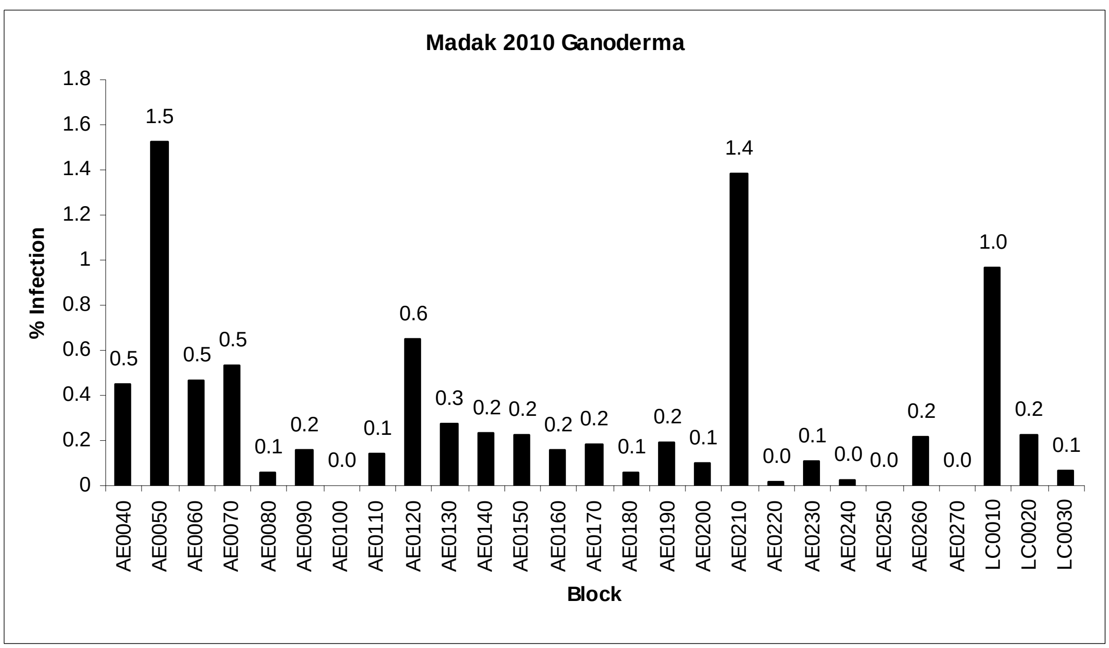

Figure 10. Reported Ganoderma infection levels in individual blocks in Madak Estate, Poliamba Ltd. in 2010.

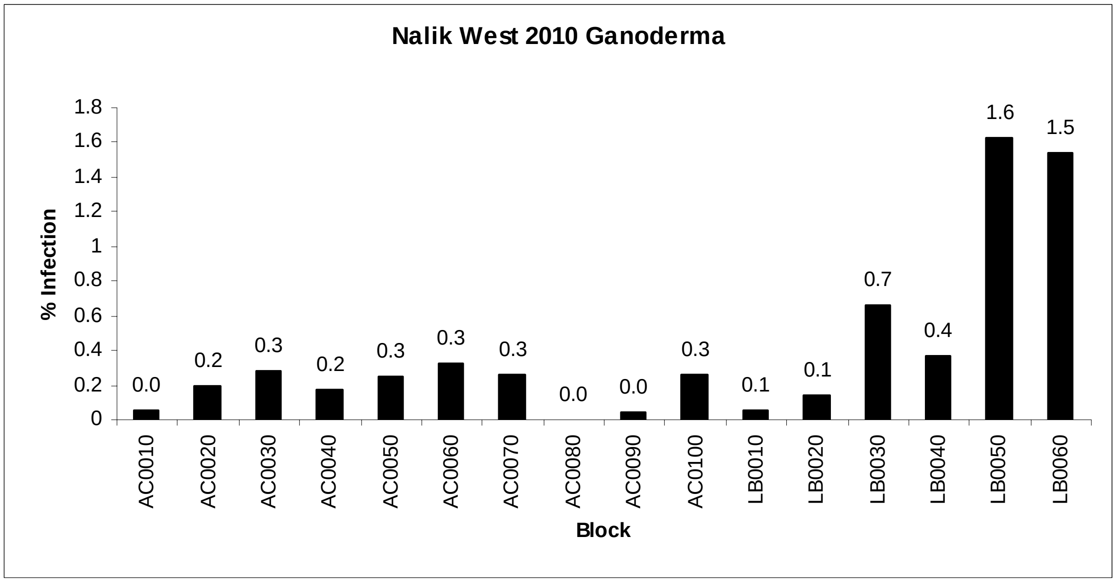

Figure 11. Reported Ganoderma infection levels in individual blocks in Nalik West Estate, Poliamba Ltd. in 2010.

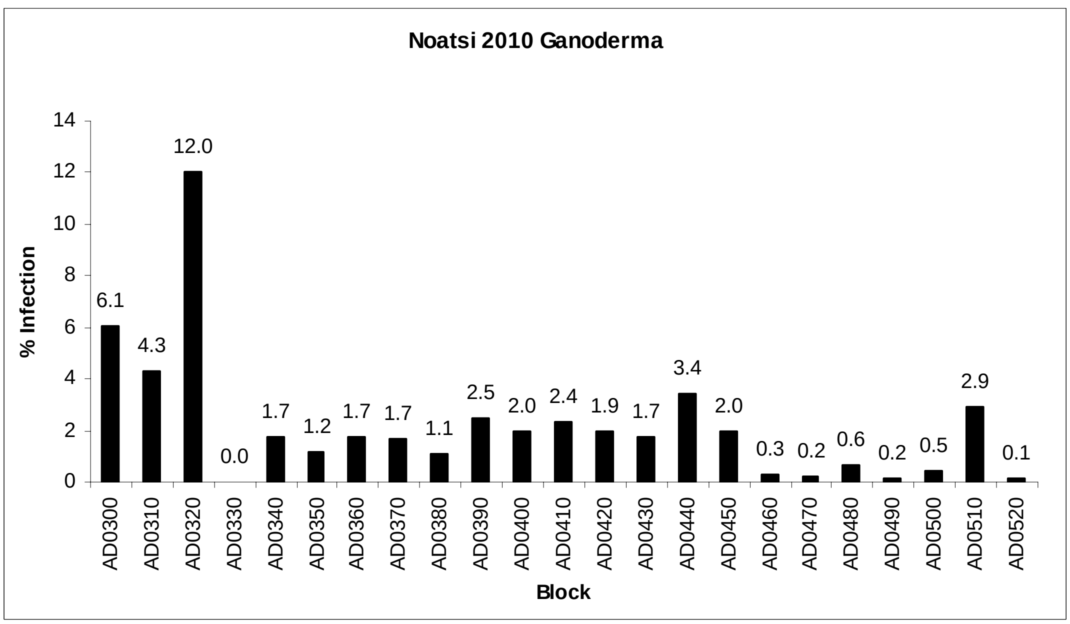

Figure 12. Reported Ganoderma infection levels in individual blocks in Noatsi Estate, Poliamba Ltd. in 2010.

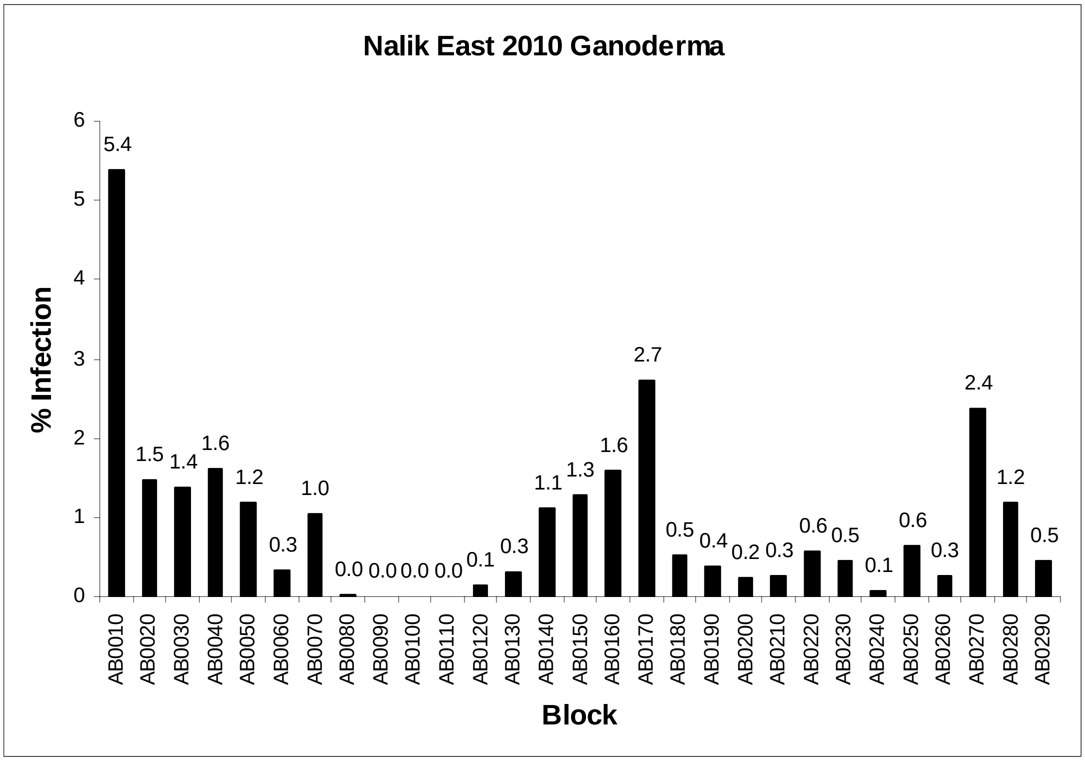

Figure 13. Reported Ganoderma infection levels in individual blocks in Nalik East Estate, Poliamba Ltd. in 2010. Note – only 50% of the blocks are shown.

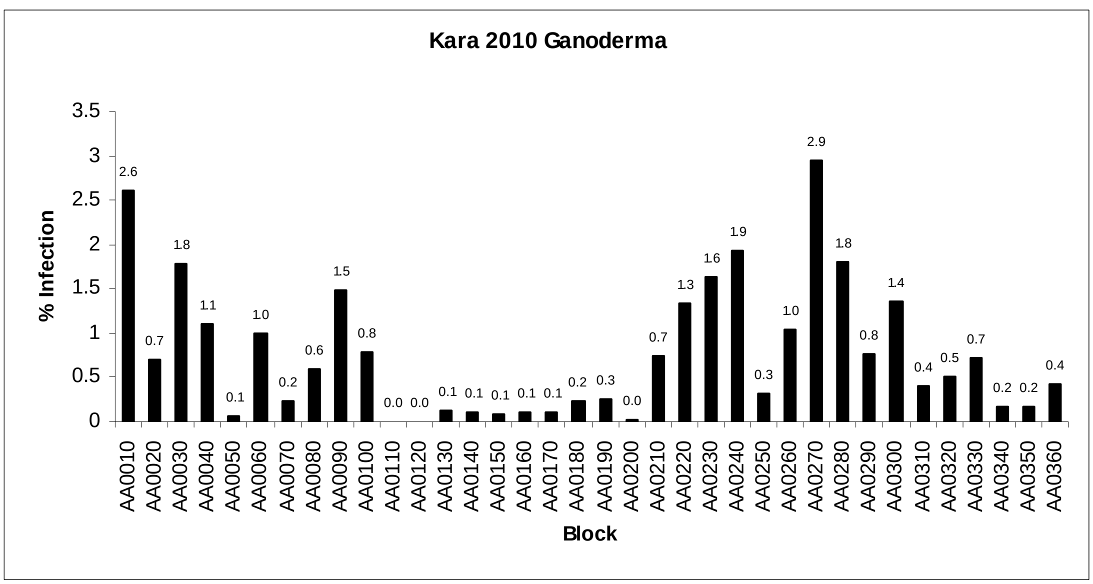

Figure 14. Reported Ganoderma infection levels in individual blocks in Kara Estate, Poliamba Ltd. in 2010.

Disease control

Improvements have been made in the removal efficiencies in each of the plantation, however the required 3 rounds of surveys is rarely achieved for all blocks in each of the plantations.

HOPL Ganoderma

Disease levels in all Estates at Higuturu Oil Palms Ltd. are shown in Fig. 15. Mean Ganoderma disease incidences were below 2% in 2010 with the highest recordings at Sumberipa which have mixed young (6-10 years) and old plantings (17-21 years). Disease levels at Sangara were similar to those at Sumberipa with 1.3%. Fig. 16 shows the percentage of suspect and bracket palms in each Estate. As for Milne Bay, the numbers of suspects exceeds the number of bracket palms in all Estates except for Mamba. This may be a reflection of the more subtle expression of symptoms at Mamba which has a higher rainfall than the lowland areas in Oro Province. Most of the data for Sangara is derived from 1996 plantings in 2010 as a high percentage of blocks in this estate were not surveyed.

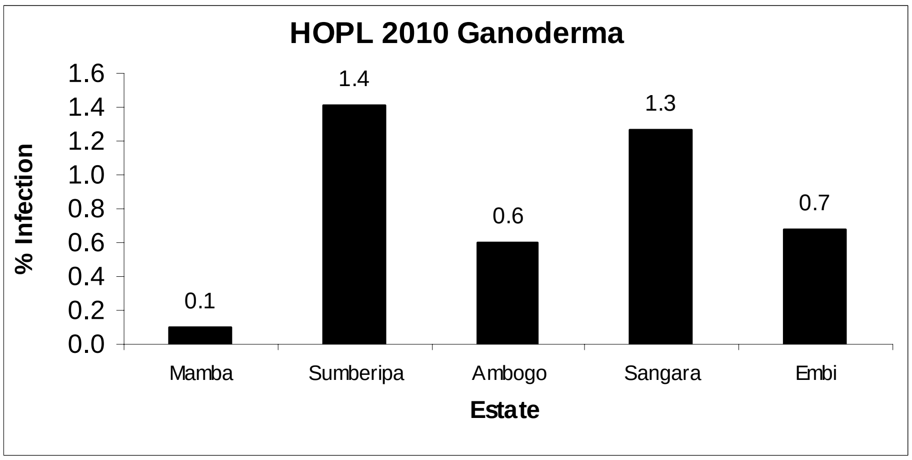

Figure 15. Ganoderma infection levels recorded for each Estate at Higaturu Ltd., Oro Province in 2010.

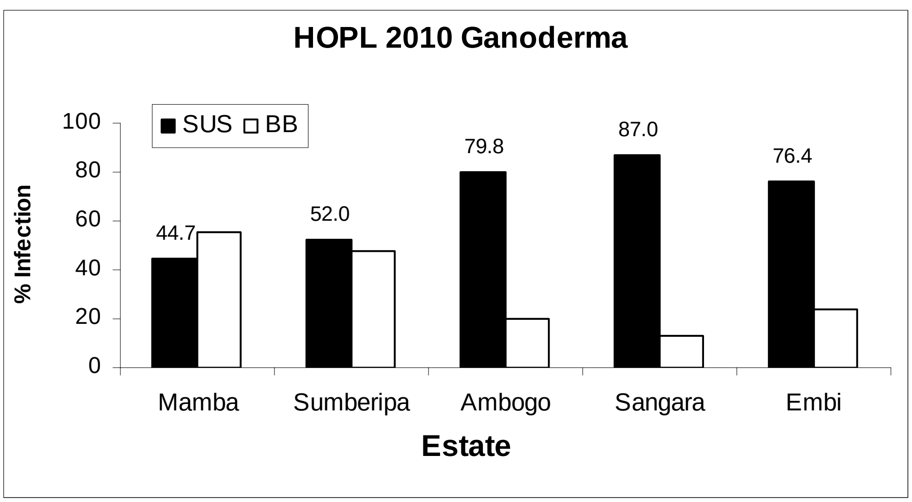

Figure 16. Numbers of suspect and bracket palms recorded at Higuturu OP Ltd., Oro Province in 2010.

West New Britain

Annual disease rates increased for all E fields at Numundo in 2010 (Fig. 17). Field E4 recorded the highest increase in rate of 0.5%.

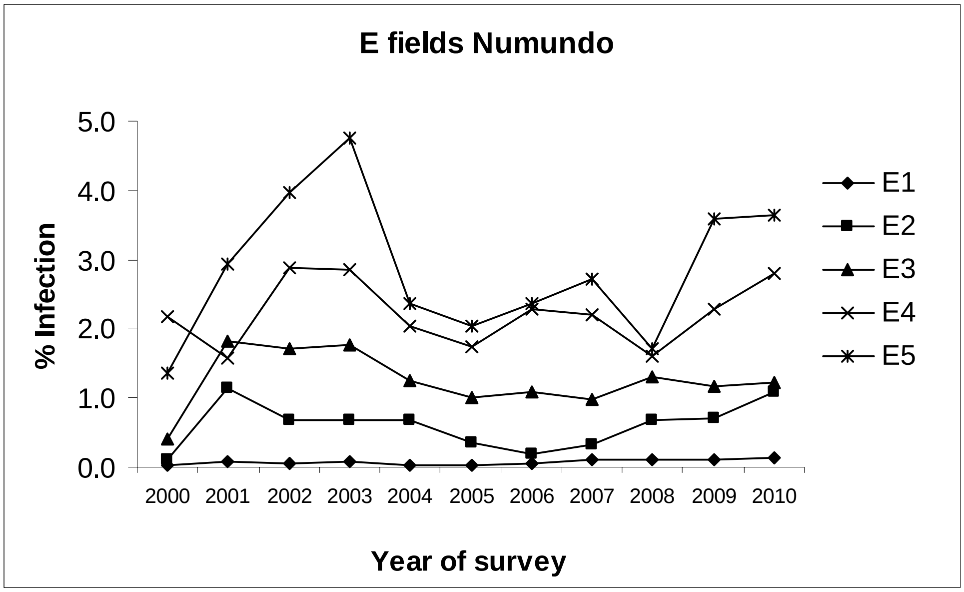

Figure 17. Annual disease incidence in 1994 Numundo E Fields, West New Britain from 2000-2010.

Disease progress curves for the period 2000-2010 show the continuing linear trend in infection rates in the E Fields (Fig. 18). Infection levels in Field E5 increased by 3.8% in 2010 and the disease incidence is now over 31%. Field E4 now has a cumulative infection level of 24.4%, above the theoretical threshold level for yield loss. Fields E1, E2 and E3 show disease incidences well below those of Fields E4 and E5 and it is not expected that these fields will have reached threshold levels at replant.

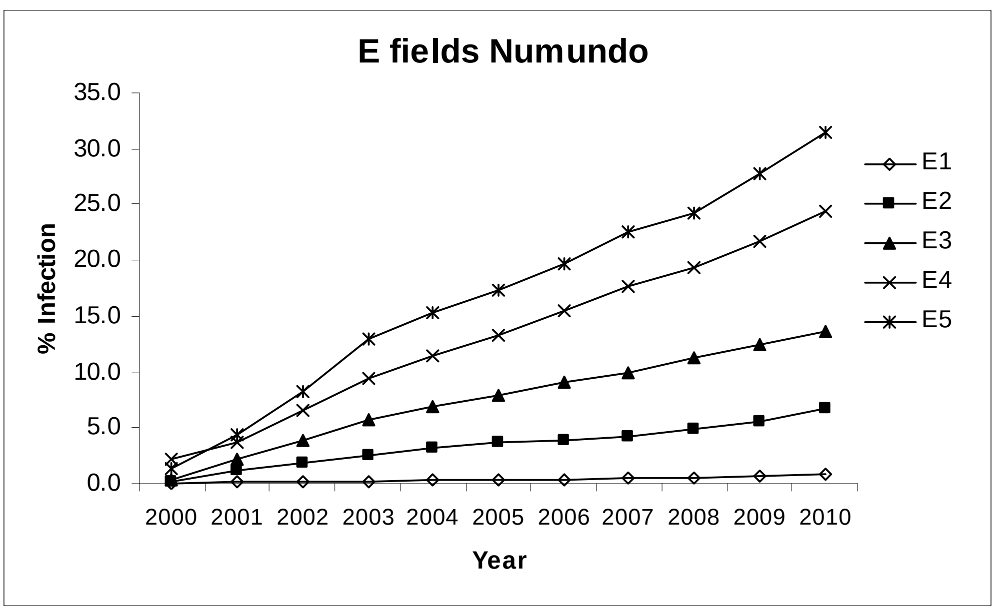

Figure 18. Disease progress curves for the 1994 E fields at Numundo, West New Britain Province from 2000-2010.

In terms of management units (MUs), as expected, the highest cumulative disease incidence (25.5%) was recorded in MU3 which comprises the worst affected Fields of E4 and E5 (Fig. 19). Levels were up 3.2% compared to 2009 (2.7%) indicating that the disease rate has increased slightly despite removals being carried out in these blocks. It's possible that removals were not completed in 2009 and standing palms carried forward to 2010. Audits have not been done to verify this.

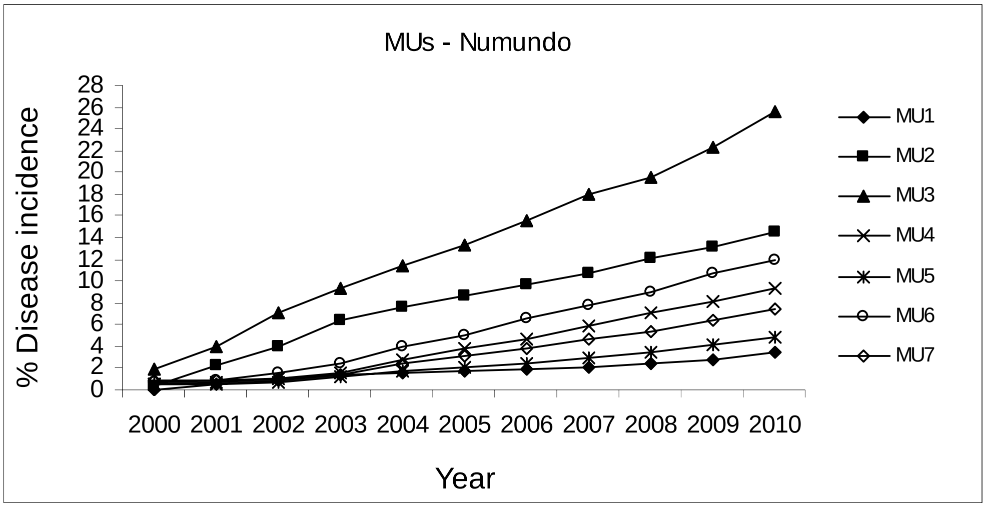

Figure 19. Disease progress curves for the period 2000-2009 for Numundo, West New Britain by Management Unit (MU). MU3 is comprised of Fields E4 and E5.

Adjacent F fields recorded only slight increases in disease rates except for Fields F3 and F5 where disease levels decreased slightly from 2009 (Fig. 20). Field F3 has the highest cumulative disease incidence of the F Fields with 13% (Fig. 21).

Disease levels for the youngest plantings and half stands (C fields) are shown in Fig. 22. Levels of infection in Fields C4 and C6 have increased since 2008 to around 6% however the disease rate has decreased in 2010 from 2009.

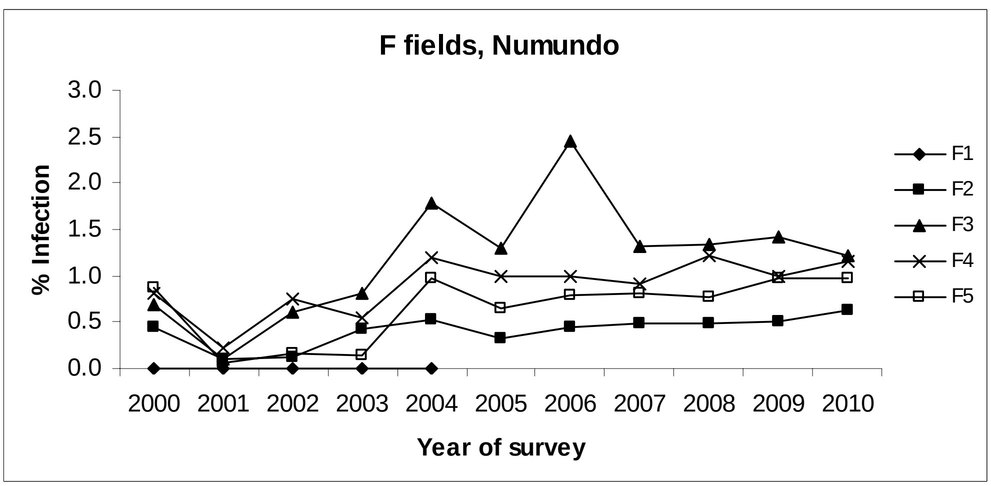

Figure 20. Annual disease losses for 1995 F Fields at Numundo, West New Britain Province from 2000-2010.

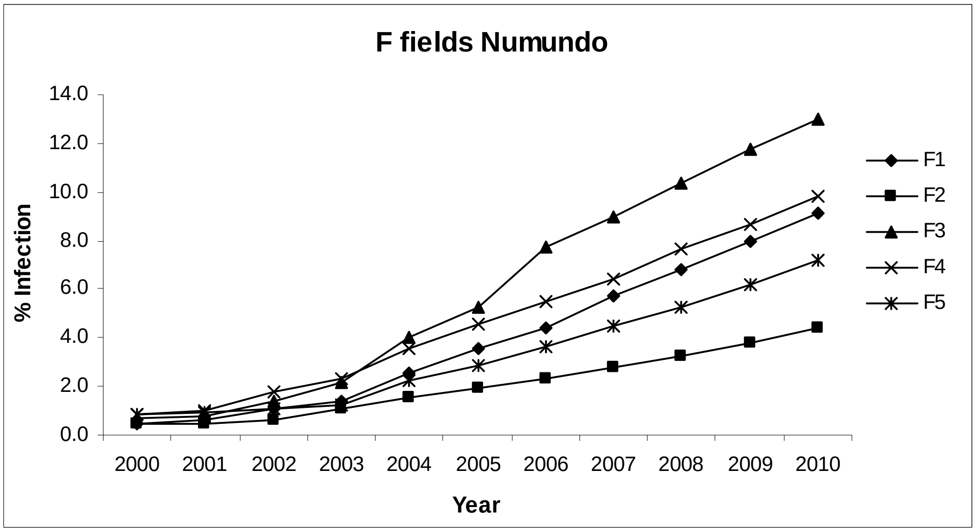

Figure 21. Disease progress for the period 2000-2010 for 1995 F fields at Numundo, West New Britain Province.

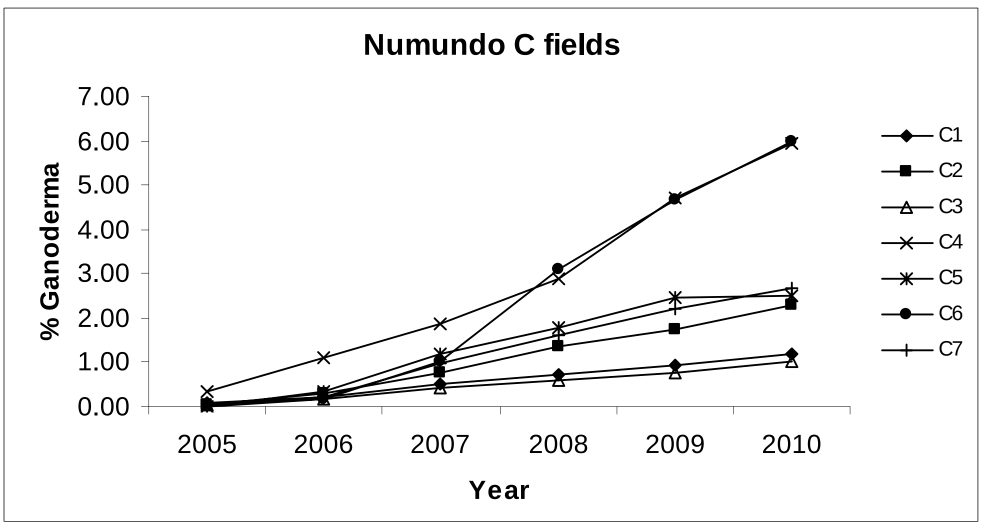

Figure 22. Ganoderma infection levels in C Fields, Numundo, West New Britain Province from 2005 – 2010. Fields were planted in 2000.

Disease control
Disease control at Numundo has generally been efficient with only a small percentage of palms remaining in the field from the previous survey each quarter.

Monitoring the effects of disease on production in selected blocks
The theoretical threshold at which yield begins to decline in a mature oil palm crop is in the vicinity of 20% of crop loss. This threshold will be dependent on a number of factors including the age of the palms, planting density, nutritional status and prevailing weather conditions, however, a knowledge of the approximate level at which production begins to decline in different areas of PNG will provide a basis for future recommendations for replanting.

The disease progress curves and corresponding yield levels expressed as yield in tonnes per palm for selected MU3 in West New Britain is shown in Fig. 23. Yield data used here has been provided from the plantations.

A small decline in yield was observed in 2010 for MU3 at Numundo with an average yield of 0.28 tonnes per tree compared to 0.30 tonnes in 2009, an average of 20kg per palm, which is probably not significant.

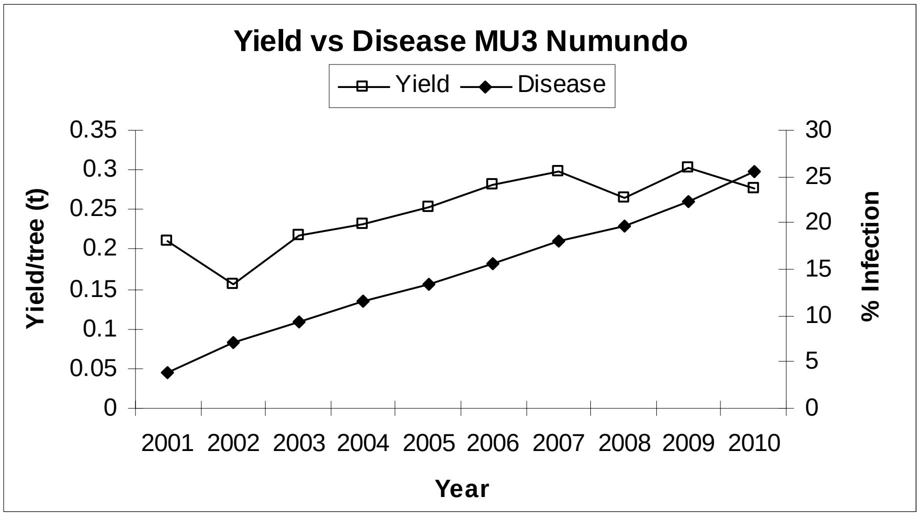

Figure 23. Effect of Ganoderma disease on palm production in fields with the highest infection levels (MU3) at Numundo, West New Britain from 2000-2010. The yield curve is derived from plantation data.

Production was variable for study blocks in Milne Bay with Blocks 7501, 7214, 6404 and 6504 recording decreasing yields and Blocks 6503 and 7213 showing increased yields in 2010 (Figs. 24 to 29). Block 7501 underwent replant in 2010 and hence production data is slightly underestimated. Disease levels are at theoretical thresholds in all blocks except Block 7213. Most of these blocks are 1986 plantings and will undergo replant in 2011 and yield decline will need to be interpolated.

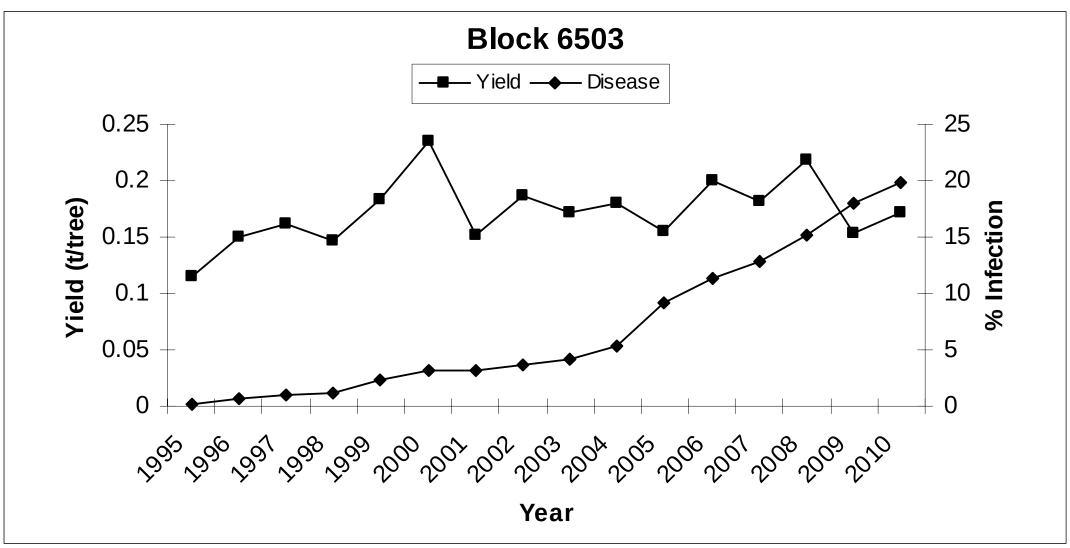

Figure 24. Effect of Ganoderma on production in Block 6503, Milne Bay Estates in 2010.

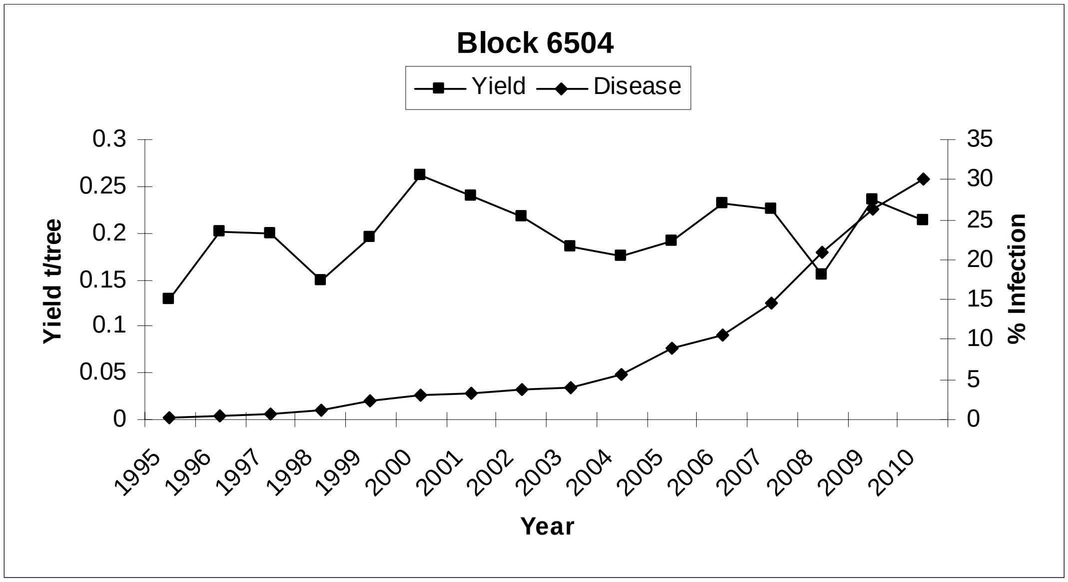

Figure 25. Effect of Ganoderma on production in Block 6503, Milne Bay Estates in 2010.

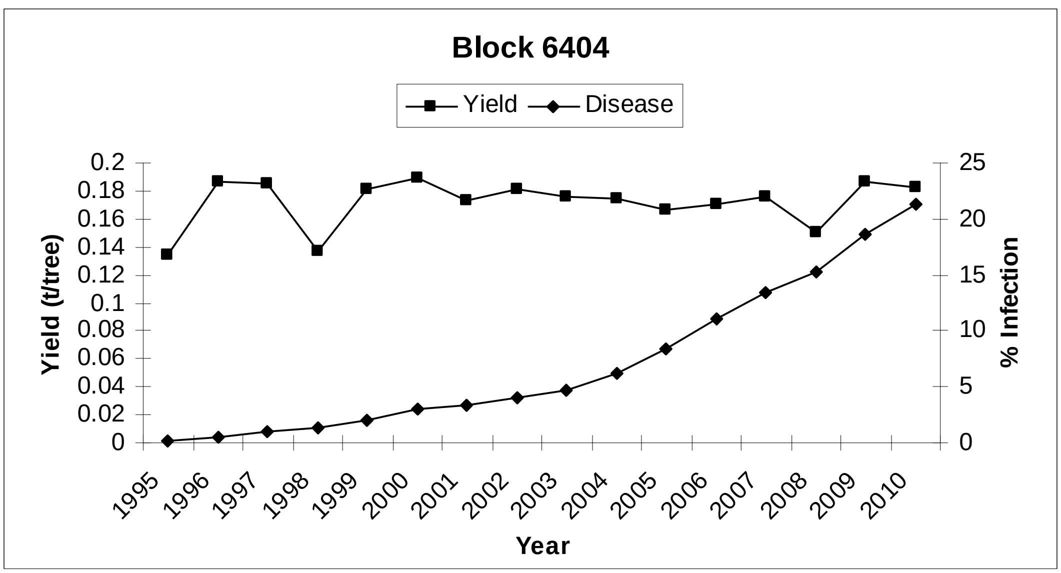

Figure 26. Effect of Ganoderma on production in Block 6404, Milne Bay Estates in 2010.

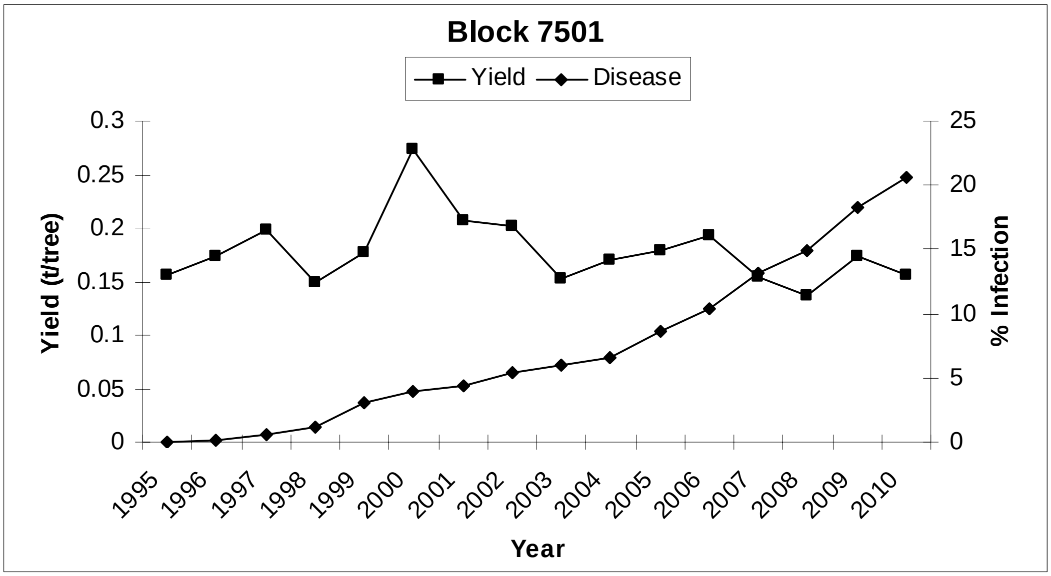

Figure 27. Effect of Ganoderma on production in Block 6503, Milne Bay Estates in 2010.

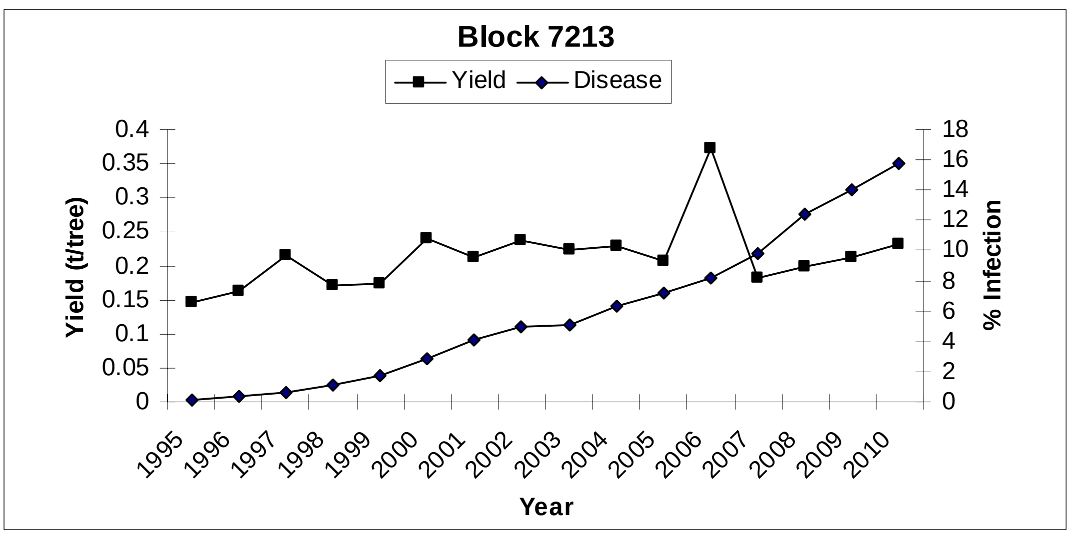

Figure 28. Effect of Ganoderma on production in Block 6404, Milne Bay Estates in 2010.

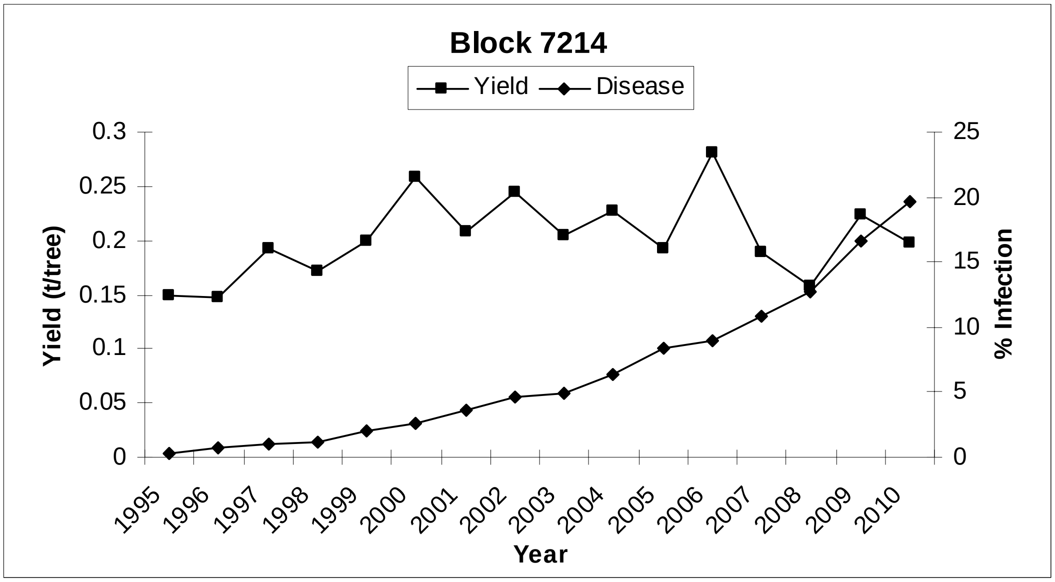

Figure 29. Effect of Ganoderma on production in Block 6404, Milne Bay Estates in 2010.

Ganoderma BMP blocks

In 2008, selected blocks were designated Ganoderma Better Management Practice (BMP) blocks in an attempt to determine the effects of efficient and timely roguing on disease rates. Data collected is summarised for Block 7213 in Milne Bay. Data for the other BMP blocks, Blocks 3707 and 9601 is not presented. Monthly surveys are conducted in BMP blocks and removals of all palms including suspect palms are carried out also on a monthly basis. Block 7214 was selected as a 'control' block as it is situated adjacent to Block 7213. Removals have not been satisfactory in some blocks and have lagged behind the surveys. The disease progress curve and corresponding removals per month for Block 7213 are shown in Fig. 30. As depicted, the removals in this block have been consistently lower than the infections over a 25 month period. Despite the discrepancy, removals are higher than other blocks within the same estate e.g. Block 7214.

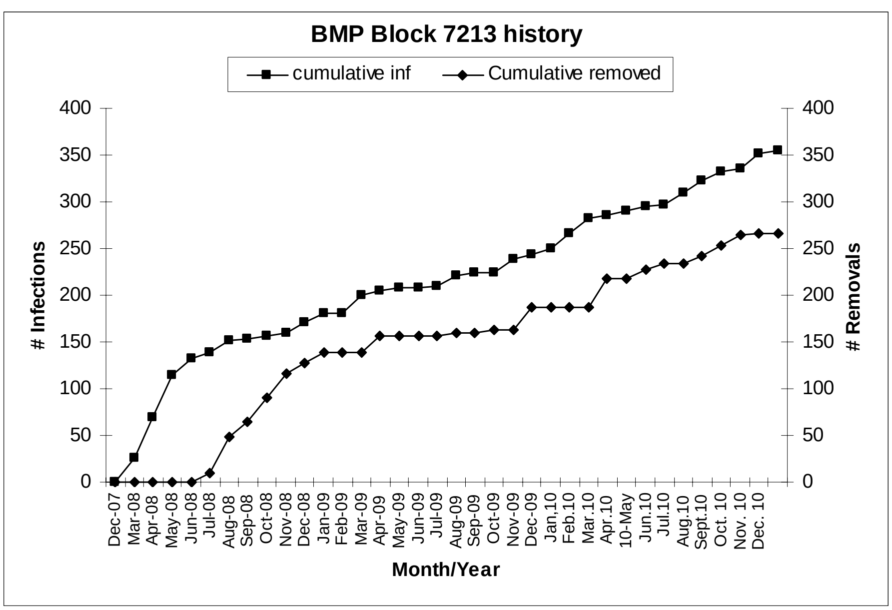

Figure 30. Frequency of infections and palm removals for each month from December 2007 to December 2010 in Block 7213 Giligili.

Annual data for monthly surveys over the 3-year period 2008-2010 are shown in Fig. 31. Aside from the high numbers recorded in early 2008 due to surveys being omitted in the month of February, there appears to be a pattern emerging. Infections appear to rise and dip every 3 to 4 months indicating that symptom expression is staggered and not correlated with periods of high or low rainfall (Fig. 32).

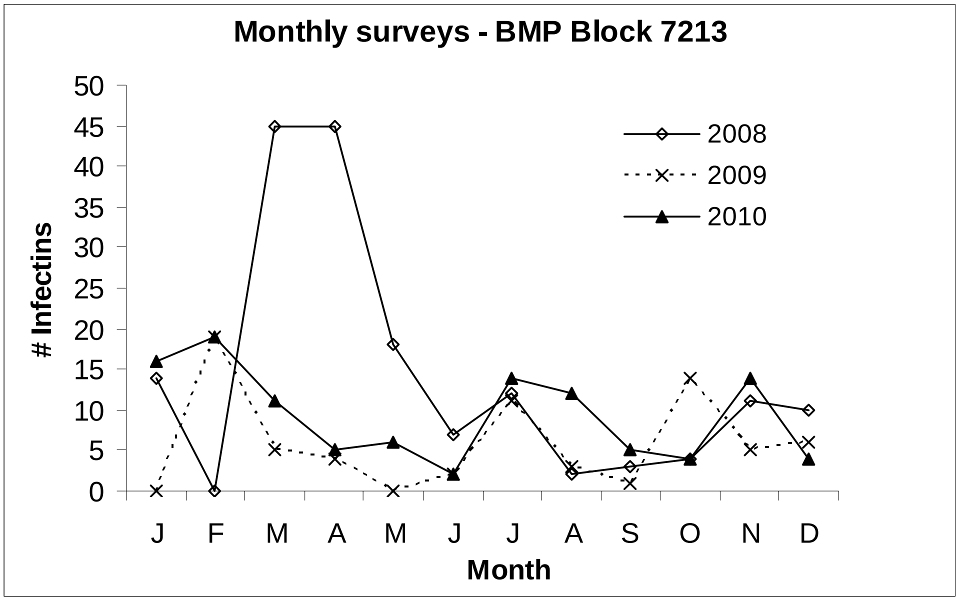

Figure 31. Frequency of infections (per month) in Block 7213 for the years 2008, 2009 and 2010.

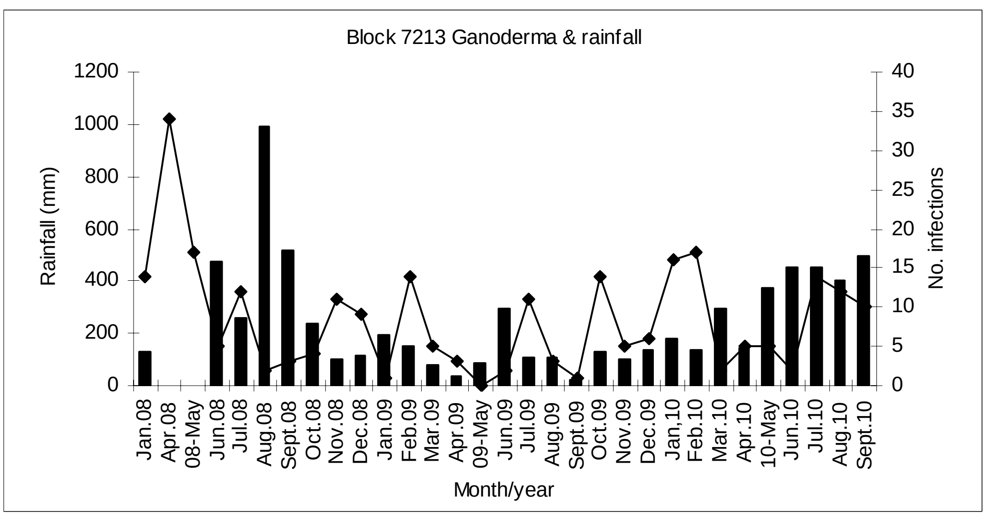

Figure 32. Frequency of Ganoderma infections in Block 7213 from January 2008 to September 2010 and corresponding monthly rainfall for Giligili.

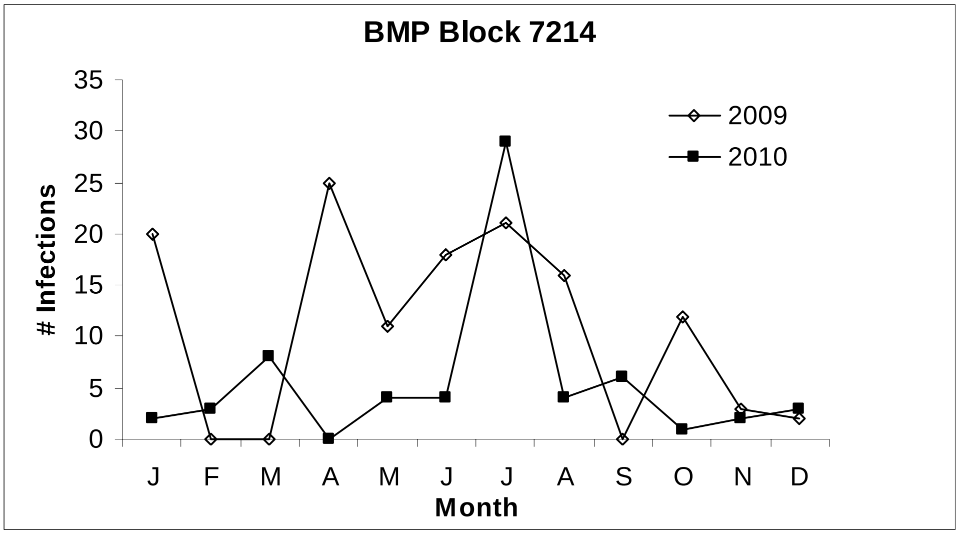

Figure 33. Infection frequencies (by month) for Block 7214 for the years 2009 and 2010.

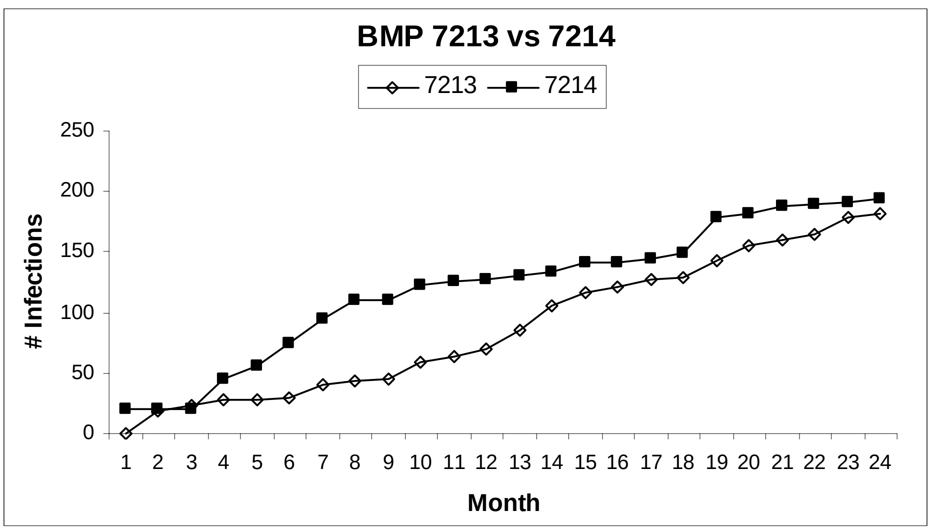

Figure 34. Disease progress curves for Blocks 7213 and 7214 for a 24 month period from January 2009 to December 2010.

Infection levels in the control Block 7214 also fluctuated over each 12 month period in 2009 and 2010 with peaks in March/April, July and September/October of each year (Fig. 33). Ganoderma palms removals were increased in this block in 2010. Prior to this, sanitation in Block 7214 was not efficient. This is clearly evident in the monthly disease progress shown for Blocks 7213 (BMP) and 7214 (non-BMP) in Fig. 34. In the first 12 months, disease progress was significantly faster in Block 7214 compared to Block 7213. However, at the beginning of 2010, (months 13 and 14) the gap in disease levels between the blocks is narrower, reflecting the increased efficiency in sanitation in Block 7214.

BIOLOGICAL CONTROL OF GANODERMA USING INDIGENOUS ISOLATES OF *TRICHODERMA* SPP. (Incorporating AIGS project N-0854) (RSPO 4.5, 8.1)

Introduction

The research in PNG continued in 2008 and in the same year, a research proposal was submitted for funding to the ARDSF Agricultural Innovations Grant Scheme (AIGS) to further this research. This project commenced in 2009. This report presents the research completed in 2010 under the AIGS Project. For most of 2010, funds were not released from the AIGS administrators and hence, much of the work focused on testing formulations with locally available materials. The remaining laboratory tests were also completed.

Results

In-vitro antagonism trials

Eleven *Trichoderma* isolates were challenged against each other on PDA plates by boring out 5 mm diameter discs of each isolate and placing them 1 cm away from each other in the centre of PDA plate (Table 3). All plates were placed in the incubator in the dark at 28^{o}C for 1 week. Linear growth of each isolate was measured and recorded after one week. All tests were carried out in duplicate. Results are presented in Table 4. Generally, there was little antagonism between the isolates although isolate BU was outgrown by the other test isolates BN, B and C. Isolate SP5A, W and BV were the fastest growing and out-competed most other isolates. Their performance in formulations will be tested.

Table 3. *Trichoderma* isolates subjected to vegetative compatibility testing.

Trichoderma isolates	SP5A	E	J	W	BV	40r	28b4	BU	BN	B	C
SP5A		√	√	√	√	√	√	√	√	√	√
E			√	√	√	√	√	√	√	√	√
J				√	√	√	√	√	√	√	√
W					√	√	√	√	√	√	√
BV						√	√	√	√	√	√
40r							√	√	√	√	√
28b4								√	√	√	√
BU									√	√	√
BN										√	√
B											√
C											

Table 4. Antagonism ratios for different *Trichoderma* isolates on PDA after 3 days of growth. Higher numbers indicate stronger antagonism.

Trichoderma isolates	SP5A	E	J	W	BV	40r	28b4	BU	BN	B	C
SP5A		1.0	1.0	1.0	1.2	1.3	1.2	1.2	1.0	1.0	1.0
E			1.1	1.0	1.1	1.1	1.1	1.1	1.0	0.8	1.0
J				1.0	1.0	1.3	1.0	1.0	0.7	0.9	0.9
W					1.2	1.5	1.1	1.1	1.0	0.9	1.0
BV						1.4	1.1	1.1	1.0	1.0	1.0
40r							1.2	1.0	0.7	0.7	0.8
28b4								1.0	0.9	0.8	0.8
BU									0..6	0.7	0.7
BN										0.9	0.8
B											1.1
C											

The results of the laboratory tests between Trichoderma isolates and Ganoderma isolates selected for initial testing are shown in Fig. 35. Antagonism against the four Ganoderma isolates on PDA was severe with the least antagonism being shown against Isolate # 1026 and the most severe against isolate # 1320. Generally, all Trichoderma isolates caused severe inhibition and eventual death of the Ganoderma isolates after 2 weeks (data not shown).

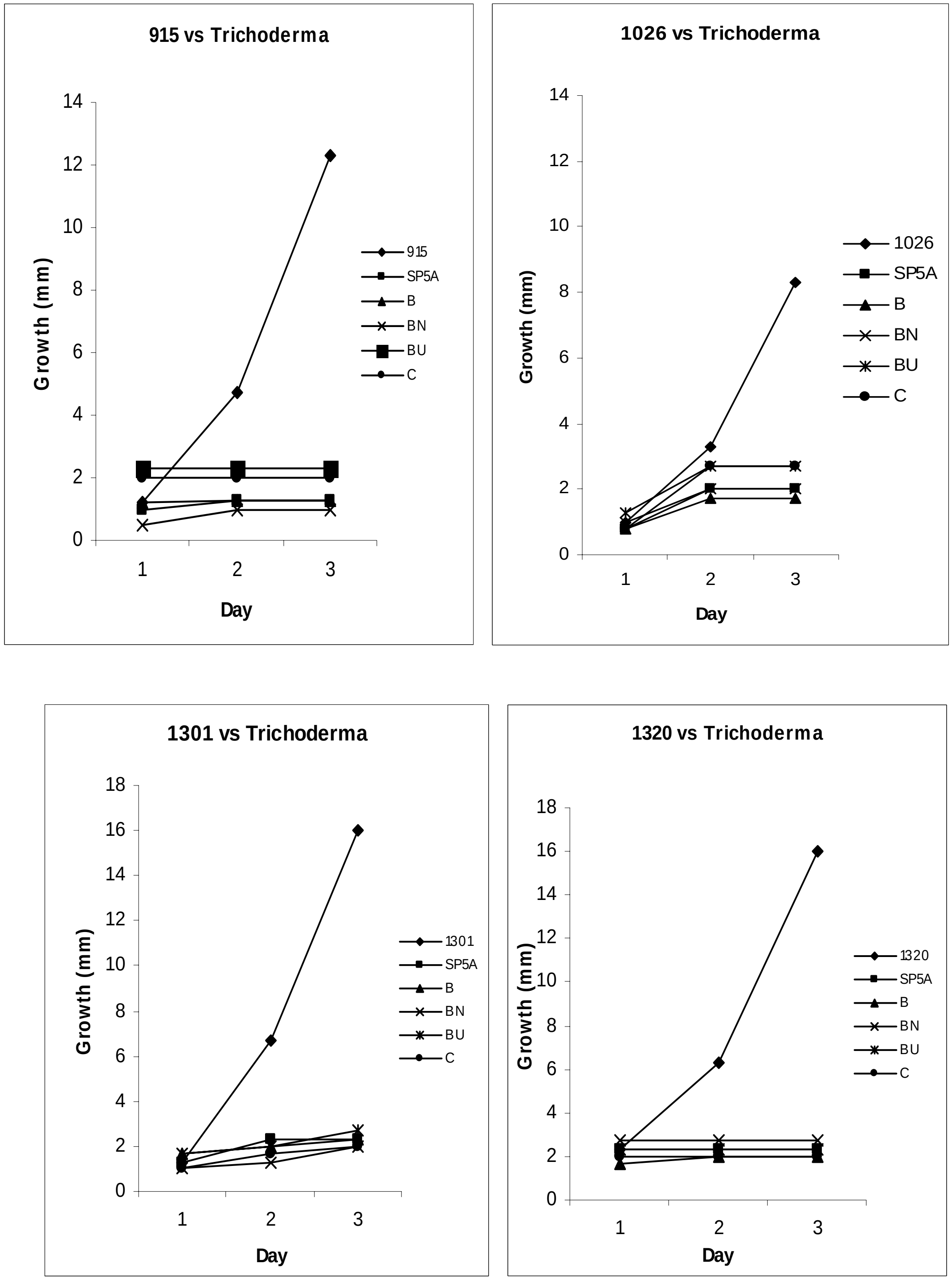

Figure 35. Growth of Ganoderma isolates 915, 1026, 1301 and 1320 on PDA in the presence of Trichoderma over a 3 day incubation period. Lines on the graphs corresponding to the isolate numbers are the controls.

Liquid culture trials- alternative source of N

Due to the high cost and difficulty of obtaining nitrates, alternatives sources of nitrogen for the liquid culture of Trichoderma were investigated. Readily available organic sources as well as inorganic N sources were tested *in vitro*. Results of these trials are shown below. The highest biomass yield was obtained using yeast extract and the least growth was obtained with urea as the N source (Table 5). In order to ascertain if the acidity or alkalinity of the solutions was a limiting factor in the use of these reagents, pH measurements were taken before and during culture. Glycine and urea had the highest pre- and post-culture pH and this had a detrimental effect on growth of *Trichoderma* (Table 6). In the presence of nitrates, the pH of the media was reduced and remained low throughout the period of incubation (Table 7). The total absence of nitrates caused poor mycelial growth and reduced spore production (Table 8).

Table 5. Average mass of *Trichoderma* spp. cultured in 100 ml basal media plus N additive after 5 days of shaking @ 120rpm and 28◦C.

N source	Mass (g) of *Trichoderma* spp /100 ml
Yeast Extract	0.928
Tryptone	0.5599
Peptone	0.4646
Glycine	0.2895
Urea	0.1944

Table 6. pH of pre- and post culture solutions with different sources of nitrogen added for the growth of Trichoderma isolates.

Trichoderma spp.	Nitrogen source	Pre-culture pH	Post-culture pH
B	Glycine	7.5	7.5
SP5A	Tryptone	7.5	7.5
C	Peptone	7.0	7.5
BU	Yeast extract	7.0	7.5
BN	Urea	7.5	8.0

Table 7. Changes in pH of media during and after liquid culture of *Trichoderma* in the presence and absence of nitrates.

pH	Nitrate added	Nitrate absent
Initial (pre-autoclaving)	5.5	7.5
Post -autoclaving	4.5	7.0
Post-culture	5.0	7.5

Table 8. Characteristics of the liquid culture of *Trichoderma* isolates over a 7 day period with and without the addition of nitrates.

	Day 1	Day 2	Day 3	Day 4	Day5	Day 7
+ Nitrate BN pH 5.0	Nil growth	Mycelia growing	Mycelia only, no spores	Mycelia and spores	Mycelia and spores	Mycelia and spores abundant
+ Nitrate BN pH 5.0	Nil growth	Mycelia growing	Mycelia only, no spores	Mycelia and spores	Mycelia and spores	Mycelia and spores abundant
+ Nitrate BN pH 5.0	Nil growth	Mycelia growing	Mycelia only, no spores	Mycelia and spores	Mycelia and spores	Mycelia and spores abundant
- Nitrate BN pH 7.5	Nil growth	Mycelia growing	Mycelia only, no spores	Mycelia only, solution is dark brown	Mycelia only, solution is dark brown	Mycelia yield lower than with nitrate
-Nitrate BN pH 7.5	Nil growth	Mycelia growing	Mycelia only, no spores	Mycelia only, solution is dark brown	Mycelia only, solution is dark brown	Mycelia only, yield less than with nitrate
-Nitrate BN pH 7.5	Nil growth	Mycelia growing	Mycelia only, no spores	Mycelia only, solution is dark brown	Mycelia only, solution is dark brown	Mycelia only, yield less dense than with nitrate

Field testing

Several sets of field spraying trials were done in 2010. Trials were concentrated on sanitized logs and the bracket/palm interface. Trials indicated that some effect might be observed on growth of Ganoderma brackets in situ however due to a lack of controls, results were inconclusive (Table 9).

Table 9. Field results after spraying of palms with different formulations of *Trichoderma.*

Test formulations	Total # of brackets that grew back	Total # of interfaces inoculated
A	6	30
B	2	18
C	3	22
D	0	13

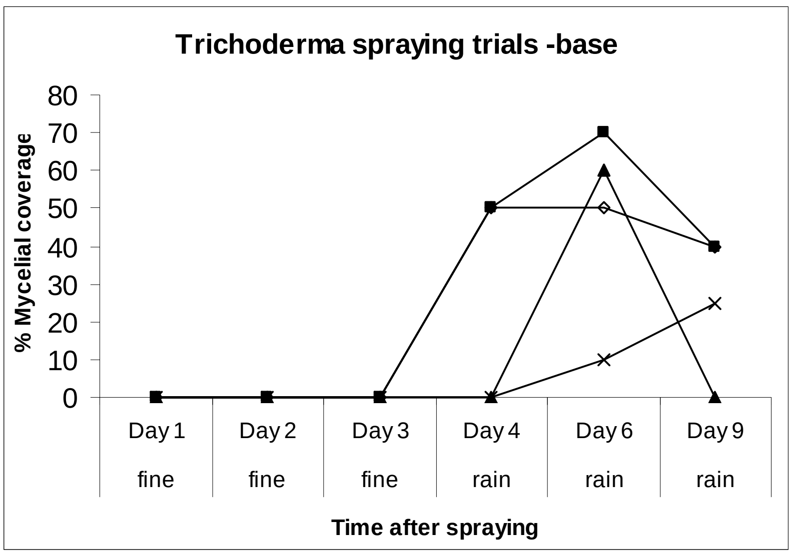

Figure 36. Growth of *Trichoderma* on sanitized bases under different weather conditions over a period of 9 days in 2010.

Numerous trials on sanitized bases and felled oil palm trunks in replanted areas were done in 2010 to test the effectiveness of different formulations of the fungus. Some results are presented in Figures 36 to 39. Growth of Trichoderma in most of the formulated products was directly affected by weather. Spraying could not be carried out during rainfall events and growth could not be established if rain fell within 2 days of spraying. This presents some challenges for formulation selection.

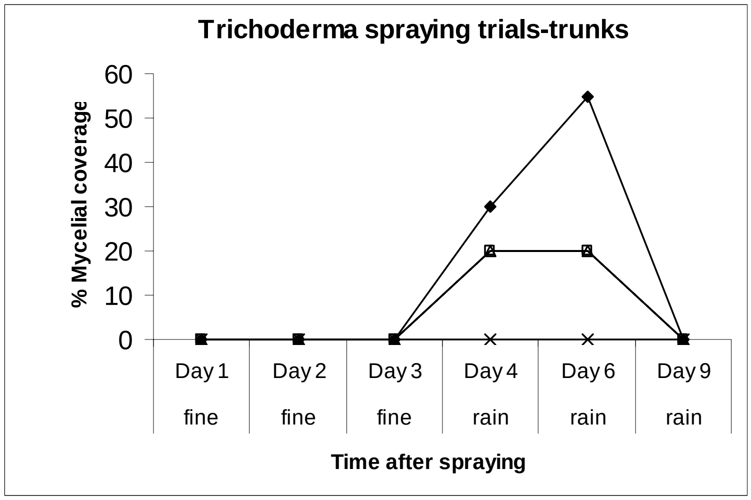

Figure 37. Growth of *Trichoderma* on oil palm trunks under different weather conditions over a 9 day period in 2010.

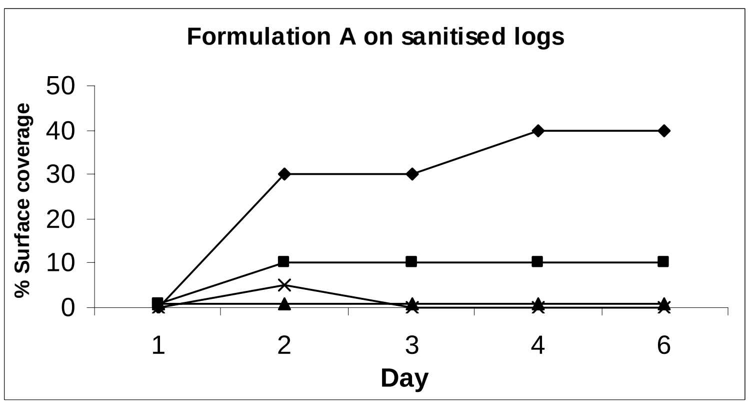

Figure 38. Growth of *Trichoderma* Formulation A after spraying sanitized logs over 6 days in 2010.

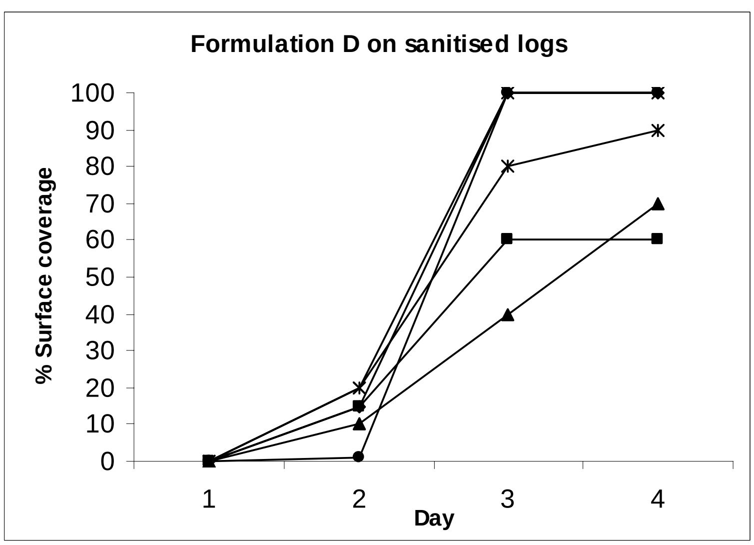

Figure 39. Growth of *Trichoderma* Formulation D after spraying onto sanitized logs over 6 days in 2010.

When sprayed onto sanitized bases, different formulations produced variable results (Figs. 38 and 39). However, good surface coverage was achieved with Formulation D over a four day period. Wet weather consistently hampered the successful establishment of the fungus and this will be a limiting factor in the application of *Trichoderma* as a biocontrol.

SCREENING FOR GANODERMA RESISTANCE (Incorporating ACIAR Ganoderma Project PC-2007/039) (RSPO 4.5, 8.1)

The control of basal stem rot caused by Ganoderma in Solomon Islands

Intoduction

Screening for Ganoderma resistance continued in 2010 with the establishment of a field trial at GPPOL in Solomon Islands. Laboratory and nursery assays also continued on seed provided by Dami OPRS. The results of some of this work are presented below. A local scientist was recruited and sent to PNG for training for 2 months from September to early November. Work on the laboratory was started in October and completed in December 2010 with only a few minor improvements remaining to be completed.

Results

Nursery assays

Three sets of nursery trials were established in 2010. All three trials tested selfs of Ganoderma infected palms as well as o x g hybrids. Preliminary results indicate that some progenies may be more susceptible to Ganoderma and these will be sampled and sent to UQ for genetic testing (Fig. 40). All trials are continuing.

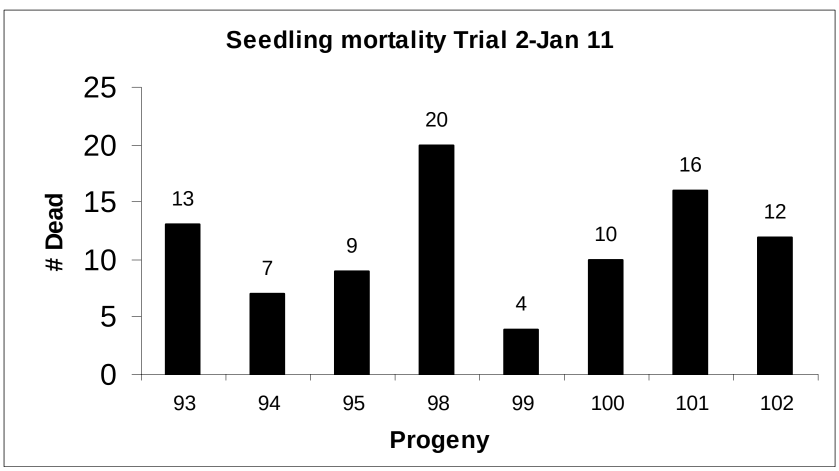

Figure 40. Seedling mortality 4 months after inoculation with Ganoderma on rubber wood blocks.

Field trials

Field trials were established at Ngalimbiu Plantation, GPPOL, Solomon Islands March and April 2010. Trial design is a randomized complete block design with 14 replicates (blocks) and a single progeny per block. Eighty one progenies provided by Dami OPRS are being tested. There are two identical trials laid out in adjacent blocks each with a different treatment at the time of felling. A layout of the trials is shown in Fig. 41. Data collection will commence in 2011.

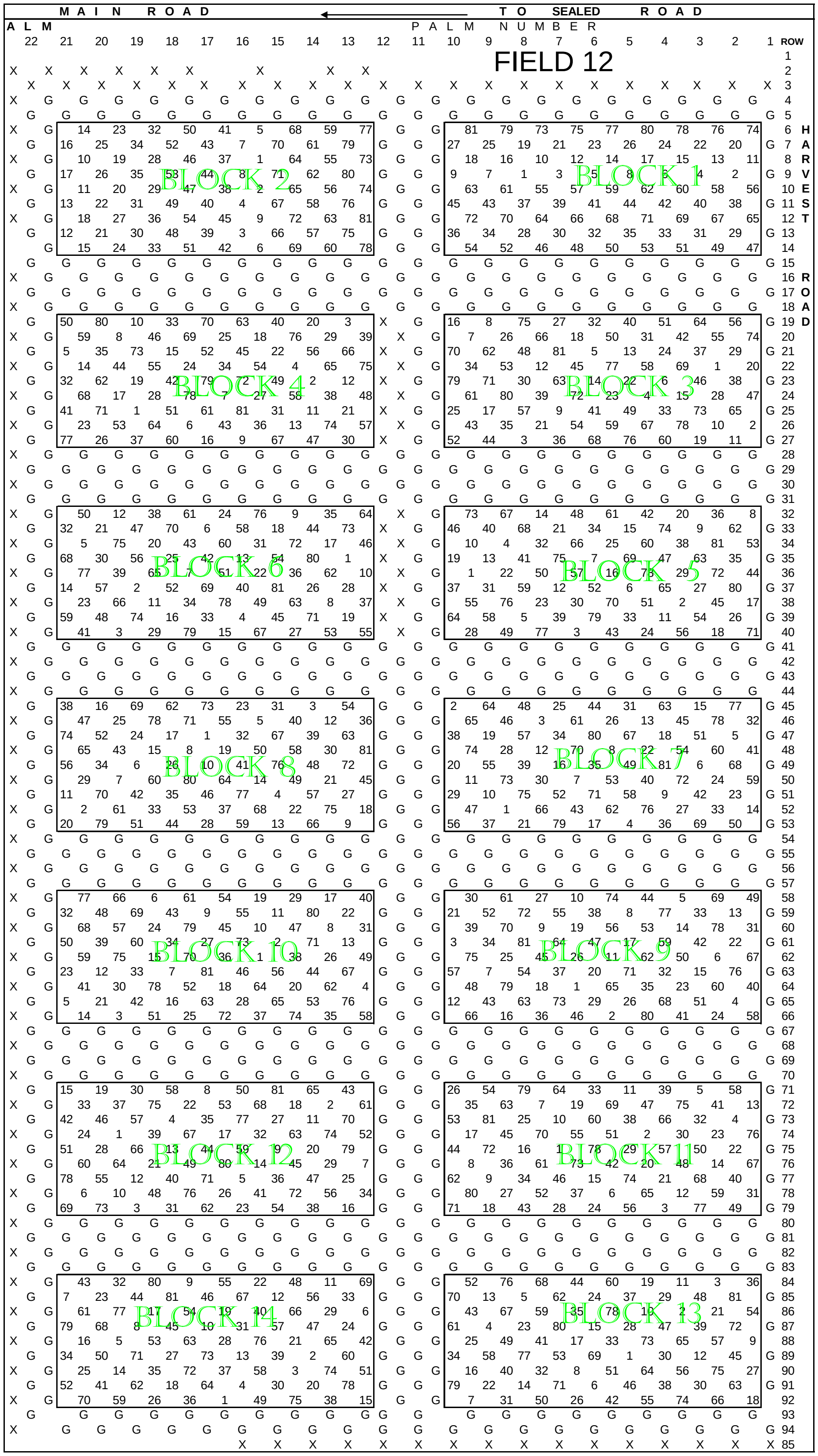

Figure 41. Layout of trial blocks in Fields 12 at Ngalimbiu Plantation, GPPOL, Solomon Islands.
Numbers represent progenies. G = guard row.

Genetic testing
In preliminary work, representative seedlings from each of 20 progenies were analysed by PCR analysis using microsattelite markers at the University of Queensland to assess the genetic diversity among parental lines and progenies from the various crosses used in a field trial in Solomon Is. The test samples used in this preliminary investigation are shown in Table 10.

Table 10. Parents and progenies subjected to preliminary genetic screening in 2010.

Parental code	Origin	Family code (progenies)
P1	Deli (female)	5
P2	Deli (female)	11
P3	Deli (female)	25
P4	Deli (female)	37
P5	Deli (female)	38
P6	Deli (female)	42
P7	Deli (female)	55
P8	Deli (female)	58
P9	Deli (female)	62
P10	Deli (female)	64
P11	Deli (female)	65
P12	Deli (female)	3A
P13	Deli (female)	8A
P14	Deli (female)	10A
P15	Deli (female)	12A
P16	Deli (female)	15A
P17	Avros (male)	16A
P18	Ghana (male)	17A
P19	Ghana (male)	18A
P20	Ghana (male)	19A

The results of the genetic testing revealed that parental lines could be separated and some diversity in the microsattelite alleles was present (Fig. 42). Further testing will be carried out in 2011.

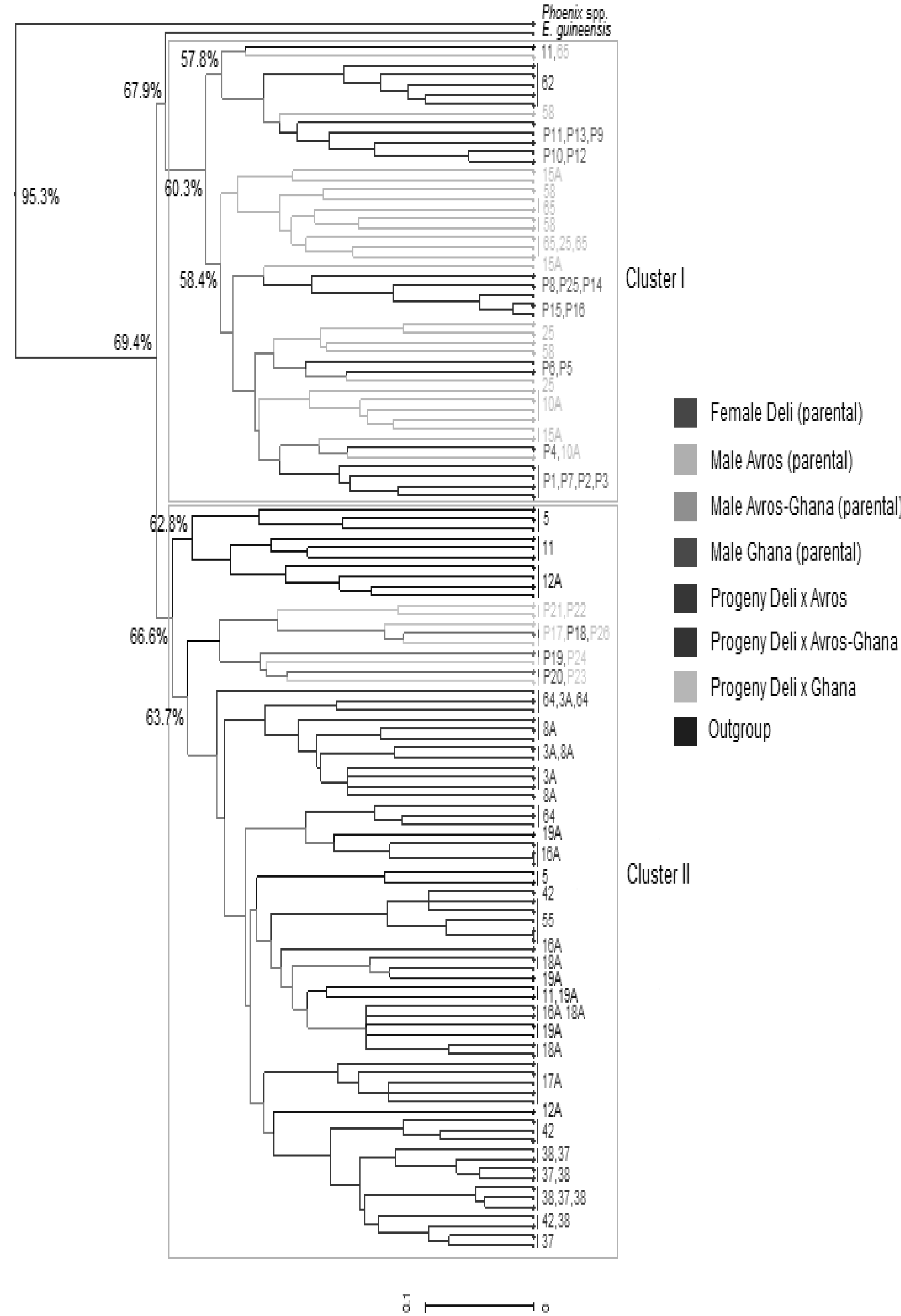

Figure 42. Dendrogram (UPGMA) showing the separation of parent and progenies being tested.

A PRELIMINARY COMPARISON OF THE MITOCHONDRIAL DNA OF GHANA AND PNG (EX-CAMEROON) WEEVILS (RSPO 8.1)

Introduction

A population of pollinating weevils was imported from Ghana by the Entomology Section as a means of increasing the genetic base of the PNG population. Interbreeding studies indicated that the populations were of the same species (despite small colour differences) and they could be released with confidence into the plantation. As a precautionary measure the mitochondrial DNA was assessed to see if there were any genetic differences between the populations. Mitochondrial DNA is maternally inherited and any differences in lineages can be seen immediately. Methods using PCR are the simplest and most rapid means of looking for differences. In this brief study, only the Cytochrome Oxidase (Cox) I gene was targeted to look for gross differences in the mitochondrial genome between the two populations.

Results

The Cox I mitochondrial gene was amplified from bulked and individual samples of weevils from Ghana, Milne Bay and Ramu. Bulked samples generated a product of the same size (approx. 650bp). Milne Bay (MB) bulks were both males and females while Ghana (G) and Ramu (R) bulks were all female weevils.

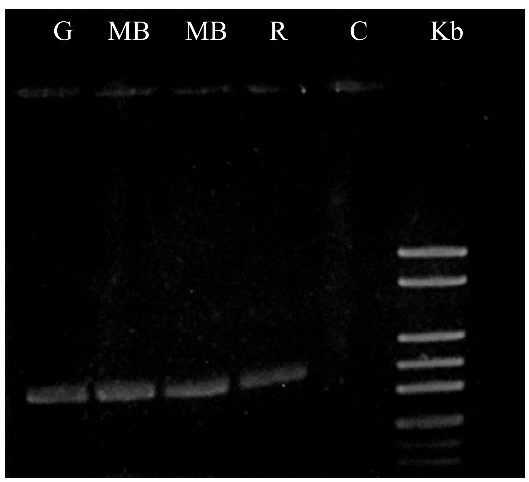

Figure 43. PCR products obtained from bulked samples of weevils from Ghana (G), Milne Bay (MB) and Ramu (R) showing uniformity of size. C = negative control.

Amplification of individual weevils was then carried out using the same primers. A total of 25 individuals from Milne Bay, Ghana and Ramu were tested. All products obtained are of the same size (Figs. 43 to 45). Amplification products were not tested for RFLPs.

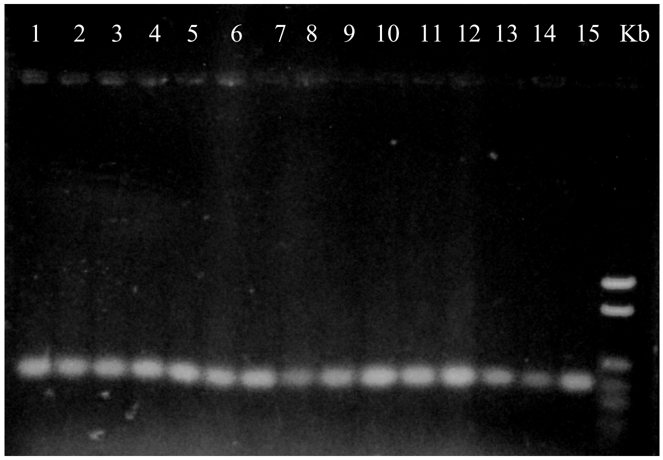

Figure 44. PCR amplification of the mitochondrial Cox I gene from individual weevils (male and female) from Ghana (Lanes 7-15) and Ramu (Lanes 1-6) showing uniformity of products.

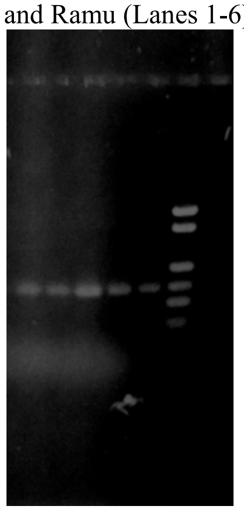

Figure 45. PCR amplification of the mitochondrial Cox I gene from individual female weevils from Ghana.

Conclusion

- The Cox I gene in both weevil populations (Ghana and PNG ex-Cameroon) is uniform. Only a single haplotype was found in a total of 25 individuals.
- The gene was not tested for RFLPs which would provide a more conclusive result.
- Other mitochondrial genes were not tested.
- This result, along with interbreeding trials done at Dami, indicates that the weevils imported from Ghana can be released without detriment to the local population.

QUARANTINE (RSPO 4.5, 8.1)

Nursery inspections

The quarantine nursery at Milne Bay was inspected on a regular basis in 2010 and no major problems were reported.

Bogia Coconut Syndrome

One meeting was held in May 2010 and this was attended by the HoPP. Input and advice was also provided for further sampling of palms in districts in Madang Province. Collected samples were processed and sent to NAQIA for analysis overseas.

PUBLICATIONS, CONFERENCES AND TRAVEL (RSPO 1.1, 4.8, 8.1)

Publications

The poster on exotic diseases was finalized and ready for printing.
No conferences were attended.

Travel

Travel was undertaken by the Head of Plant Pathology (HoPP) for normal plantation site visits and project work (Table 11).

Table 11. Travel undertaken by HoPP during 2010.

Month	Plantation/Visit
February/March	GPPOL, UQ
May	Port Moresby (BCS meeting)
June	GPPOL
August	Poliamba Ltd.
September/October	Higaturu Oil Palms Ltd.
October	NBPOL
November	GPPOL, UQ

OTHER ACTIVITIES

Project administration

General administration and reporting for the AIGS and ACIAR Projects was accomplished throughout the year.

LPC Meetings

Head of Plant Pathology attended four LPC meetings held throughout the year in Milne Bay and one at Poliamba.

DISEASE REPORTS (RSPO 4.5, 8.1)

A list of disease reports attended to in 2010 by staff in West New Britain and Milne Bay is shown in Table 12.

Table 12. Disease reports attended to in West New Britain, Milne Bay and Oro in 2010.

Month	Area	Block	Report
February	Nahavio-Patanga/Kilu	026-0021	Ganoderma
February	Kavui	006-1768	Ganoderma
March	Siki	009-2200	Ganoderma
April	Nahavio-Dagi	010-0071	Ganoderma
June	Nahavio-Gaongo	117	Ganoderma
June	Nahavio-Gaongo	251	Ganoderma
June	NBPOL Division 2	MU8B	Stem wet rot
June	MBE -Padipadi		Crown disease/wind damage
June	Hagita	New planting	Spear rot
July	Nahavio-Tamba	002-0518	Ganoderma
July	Nahavio-Tamba	002-0523	Ganoderma
July	Nahavio-Dagi	33	Ganoderma
July	Nahavio-Dagi	39	Ganoderma
July	Nahavio-Dagi	291	Ganoderma
August	Ewasse	VOP	Ganoderma
August	HOPL, Area 10		Ganoderma
August	Mamota		Ganoderma
October	Hagita	Nursery	Mole cricket & Curvularia

October	Mamba	92B and 92C	Ganoderma & insects
November	Waigani	AJ1140	Crown Disease

TRAINING (RSPO 1.1, 4.8, 8.1)
Training during the year is summarised in Table 13.

Table 13. Training and awareness sessions held throughout the year for OPIC and plantations.

Date	Training/awareness	Area
13-Apr-10	Field day	Buvussi
20-Apr-10	Field day	Galai 1
27-Apr-10	Field day	Galai 2
04-May-10	Field day	Kavui
11-May-10	Field day	Kapore
18-May-10	Field day	Gaungo/Mai
24-May-10	Ganoderma Training	Poliamba
08-Jun-10	Field day	Hoskins
15-Jun-10	Field day	Siki LSS
29-Jun-10	Field day	Rikau
06-Jul-10	Field day	Dagi
13-Jul-10	Field day	Morokea
20-Jul-10	Field day	Rerengi
27-Jul-10	Field day	Liapo
03-Aug-10	Field day	Umu
04-Aug-10	Field day (OPIC Bialla)	Lalopu/Bialla
August 2010	Ganoderma VOP training	Rabe, MBP
17-Aug-10	Field day	Silanga
17-Aug-10	Field day	Mamota
18-Aug-10	Field day (OPIC Bialla)	Soi
24-Aug-10	Field day	Sebal/Malele
31-Aug-10	Ganoderma training- VOP	Giligili
6 Sep-10- Sep-10	Provincial Vocational Education & Training Trade Show	
Sept. 10	Ganoderma VOP training	Naura/Baraga
07-Sep-10	Field Day	Lavege
14-Sep-10	Field Day	Balabolo
21-Sep-10	Field Day	Bubu
28-Sep-10	Ganoderma for OPIC-BIALLA Field Staff	Bialla
05-Oct-10	Field day	Masakili
12-Oct-10	Field day	Masakili
27-Oct-10	Ganoderma for OPIC -HOSKINS Field Staff	Hoskins
4-Nov-10	Ganoderma training - VOP	Ata'ata
17-Nov-10	ACIAR CEO's Visited-PNGOPRA Dami-Review Projects Closed trials,Sustainablity Project & Food Security project-Field trip Sarakolok Smallholder block	Sarakolok/Dami

4. SOCIO-ECONOMICS RESEARCH

HEAD OF SECTION: JESSE ANJEN

SMALLHOLDER ENGAGEMENT STRATEGY (RSPO 4.8, 6.2, 8.1)

In 2010, PNGOPRA initiated discussions on assessing the effectiveness of smallholder extension services in the Hoskins project. As part of the overall strategy, a student project was supported by Curtin University of Technology, Australia in partnership with PNGOPRA. The fieldwork for this study was undertaken midyear 2010 and supported by the socioeconomics section. Field day surveys were designed to get feedback about the information posters and presentations in the field and develop new ideas and concepts for improving information services to the growers. At the same time, PNGOPRA has applied for a detailed research project, within the support framework of the Smallholder Agricultural Development Project (SADP), to determine the most effective and appropriate extension methodologies to apply in SADP project areas. The project would be carried out in two phases: 1) a research phase to document the educational levels and strategies of the smallholder oil palm population in Bialla, Hoskins and Popondetta; and 2) the production of a smallholder engagement strategy for OPIC. The field day surveys will be continued in 2011 and, if funding from SADP becomes available, a detailed program would be undertaken to document the key characteristics and catalytic agents for changes in the delivery of extension to oil palm growers.

MOBILE CARD SCHEME – BIALLA (RSPO 6.1, 6.2, 6.5, 6.10, 6.11, 8.1)

Several visits were undertaken in 2010 after a review in late 2009 on the progress of the Mobile Card following concerns that the number of Mobile Cards in use in Bialla had declined. Some of the key action points from the review were acted upon in close collaboration with Hargy Oil Palm Ltd. (HOPL) and OPIC. These included:

- Stamped dockets for pickups of FFB harvested and weighed on the Mobile Card, to ensure FFB is not mistakenly weighed on the Papa Card. Drivers were thus advised to weigh FFB from a Mobile Card on a separately stamped docket.
- For blocks employing hired labour or using sons as Mobile Card workers, ensure that the Papa and Mobile Card dockets are processed separately with the percentage split calculation applied to only that FFB weighed on the Mobile Card docket.
- For Caretaker blocks, the percentage split should continue to be calculated on the total production of the block.
- Introduce automatic renewal of Mobile Card contracts on expiry. Rollover of contracts should be indefinite until OPIC and HOPL are advised by the leaseholder to terminate the contract.
- Implement a Mobile Card awareness program, initially at the LSS subdivisions. It is recommended that the two previously employed Mobile Card Officers run workshops with OPIC extension officers to explain how the Mobile Card works before awareness among growers begins. This was endorsed by the Local Planning committee of the Project.
- Alongside the Mobile Card awareness program, specific groups of farmers should be targeted to take up the Mobile Card. These include low producing blocks with caretakers, deceased estates where there is conflict amongst brothers, and blocks with elderly/widowed growers. This program is now being centred on the Wilelo subdivision but interest has been expressed by the other divisions.

Two specific visits to follow up on the progress on the Mobile Card were done during the year. A radio program on the Mobile Card was also aired on the National Broadcasting Corporation in Kimbe as part of the awareness program for the growers. The number of Mobile Card owners has increased from 56 to 86 with new applications still being received. A training awareness was also conducted at Baubata for the OPIC divisional managers and extension officers of the Bialla Project. The aim of the training was to explain how the Mobile Card works including payments, percentage splits, contract renewals, etc. During the grower awareness visits we also visited some block owners now using the Mobile Card. Some blocks with labour supply problems stemming from under-payment of family labour have begun using the Mobile Card. For instance, in Section 5, Wilelo, in one of the blocks, the mama card goes to the daughter and the Mobile Card goes to the son, and the papa card goes to the father. In a nearby block, 20% from the Mobile Card goes to the daughter of the owner of the block and her husband, 80% of the Mobile Card payment is added to the Papa Card payment and is paid to the father, and income from the Mama Card is paid to the mama. Because these different family members are now receiving what they consider to be fair payment for their labour, they are now more willing to contribute labour to oil palm harvesting, thereby improving block productivity.

A new way of using the Mobile card has been developed by growers themselves, which they are calling the "Papa Levy". By using the Mobile Card, the elderly leaseholder relinquishes control of the block to his sons but is guaranteed a fixed proportion of the income from the block through the Mobile Card. Growers using this system have adopted a percentage split of 20% to the father and 80% to the sons. There is a great deal of interest in this initiative and information needs to be made available to new growers keen to participate in the scheme. One grower, a former village court magistrate from Section 5 Wilelo, is leading efforts to promote the "Papa Levy" concept. He is now using the Mobile Card on his two blocks. On the first block, the Papa Card goes to his wife and the Mobile Card (20%) goes to him and the *lus frut* goes to his son's wife. Since his two sons are married, the Papa Card from the second block goes to them on a rotation basis (*makim mun*). The father gets 20% of the crop paid to his Mobile Card and the *lus frut* goes to his daughter in-law, his second son's wife. He has also promoted and explained the concept to other growers by sharing his experiences with them. By using the Mobile Card on his block, the responsibility for the management of the two blocks has been handed over to his two sons. He spends time doing other things and through using the Mobile Card he receives 20% of the value of the crop from each of the two blocks. There are no disputes over labour and income distribution and all the family are willing to contribute labour to oil palm production.

The Papa Levy concept has the capacity to address a common problem affecting labour productivity on the LSS – the reluctance of elderly growers to hand over block management to their sons because of their fear that their sons will not share oil palm income with them when they take over management. However, when elderly leaseholders hang on to control of the block and control income distribution, the sons (who are often married with their own families), are reluctant to contribute labour because they feel they are inadequately paid for their work. Productivity can therefore be low despite a large potential labour force residing on the block. The "Papa Levy" version of the Mobile Card, therefore facilitates the generational transfer in block management while protecting the financial interests of the elderly leaseholder. The sons, now guaranteed fair payment for their labour are more willing to contribute labour to oil palm production.

CUSTOMARY LAND USE AGREEMENT (CLUA) (RSPO 1.1, 2.1, 2.2, 2.3, 5.1, 6.1, 6.2, 6.4, 7.5, 8.1)

In 2010 discussions continued on the newly proposed CLUA template designed by OPRA with key stakeholders, including customary landowners and migrants involved in land dealings. As outlined in last year's annual report, current procedures for dealing with new oil palm plantings on Customary Rights Purchase (CRP) blocks and existing Clan Land Usage Agreements (CLUA) used by OPIC do not provide adequate land tenure security for the outsider 'purchasing' or leasing land; nor do they ensure that all members of the landowning clan agree to, or benefit from, these land transactions. Furthermore, the existing CLUA is not RSPO compliant. Therefore, there is a need to review current practices relating to the establishment of CRPs. The design of a new CLUA template is part of a collaborative ACIAR research project with Curtin University which started in 2008. In March 2010 a workshop was held in Popondetta with OPIC managers and extension officers to receive feedback on the proposed CLUA template, and in August discussions were held in Port Moresby with Felix Bakani (OPIC Secretary) and with Mike Scott (SADP). OPIC and SADP would like to see the new CLUA used on SADP infill blocks. Importantly, the proposed CLUA template is compliant with RSPO requirements relating to land use rights (in particular proof of land ownership and defined legal boundaries of land), and central to the new CLUA template is the concept of Free, Prior and Informed Consent (FPIC) amongst all parties to the transaction in accordance with RSPO principles. This means that each party (customary landowning group and the person seeking to acquire a specified parcel of land parcel) must be fully informed about all aspects of the transaction prior to making a decision as to whether or not to proceed with the land transaction.

Visits to landowning groups 'selling' land to outsiders continued in 2010. The visits revealed the ongoing inadequacies of the current procedures in place to deal with newly acquired CRP blocks. One such village visited has an Incorporated Land Group (ILG), which was established several years ago for logging activities on their land. An outsider, more literate than the local villagers in this area, assisted with the establishment of the ILG. Since he helped the villagers in this way, he was given land to settle and then became the spokesman for the ILG. When the logging operations ended, the ILG shifted its focus to selling land to outsiders to grow oil palm. All outsiders and local landowners wishing to plant oil palm in the area were to seek the approval of the ILG before being forwarded to OPIC. The idea was that the ILG would collect land rentals on behalf of the landowners. Several dubious standards evolved during this time. Buyers paid money to the ILG and part payment was also made to landowners as an incentive to please them. The arrangement was for buyers to pay an initial amount of K200 to settle and develop the land under oil palm and later make instalment payments when the palms come into production. These arrangements were agreed to during discussions and meetings between the ILG and the 'buyer'. In most cases an OPIC Purchase Agreement Form Contract was signed and all monies were to be paid through the ILG. However, many buyers who initially paid the K200 deposit have defaulted in instalment payments. Many customary landowners felt that they did not have sufficient control over that ILG land fees and instalment payments, and there were allegations that the ILG spokesman, who was not a real landowner, was stealing money from the ILG. Due to these allegations, some customary landowners reverted to the old system of selling land individually and not collectively. In some cases individual clan members were selling land without the consent of the clan, especially young people seeking money. In the process, traditional and sacred sites were not protected.

A typical example of some of the problems emerging on the CRP blocks in the village is when an outsider buys a 4 ha block, and completes a "Purchase Agreement Form contract" with landowners and OPIC lands officer. The buyer initially plants 2 ha, which is standard policy, with the intention of planting the remaining 2 ha at a later stage. However, it is not uncommon for the landowner to sell the remaining 2 ha to another person. There may be several reasons for this: (i) there is a misunderstanding/ excuse/confusion by the landowners of the area of land 'sold'. When the initial 2 ha is planted, the landowner believes that the full area sold was planted. The landowner then sells the remaining (unplanted) 2 ha to another interested buyer. (ii) when the block is purchased, the vendor and buyer sign a "Contract of Purchase Agreement" form. In this form, the full payment price and the initial deposit paid are noted and both parties agree on the duration of time to complete the outstanding payment. As mentioned above, the terms of the agreement are often breached mostly due to the landowner being illiterate/semi-literate and the buyer taking advantage to delay instalment payments. When instalments are delayed, the dissatisfied vendor resells the remaining 2 ha (unplanted) to a third party. Thus there is a double breach of contract by both parties. (iii) dishonesty and the lure of money is a common problem with land dealings. This sometimes leads to landowners being lured with large amounts of money from another interested buyer wishing to purchase the unplanted area. This problem is also found on 4 ha CRP blocks in other VOP divisions in the Hoskins project where the first phase of 2 ha has been planted to oil palm and the second phase delayed until the first phase is in production. Many customary landowners believe that if land sold to outsiders is not planted to oil palm within a couple of years, the transaction is invalidated and they have the right to resell the land to another "outsider" without compensating the original "purchaser". Since cash transactions are handled outside of any organized payment mechanism, there are no records of the payments made. If the payment mechanism is properly handled by OPIC and the company as proposed in the new CLUA, it would reduce conflicts between outsiders and landowners.

The above example, illustrates that current practices relating to the establishment of CRPs need to be improved including: (i) Land boundaries to be clearly defined and surveyed with a GPS (and marked with Cordyline '*tanget*' or coconut/betel nut palms). The coordinates of the land boundaries should form part of the CLUA. (ii) Both parties should learn to honour the terms of the agreement, and payment arrangements should be transparent and accountable. Ideally, instalment payments should be paid directly into an account of the landowning group, so that there is a permanent record of payments. (iii) A more detailed description of the rights and obligations of the clan leaders disposing of the land, other clan members and the 'buyer' (lessee) should be included in the CLUA. For example, the rights of the 'outsider' to plant other cash crops and food crops, and to establish businesses, houses and other assets should be specified. The transfer rights of the lessee should also be made clear, as should the rights of the clan leaders to repossess the land due to breaches of the terms of the CLUA. OPIC could act as referee in such disputes. Similarly, all covenants on the land should be specified in the CLUA, such as restrictions on the transfer or sub-leasing of all or part of the block to another person during the period of the CLUA, or any restrictions on the disposal of the payments by clan leaders. The newly proposed CLUA template designed by OPRA will provide greater land tenure security for the outsider "purchasing" or leasing land and aims to ensure that all members of the landowning clan agree to and benefit from land "sales"/leases to 'outsiders'.

Based on the work investigating land tenure issues in Papua New Guinea and especially for oil palm, three OPRAtive Word Articles have been published:

Types of Land Tenure Governing Smallholder Oil Palm in Papua New Guinea. OPRAtive Word, Technical Note 18, August 2010

Land Tenure Conflicts on Oil Palm Land Settlement Scheme Blocks in Papua New Guinea. OPRAtive Word, Technical Note 19, August 2010

Towards Sustainable Land Use Agreements for Smallholder Oil Palm on Customary Land. OPRAtive Word, Technical Note 20, August 2010

HOUSEHOLD SOCIOECONOMIC AND DEMOGRAPHIC SURVEYS (RSPO 6.1, 6.2, 8.1)
The household socio-economic and demographic surveys among LSS smallholder households started in the last quarter of 2009, continued in 2010. At Hoskins, Bialla and Popondetta, 100 LSS blocks were randomly selected for the survey. All households surveys for the Higaturu project have been completed and coding and data almost done. At Bialla the household surveys are nearly finished and data entry is almost complete. The Hoskins household socio-economic and demographic surveys will be completed by June 2011. The household survey data update the 2000 household survey data conducted at Hoskins, Bialla and Popondetta and will enable OPRA to assess changes in population, agronomic practices and

socio-economic conditions on the block over time. The household socio-economic and demographic surveys collect information on the following:

- Oil palm planting details (year of planting and area planted).
- Ownership status.
- Land disputes on the block.
- Demographic data (age, ethnicity, total population, total number of households, temporary visitors.
- Livelihoods. Range of non-oil palm income sources pursued by households on the block.
- Labour supply and agronomic practices.

In the 2010 household survey additional questions were included on food security. For example, where the main food gardens were located, dominant garden food crops, commercial sales of garden food crops and access to garden land.

In 2011 the first household socio-economic surveys will conducted on the CRP blocks at Hoskins.

SMALLHOLDER FOOD SECURITY PROJECT (4.2, 4.8, 5.1, 6.1, 8.1)
In 2010, the socioeconomics section, in collaboration with the agronomy section, jointly applied for and succeeded in securing a smallholder project titled "Improving food security and marketing opportunities for women in smallholder cash crop production". It is a 2 year project with funding from the Agricultural Innovation Grant Scheme (AIGS), an initiative of the Australian Government through the Agricultural Research and Development Support Facility (ARDSF).

Food and income security among oil palm smallholders in Papua New Guinea is central to the long term sustainability of the oil palm sub-sector. A diverse range of livelihood options are pursued by smallholder farmers with the principal intent to ensure household economic and social security. To think of oil palm as being the only and dominant economic activity of smallholders is misleading because other important livelihood strategies are obscured such as food gardening for household consumption and marketing. Rising population pressures and recently high oil palm prices have encouraged smallholders to fully plant their 6 ha block to oil palm. This practice has displaced food gardens to environmentally sensitive lands such as buffer zones, riparian habitats or on to adjoining land belonging to neighbouring customary landowning groups, state land and company land. In the context of rising population and land shortages on land settlement schemes, there is a need to develop sustainable production and farming systems to overcome these problems. One option is to look at innovative ways of utilising the limited land, (blocks are typically 6-6.5 hectares) by intercropping oil palm with food crops. This project would develop spacing trials for oil palm to enable intercropping with food crops without necessarily penalising yield losses, hence improving production and productivity of both oil palm and food crops.

The project aims to improve food security and marketing opportunities among oil palm smallholders residing on the Land Settlement Schemes (LSS) in Papua New Guinea by: (i) investigating the optimal planting arrangements for oil palm to facilitate intercropping of food crops and fuel wood species for home consumption and sale at local markets while sustaining oil palm incomes (ii) develop policies to enhance food production on the land settlement schemes. The project will at the same time monitor changes in quantities produced and amounts sold and consumed when gardens are brought back on to the block. Spacing trials would help to ameliorate the land pressure for making gardens on marginal and environmentally sensitive areas like the buffer zones. At the same time it would greatly improve women's access to land for food production, thereby contributing to food security and enhancing income opportunities. Whilst the spacing and intercropping trial may not be the panacea, it is one way to responding to the challenge arising from the declining access to land for food gardening, marketing and income generation.

PNGOPRA, and OPIC as project partners, will lead outreach efforts to show the successful outcomes of innovation by demonstrating and raising the awareness of oil palm smallholders, and grower organisations on the biophysical and socioeconomic benefits that accrue from this innovation.

The project although approved in 2010, was delayed due to the documentation process. Funding has now being made available in the first quarter of 2011. However, the agronomy staff have proceeded with identifying smallholder blocks in Popondetta, Bialla and Hoskins. So far, 2 blocks have been identified in Popondetta and one at Bialla respectively. Additional 1-2 trials blocks will be identified for the trial establishment and work will begin in 2011.

FIELD DAYS AND RADIO PROGRAMS (RSPO 1.1, 4.8, 8.1)
The socioeconomics section attended a number of field days in Popondetta and Hoskins. We were not able to attend field days in Bialla due transportation difficulties. The section is only able to attend field days where other OPRA staff are present. Two radio programs were aired during the year. Radio programs are scheduled by OPIC in the Bialla, Hoskins and Higaturu Projects respectively.

TRAINING, WORKSHOPAND STUDENT ATTACHMENT (RSPO 1.1, 4.8, 8.1)
Short-term external training is attended by staff from the section when available. In particular, a workshop was organized by the Agricultural Research and Development Support Facility (ARDSF) on Gender and HIV/AIDS Mainstreaming in Port Moresby. This workshop looked at how we can mainstream gender and HIV/AIDS issues into our work place as well in our programs, projects and activities with key stakeholders and partners. The section also hosted two Papua New Guinean students undertaking postgraduate studies in Australia. A Doctor of Philosophy (PhD) and a Master by Research student from Curtain University of Technology were provided research assistance and logistical support by the section over a 3 months period. The PhD candidate did her fieldwork in Bialla and Hoskins looking at the food security issues on the LSS blocks while the MSc student was based in the Hoskins project examining the effectiveness of extension services provided by OPIC to the growers in the Village Oil Palm and Land Settlement Scheme in the Hoskins Project. As part of our household socioeconomics survey in Popondetta, we also conducted half day training for OPIC officers on basic approaches to conducting surveys and doing field interviews. Two casual staff were also engaged, trained and assisted with conducting surveys.

INDUSTRY SUPPORT AND STAKEHOLDER LIAISON (RSPO 1.1, 4.8, 8.1)
Ad hoc information and statistics requests are processed for OPRA staff and other stakeholders from time to time. An AusAID review team also visited the Hoskins Project looking in to programs and projects funded by them including the Australian Centre for International Agricultural Research (ACIAR) and looking at the success of previously funded projects, their outcomes and adoption by the industry including looking at the success of the Lus Fruit Mama Scheme. Other external consultants and researchers are also assisted from time to time based on consultation with the Head of Research.

SPECIFIC STUDIES REQUESTED
Two specific studies were undertaken during 2010, at the request of stakeholders, to help understand smallholder constraints under particular conditions. These two studies were presented as reports and are reproduced below:

First Study: ***Assessment of interest and perception of villagers to take up oil palm as alternative cash crop: Ramu Field Trip Report by*** *Jesse Anjen and George Curry, 8 June 2010* **(RSPO 1.1, 2.3, 6.1, 6.2, 7.1, 7.5, 8.1)**

Introduction

This report documents the fieldtrip to Ramu Oil Palm from 8 to 11 March by Jesse Anjen and George Curry from the PNGOPRA Socio-economics Section. The trip followed an invitation from Mr Joe Castle with the purpose of answering two questions:

1. What do smallholder farmers who have recently planted oil palm think of this new crop?
2. Why are some smallholder farmers reluctant to plant oil palm as a cash crop?

Oil palm was introduced to the Ramu Valley by Ramu Sugar in 2001 in an experimental trial and commercial plantings began in 2003. Since NBPOL took over in 2008, expansion of oil palm plantation estates has been rapid with around 9000 ha in total now planted. There has been considerable opportunity for farmers in the areas serviced by Ramu Agri-Industries to take up oil palm under the Village Oil Palm scheme, but surprisingly, the uptake rate has been slow with only 130 growers by March 2010 and a total area of 260 ha under VOP. Oil palm is a new crop for farmers and very few farmers have previously worked in oil palm or visited an oil palm growing region. Generally, their knowledge of oil palm is limited to their observations of plantation production and interactions with the small number of farmers who have taken up oil palm.

Several meetings were organised with key players from the company, local customary landowners and farmers from several village communities (Appendix 1 provides a list of meetings). The landowner/farmer group included oil palm growers and farmers who were undecided or reluctant to plant oil palm. These meetings included interviews of individual farmers and focus group discussions with farmers from several village communities, and discussions with staff of the company. These meetings were the primary source of information for this report.

The following topics/questions were used as a guideline during meetings with farmers:

- Types of income sources pursued by farmers before taking up oil palm.
- How these other sources of income compared with oil palm (e.g. amount and frequency of income, labour inputs and costs of production).
- Advantages and disadvantages of oil palm relative to other cash crops.
- How farmers learned about or obtained information about oil palm production.
- Who in the family does the work in oil palm? Does everyone in the family help?
- The reasons why some farmers are reluctant to plant oil palm.
- Are more farmers likely to take up oil palm in the future?

Levels of Interest in Oil Palm Cultivation

Generally speaking, farmers who had planted oil palm were pleased with their decision. Some farmers had been harvesting crop for seven months and were earning what they considered to be a reasonable income. Although most growers were satisfied with the rate of return from oil palm production, concerns were expressed over two matters: poor road access to some blocks; and, the high rate of loan repayment for their 2 ha block development loans. The team visited some of the blocks where harvesting was occurring. Road access was poor. Several blocks had no road access and FFB was being carted by wheelbarrow for around 200 m from the block to the feeder road. Several service roads are probably impassable in very wet conditions, meaning that FFB pickup schedules may sometimes not be able to be met. At present, FFB is being brought out in utility vehicles which will not be sufficient for the task when these blocks come into full production.

Block development loans for K10,000 from the Regional Development Bank (RDB) are charged a 10% interest rate and are repaid at a rate of 50% of gross income. Despite the high rate of repayment, the majority of growers were satisfied with their income from oil palm which they all realised would increase through time as their palms come into full production. While there was a relatively high level of satisfaction amongst growers who had taken up oil palm, a 'wait and see' attitude was common amongst potential oil palm growers in most areas visited, and some farmers were reluctant to plant oil palm in the Brubri, Issitin and Wagasantan areas. The reasons for these attitudes are explained in the next section of the report. However, it is worth noting that farmers in some areas were keen to plant oil palm. These areas included villages like Faria, Onge and Dumpu village near Dumpu Estate, some villages around Impu and Wagasantan, and villages further away from company operations such as Kesawai, Sausi, Walium and Usino. Unfortunately, these latter groups of villages (Kesawai, Sausi, Walium and Usino) are beyond the boundary that the company wishes to support smallholder oil palm development (transport costs at present too high). Farmers interested in planting oil palm in these areas will have to wait until the company has established plantations nearby and the associated transport infrastructure.

Most oil palm growers previously relied on peanuts as their main cash crop. Growers have been reported to plant up to 1 ha of peanut per year with yields ranging from 0.9 to 2.0 t/ha of pod peanuts (Bourke 2009, 155). However farmers reported to us a smaller area of cultivation with the typical grower cultivating peanuts in 100 m X 20 m plots (0.2 ha), with two to three plots planted each year (0.6 ha in total per year). Peanuts are sold in 50 kg bags to highlanders who transport them to the markets of Lae, Madang and the Highlands for sale. If farmers produce a crop in the dry season from May to November, they could expect to receive a price of between K50-K120 for a 50 kg bag of peanuts (average K1.70/kg). In the wet season from December to May they expect a lower price of between K20-K25 per 50 kg bag (average K0.45/kg). If farmers achieve yields of 2 t/ha and produce two crops in the dry season and one in the wet, their annual revenue would be as follows:

Dry season: 400 kg X K1.70 = K680 X 2 =	K1,360
Wet season: 400 kg X K0.45 = K180 =	K180
TOTAL REVENUE	K1,540

However, growers reported high yield variability and high production costs for peanuts. Peanut yields can be so low that farmers can incur losses (margins are certainly lower in the wet season). High production costs were because of the relatively high upfront cost of tractor hire for ploughing (K100 per 0.2 ha plot or K500 per ha). If a reasonable quantity of crop is produced, then a youth group may be hired for harvesting at an additional cost of K100 per 0.2 ha plot or K500 per ha, plus food expenses for the work group. Assuming that farmers rely on family labour rather than hired labour, net annual returns for farmers would be K1,240. There is also some cost for transporting bags of peanuts to the roadside market at Watarais at the junction on the Highlands Highway. With unpredictable yields and the high upfront cost of tractor hire to prepare land for planting, peanut production is a risky enterprise. In summary, oil palm growers said that the switch from peanut cultivation to oil palm production was economically worthwhile.

Reasons for the reluctance of some farmers to plant oil palm

A range of reasons were put forward by farmers for the slow uptake of oil palm or their reluctance to plant oil palm. The main reasons were:

- a ‘wait and see’ attitude
- land disputes amongst customary landowners over land for oil palm production
- delays in land surveys
- poor accessibility
- the continuing effects of an NGO campaign against oil palm
- a perceived lack of skills/knowledge for oil palm cultivation amongst some potential growers.

Each of these factors is discussed below.

The ‘wait and see’ attitude
The wait and see attitude was common amongst farmers in the valley. Many farmers were cautious about taking up oil palm and were closely monitoring those farmers who were early adopters of oil palm. While a certain level of conservativeness about trying new crops is to be expected in all farming communities, the proportion of farmers who fall in this category is probably higher than would be expected. Their level of conservativeness may be a legacy of a 2006 anti-oil palm campaign in the area (discussed further below). To date, the positive experience of farmers who have planted oil palm is likely to encourage more farmers into the industry. Potential growers in the ‘wait and see’ group are looking at the labour requirements of oil palm, returns to labour and the impacts of oil palm on the environment. It is anticipated that many more farmers in this group will take up oil palm as they learn more about it, the potential income benefits and as their initial concerns about environmental damage decline. Perhaps the major area of potential concern is transport. If transport infrastructure does not keep pace with the expansion in production, then this may be a major disincentive to potential growers, especially if irregular pickups of crop lead to poor loan servicing and low income from oil palm. The is one of the major risks for the company in encouraging smallholder oil palm production and this must be monitored carefully to ensure an effective transport service is in place for growers.

Land disputes
Land disputes are common in the area. Land identified as suitable for oil palm has not been planted because of land disputes amongst landowning clans and sub-clans. For instance, at Impu, where village land borders the plantation, land disputes amongst three clans have prevented the planting of oil palm even though some farmers are keen to enter the industry. These land disputes are present on both the Madang and Morobe sides of the company estates.

There are two factors to keep in mind when considering land disputes. First, disputes are less common when land is in short-term use (e.g. peanut cultivation), than when it is being considered for long-term use (e.g. oil palm). When land is allocated to perennial crops like oil palm, land use rights are more tightly regulated because the land is excised from the communal pool of land for individual use for much longer periods. Land allocated for short-term use such as subsistence food crops or cash crops like peanuts is often given freely both within and between groups because the underlying land rights of the customary land-owning group are not threatened. It is possible, therefore, that the rise in the incidence of these disputes reflects the increased desire of farmers to expand perennial cash cropping, and the corresponding concerns amongst some clan members that long-term alienation of land will lead to the loss of communal land.

However, land disputes can be indicative of other concerns that may not be about land ownership, *per se*. A land dispute may be initiated by some group members to prevent a land-use activity that is perceived to be undesirable such as the creation of inequalities in land access within the village. For example, if some members of the land-owning group believe that oil palm is likely to have detrimental effects on the community or environment and are therefore opposed to its establishment, a land dispute may be instigated as a strategy to prevent planting. There is some evidence that this is indeed the case. In some villages such as Dabua, Impu, Brubri, Issitin, Wagasanta and Marawasar, planting of oil palm has not proceeded because some members of the group were opposed to oil palm and were disputing ownership rights of villagers wishing to plant oil palm. One farmer mentioned that there were no land disputes concerning the planting of cocoa, a perennial cash crop, suggesting that these land disputes are at least partly driven by anti-oil palm sentiments. At Brubri Village one grower explained that if a man wants to plant oil palm, another will stand up and dispute his right to plant. This makes it very difficult for farmers to take up oil palm because one needs the consent of the broader landowning group before oil palm can go ahead. It is instructive that of the ten farmers who planted oil palm at Brubri, all of them belong to the same lineage. No-one from the other lineages has yet planted oil palm. Furthermore, some people pointed out that those most opposed to oil palm were from secondary subclans and lineages in land-holding groups and therefore stood to lose the most if land were converted to oil palm. If oil palm planting were to proceed, members of land-holding groups with primary rights in the land might not permit those from secondary groups to plant oil palm because the long-term alienation of land for oil palm would effectively be giving the land away. Also, if oil palm planting were to proceed, the total pool of land available for short-term land use practices such as peanut production would contract with disproportionate negative impacts on land-holding groups with secondary rights. The company should carefully monitor smallholder oil palm expansion to ensure that there is sufficient land available so that these problems do not emerge.

While land disputes appear to be an important factor in discouraging people from planting oil palm, it must be stressed that not all areas seem to be affected. On a visit to some villages near Dumpu, villagers reported that there were no land disputes between families and clans, though this would need to be confirmed. Villagers had already met to discuss clan land boundaries and demarcate areas of land suitable for oil palm.

We heard reports of land sales to ‘outsiders’ (mainly highlanders). Land sales have been going on for some time, but were mostly limited to land for residential lots along major roads. However, although we did not see evidence of this for ourselves, we heard of several instances of land being sold to highlanders for oil palm development. It is important that the company monitor these closely as there is potential for disputes to arise in the future between customary landowners and migrants, because of the long time periods involved in oil palm cultivation.

Delays in land surveys

Before a block development loan from the RDB is approved a land survey must be completed, and in several areas delays in land surveys have hindered smallholder oil palm development. Villagers around Dumpu were frustrated with the delay in getting the provincial survey team from Madang to survey their land in preparation for oil palm cultivation. The provincial survey team started around Kesawai and were working towards Dumpu, but ceased work for two reasons. First, it was found that the Kesawai area was beyond the 150 km boundary set by the company for oil palm development (distance made transport costs too high), and second, their funding ran out and they need additional funds to continue surveying in the Dumpu area. Delays in surveying land have been compounded by other factors. The Customary Land Usage Agreement (CLUA) and loan application to the RDB for VOP block development are normally facilitated and supported by the company. Villagers around Dumpu said they were waiting for the company to approve VOP development in the vicinity of the company estate at Dumpu. Land surveys, especially at Dumpu, need to be restarted to raise outgrower participation. Uncertainty in the minds of farmers about the company position on the boundary established for smallholder oil palm development could be resolved with a programme for smallholder oil palm development that is linked to and conditional on estate development. That is, the boundary for smallholder oil palm development should follow estate development, as economies of scale are achieved in transport.

Access roads
As mentioned above, road access was an important concern raised by farmers in group discussions. Some blocks are not on feeder roads and growers are carting FFB to the nearest feeder road in wheelbarrows. This is not a serious problem at present because the palms have recently come into production and the quantities of crop are still relatively small. However, the condition of feeder roads is poor and some are impassable to trucks. These roads will need to be improved as the quantity of crop increases. It is very important that smallholder oil palm development does not proceed without adequate road infrastructure in place. Good transport infrastructure means regular and predictable pickups of crop that will instil confidence in growers that their labour and financial investments will be rewarded. Poor road infrastructure means irregular pickups of crop, lost production and poor servicing of loans which can undermine the motivation of growers to produce oil palm as they become disillusioned with the industry. If such a situation were to eventuate, it would be a major deterrent to entry to the industry of other potential participants.

NGO campaign
It was clear in discussions with farmers that there was a great deal of concern about potential negative impacts of oil palm on the environment (soils, water, game and vegetation), land access, the local economy and village society. These negative views of the impacts of oil palm were propagated by an NGO — the Bismarck Ramu Group (BRG) — which ran an anti-oil palm campaign in the area in 2006 when Ramu Sugar began diversifying into oil palm. The campaign has been successful and its effects are still apparent in the views of some farmers who accepted the claims of this NGO. BRG was established in 2000 and is based in Madang Province. According to their website, the NGO is: "built on the foundation that continued ownership and control of land and resources by the people of Papua New Guinea ensures their independence and food security. … BRG's purpose is to fight against the exploitation of people, land and resources in Papua New Guinea. We educate, inform and empower people so they can organise, make informed decisions, speak out freely and act to protect and keep control over their land, resources and livelihoods."

Several farmers said that BRG recruited village representatives for training in Madang for the anti-oil palm campaign. They returned to their communities with posters and pictures which they used in workshops with farmers to demonstrate what they claimed would be the impacts of oil palm on their communities if oil palm were to go ahead. Farmers at one meeting claimed that there were photos of houses of oil palm growers in Popondetta, which were small, very run down, and barely fit enough to house pigs. They claimed Popondetta growers had become enslaved, were living in poverty and in a degraded environment with no future for themselves or their children. The main elements of the campaign as related to us by growers were:

- The company will plant oil palm right up to the river's edge
- Rivers will dry up
- Mill waste will pollute water supplies
- Runoff of fertilisers, pesticides, fungicides and herbicides will contaminate water supplies leading to adverse health effects and fish poisoning
- Oil palm wastes will smell and attract a lot of flies
- Reduced soil fertility will undermine food security
- Land that has been planted to oil palm will never again be able to grow food crops
- Coconuts will not produce well
- HIV-AIDS will increase with more cash (prostitution) circulating in the community
- Mosquitoes will breed in waste water from the mill and increase the incidence of malaria

- Rat bait will poison village pigs and dogs
- The palm thorns will make you ill
- Income from oil palm will be very low and villagers will all live in poverty
- The high labour demands of oil palm mean people won't have enough time to look after their food gardens and houses properly
- Excessive work burdens will lead to people becoming sickly and malnourished

The Ramu Valley was never a significant source of labour for the oil palm plantations in WNB and Oro, and nor was it a source of settlers for the LSSs. The vast majority of villagers, therefore, have had no previous experience of oil palm, and consequently did not have the knowledge or experience to evaluate the validity of the claims of the BRG. This is perhaps the main reason why the campaign was successful and an anti-oil palm sentiment remains fairly strong four years after the campaign. However, there is evidence that farmers are gradually changing their views in the light of the experiences of the early adopters of oil palm who are earning good returns from oil palm, and the extreme claims of environmental and social damage prove untrue. It is anticipated that anti-oil palm sentiments will decline further as the income earned by the early adopters increases as their palms come into full production.

Growers' lack of skills in growing oil palm
We heard of only two men (elderly farmers from near Dumpu) who had prior oil palm experience, both of whom had worked on the plantations in WNB. All current oil palm growers have had no prior experience of oil palm production and were learning as they went along. There is one person from the company responsible for VOP development and extension and he, like the VOP growers, is learning on the job. Some of these growers suggested that it would be beneficial if some of them were to attend training workshops by OPIC in WNB to improve their skills and knowledge of block maintenance. They would become model farmers on their return to Ramu. There is merit in their suggestion and their visit to WNB would also help dispel some of the negative perceptions surrounding oil palm.

Increase capacity for VOP extension and awareness
At present there are not too many growers, but as their number increases it will be necessary to ensure that the capacity of the company (or OPIC later) to deliver extension keeps pace with this growth. Much of the company VOP officer's time is currently taken up with assisting growers to deliver their fruit to the mill. The transport needs of smallholders will need to be addressed separately so that the company VOP officer can concentrate his efforts on extension delivery. Extension is critical in this early phase of VOP development. An effective and accessible extension service will make it easier for farmers to switch to oil palm and give them confidence that the company is supporting them in making the transition to oil palm production.

Other comments

Women in oil palm
Several women attending the meetings raised the issue of the distribution of oil palm income in the family. Some women said that they do a lot of work in oil palm and are not paid well by their husbands. When the number of outgrowers increases, it is recommended that the *Mama Lus Frut* scheme be introduced to enhance the income benefits for women.

Mapping VOP blocks
For planning purposes, it would be useful if all current and future VOP blocks were mapped using GIS. The GIS unit from the OPIC Hoskins project is suitable for this kind of work.

Non-oil palm income sources
The important sources of non-oil palm income for villagers in potential VOP areas include peanut, watermelon (SDA community), cocoa and betel nut. Peanut and watermelon now dominate as income sources because betel nut income has dwindled because of a virus affecting the palms.

The Way Forward
The best advertisement for smallholder oil palm expansion is a rising number of satisfied growers joining the industry. Current participants in the industry are pleased with their decision to establish oil palm. With rising returns to growers as their palms come into full production, more of the "wait and see" farmers will be enticed into the industry as they begin to recognise the income benefits and as their initial concerns over negative social and environmental effects are allayed by their observations. Poor transport and roads pose the largest threat to the confidence of existing oil palm growers and deterring new ones from entering the industry. It is critical that the capacity of transport infrastructure keeps pace with expanding production to service growers. Failure in this area as indicated by irregular pickups of crop leading to low incomes and poor loan servicing would be a major barrier to expanding VOP production. It is important, therefore, that approval for smallholder oil palm development is conditional on adequate road infrastructure being in place to service new growers. In addition, the company should ensure that the planting of oil palm in new areas does not contribute to land pressures and increased inequalities in land access. There should be sufficient land to ensure the subsistence needs of the local population can be met into the future as well as the cash cropping needs of the next generation of farmers. Where inequalities in access to land for cash cropping may arise because of differences between the rights of primary and secondary landowner groups, consideration should be given to the use of CLUAs to address this problem. As indicated above, primary land-holding groups may be reluctant to grant long-term access to land for oil palm to secondary subclan members because such land transfers may be perceived to undermine their primary rights in the land. There are CLUAs available which recognise the underlying and ongoing tenure rights of the primary landowning group while providing secure tenure for secondary group members for an oil palm planting cycle (20-25 years). PNGOPRA has done much research in this area and could assist in developing appropriate CLUAs to address such situations.

It is also recommended that the company develop a programme for smallholder oil palm development that is tied to estate development. At present the company has established a boundary beyond which it has told growers there will be no smallholder oil palm development. However, it is likely that as estate development progresses beyond this boundary, communities near these new developments will be supported to plant oil palm. Growers should be informed that support for smallholder oil palm development will be contingent on these estate developments as transport economies are achieved thus making smallholder development viable. This will remove some of the uncertainty of future plans for growers and lessen frustrations amongst farmers when they see some areas being supported for VOP development while they believe their own areas are being neglected. As a final point, the company may wish to consider assisting some village representatives to visit smallholder communities in WNB to see for themselves the advantages and disadvantages of oil palm for smallholder farmers. This may help dispel some of the more extreme negative views surrounding oil palm. It may also provide an opportunity for OPIC to train some lead farmers in various aspects of oil palm production.

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Appendix1. Meetings attended and key people interviewed

Dates and Locations of Interviews

8/3/10 Joe Castle's office. Present: Joe Castles, Ian Winstanley and Ludwig Muriki
8/3/10 Bairook, Dabua Village. George Curry and Ludwig Muriki met with Baida Isi, Chairman of Growers' Association.
8/3/10 Bruburi Village. Meeting with 14 farmers (9 male and 5 female). Ten of the farmers each had 2 ha of oil palm.
9/3/10 Company Land Officer's office. Meeting with Adolf Duangha, Lands Liaison Officer, and Matthew Tawia, Land Officer.
9/3/10 Watarais. Meeting with growers from Issitin and Wagasantan
10/3/10 Research and Sustainability office, Meeting with Dr Lastus Kuniata
10/3/10 Faria Village, Dumpu. Meeting with Villagers
11/3/10 Manawasar village. Meeting with Ani Kakar, former village magistrate and current spokesperson (mausman)
11/3/10 Ragijaria village. Meeting with Muri Sagriang, Ragijaria village land owner

List of people interviewed

Ian Winstanley, Ramu
Ludwig Muriki, Ramu
Mathew Tawia – Company Lands officer, Ramu
Adolf Duhanga – Company Lands Liaison Officer, Ramu
Baida Isi, Chairman of Growers' Association
Dr Lastus Kuniata, Ramu
Ani Kakar, village spokesman (mausman), former village magistrate
Muri Sagriang, Principal Landowner

Second Study: *Higaturu Smallholder Production Assessment Report* *by Jesse Anjen, Merolyn Koia and Pauline Hore; PNGOPRA December 2010* **(RSPO 1.1, 2.3, 4.2, 4.3, 4.8, 6.1, 6.2, 7.1, 7.5, 8.1)**

Summary of Report

Reasons for productivity losses from smallholders

The reasons for low production and productivity losses from smallholders were many and varied and very complex. The key reasons being:

- Poor block management: most the smallholder blocks in the Higaturu project are in poor condition due to neglect and poor management over a long period of time.
- Aged palms: many smallholder blocks are overage and due for replant. These blocks are giving low yields due to poor management over the years.
- Shortage of labour: some blocks are faced with a labour shortage due to the aging population of the original owners and some adult children with good education moving out of the blocks for paid employment opportunities.

- Fertilizer delay or not supplied: fertilizer have been delayed and/or not supplied over several years for various reasons including existing debts owed to HOPL
- Caretaker disputes: caretaker disputes over payments and ownership rights have put the disputed blocks out of production.
- High density palm: high density planting from the World Bank funded "Oro Expansion project" is giving low yields as palms get bigger and compete for sunlight
- Skip harvesting due to low crop (ripe bunches): Skip harvesting is prevalent from 28 days harvest to 3 month maximum to get sizable FFB numbers in low production blocks.
- Harvest on a need basis: harvesting especially in the VOP blocks is irregular and is driven by an economic need for cash to meet social, economic and other community obligations.
- Incomplete harvesting (partial): partial harvesting is being practiced in blocks with labour shortages.
- Shifting crop: crop shifting is being practiced to avoid paying debts on their blocks and also being done on caretaker blocks.
- High debt during school fee times: farmers are reluctant to get tools/fertilizer and replant when their children are in school and school fees have to be paid.
- Intimidation of blocks owners (LTC) by landowners: some growers are finding it hard to replant and also produce FFB as landowners demand payment in cash and kind.
- Replanting using volunteer palms: some farmers are beginning to plant volunteer palms as replacement for wilted palms as well as using them for replanting.
- Poor road access: some smallholder blocks are currently out of production due to poor access roads and also roads damaged by cyclone Guba.
- Bridges washed away: some bridges and culverts were washed away during Cyclone Guba in 2007 and they have not been replaced.
- Delay harvesting: harvesting is delayed as growers sort out queries and irregularities. This can take a long time.

Proposal to take over crop management and harvesting in low producing LSS and VOP blocks
Current smallholder management and harvesting is erratic and on an ad-hoc basis. There is potential for yield intensification from existing smallholder blocks through innovative management approaches. The proposed idea is for the plantation (HOPL) to take over the management and harvesting for interested smallholders willing to participate in such a scheme. Work would be undertaken on a fortnightly basis with plantation labourers provided and managed by the milling company. In our discussions with growers from two divisions (Igora and Sorovi) in the Higaturu Project covering both the Land Settlement and Village Oil Palm Schemes, there was favourable response from over 20 growers visited. Most of the growers liked the proposed ideas and would like to see it happen. A few of the growers especially for the VOP were unconvinced saying that they are able to manage their own blocks.

Some questions posed by growers

- Block ownership: what will happen to the ownership of the block being taken over as per the proposed initiative by the company? It was clearly explained to the growers that the ownership of the block remains with the owner, the company is only interested in helping the growers to manage and harvest the crop.
- Duration of management takeover: another question was how long would such an agreement last and what happens that contract agreement period ends?
- Debt situation: for growers that are interested in participating in such a scheme, how will their existing debts with the company be sorted out?

Concluding remarks

- Growers need to be made more awareness if such an idea is to be initiated.
- Some selected blocks could be trialed to demonstrate the appeal of such a scheme and help to get nearby farmers more engaged and aware. These blocks can be used as demonstration blocks (Best Management Practice) for growers within these areas during OPIC organized field days
- PNGOPRA will be willing to participate in such initiative for leaf tissue sampling and yield data assessment for crop response to improved management practices in a "before and after" scenario.
- Some growers are adopting a "Wait and see attitude" to see the effectiveness and benefits of such a scheme before they participate fully.
- Selection of blocks for such trials should include high debt low producing blocks, labour shortage blocks and poorly managed blocks.

Introduction

This study was initiated following an invitation from Mr. Mike Jackson, General Manager of Higaturu Oil Palm Limited (HOPL) to assess the production and productivity issues affecting smallholders in the Higaturu Oil Palm Project and look at proposed plans to take over crop management and harvesting in low producing LSS and VOP blocks. HOPL is looking for innovative ways in trying to assist smallholder oil palm growers from the Land Settlement Scheme (LSS) and Village Oil Palm (VOP) to improve production and productivity. On the grand scale, key infrastructure and support services within the project area has been neglected by the Provincial and National Government. The proposed idea is to sensitize smallholder production issues and look at alternative institutional arrangements to increase production from low production blocks.

Conceptual idea:

- Engage with low producing smallholder blocks and run the LSS/VOP blocks just like the Plantation.
- Employ Plantation labourers and engage them in a rehabilitation programme to increase production from 11 tonnes to 25 or 30 tonnes/hectare.

This idea is closely linked to the RSPO generic guidance (see 'Scheme Shareholdings' below)

The PNGOPRA Team comprised of Jesse Anjen, Socioeconomist; Merolyn Koia, Smallholder Supervisor, and Pauline Hore, Smallholder Supervisor , PNGOPRA Socio-economics Section conducted a field visit to the project area and consulted key stakeholder and farmers from the 25th to the 28th of August 2010.

Objective

The objective of the study was to:

- Identify the causal agents affecting smallholder FFB production
- Gather solutions offered by the growers
- Seek feedback from the growers on the proposed plan by the company to take over crop management and harvesting on smallholder blocks.

Several meetings were organised with key players from the company, OPIC, LSS Growers and landowners and farmers from several village communities in the VOPs. (See Appendix 1)

In Sorovi division, ten growers were interviewed, 5 from the LSS blocks and another 5 from LTC blocks which are known as VOP blocks on OPIC and Company Data Base. 7 growers from Igora division were also interviewed. These covered growers from VOP and LSS Blocks (original and care takers). These meetings included interviews of individual farmers and their families, children of elderly farmers in individual smallholder blocks, with observers from the neighbouring blocks and discussions with staff of the company and OPIC. These meetings were the primary source of information for this report.

Smallholder production

Since the Popondetta Oil Palm scheme was initiated in 1976, the number of smallholders, both LSS and VOP, has increased from a mere 795 to over 5500 smallholders in 2010. The World Bank funded "Oro Smallholder Oil Palm Expansion Project" in the 1990s significantly increased the area under smallholders, particularly the VOP. In 2004, the smallholder hectarage was estimated at 14,515 hectares in both the LSS and VOP compared to the plantation which currently has only 9007 hectares. This means that the Higaturu Oil Palm Limited (HOPL) has only about 38 percent of the total hectarage.

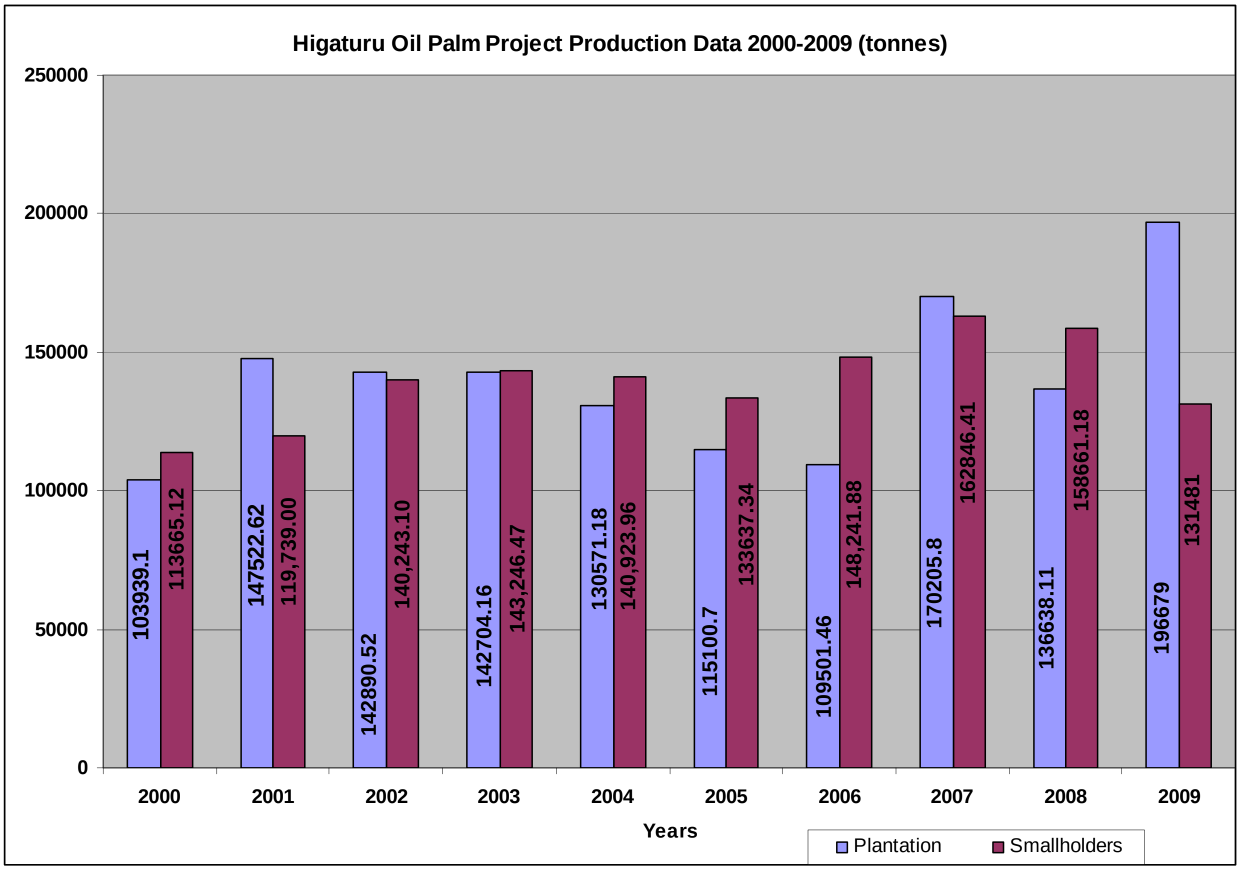

Figure 1. FFB from plantation and Smallholders over a 10 year period

However, looking at the production figures over the past 10 years since 2000 (Fig.1), the milling company in Popondetta is producing about the equivalent of the FFB crop and sometimes even more than the smallholders although it has less hectarage. Smallholder production has stabilised around the range of 100, 000 – 150, 000 tonnes in the past 10 years with no noticeable or significant increase in production during this period. Smallholder productivity in 2009 was 11 tonnes per hectare. This is far lower than those reported in other smallholder schemes around the country. For the total number of growers reported, over 90 percent of the growers are at the bottom of the production category producing less than 50 tonnes per hectare per block per year.

Smallholder Productivity Issues
In the Higaturu Project, OPIC management has reported that smallholder productivity has drastically fallen since the 1980s. Smallholders from the project were producing more than 20 tonnes per hectare but that is not the case right now. There are only 7 top smallholder producers in the project followed by another 85 growers in the second highest category contributing 1.6 % of the total smallholder production in Popondetta (see Table 1 below).

A number of reasons can be attributed to the decline in the smallholder productivity in the project area. The details are further described below.

Table 1. Different categories of smallholder producers and their annual production for 2009 (FFB)

Number of growers	Tonnes per block
4473	0-50
229	51-65
86	66-75
85	76-130
7	130 Plus
Total Growers = 5707	Average tonnes/ha = 11

Reasons for productivity losses from smallholders
The reasons for low production and productivity losses from smallholders were many, varied and very complex. The key reasons being:

- Aging population
- Shortage of labour
- Lack of fertiliser/tools
- High debt situation
- Economic need to produce
- Landowners harassment
- Caretaker disputes
- High density planting under Oro Expansion Project (lining)
- Land title disputes
- Some blocks are inaccessible by road.
- Overage palms due for replanting
- Skip harvesting
- Cyclone Guba
- Ratio of Extension Officers to growers
- Incomplete harvesting

Each of these factors is discussed below.

Poor block management and sanitation
A VOP farmer has three blocks comprising two 4ha blocks and one 2 ha block. He has no brother or sons, only girls. Due to this labour shortage, he sometimes leaves 2 blocks and only harvests from one block. Occasionally he hires extra labour to harvest and moves the crop to the market place for pickup. Skipping is also common to accumulate the number of ripe fresh fruit bunches. Usually, he would make 2-3 nets but sometimes 5 or more with additional labour. He has 4 ha of overage palms waiting to be poisoned and replanted. 2 ha from this second 4 ha block has been poisoned and replanted whilst the third 2 ha block is a new planting that has yet to be harvested. He got fertilizer last year and is yet to get his quota for this year.

Generally, the block management and sanitation in smallholder blocks is very poor. From our observation, blocks have not be maintained and attended to for quite some time. Some blocks were very dark with overgrowth and hanging dried fronds. Fronds at the crown were straight up and there were no black bunches on these palms. The palms were tall and overdue for replanting and harvesting from the tall palms is also a problem itself with shorter harvest poles being used. The poor state of these blocks would take some time to recover under a very good management system. This is a problem that has been compounded by lack of tools and equipment, fertilizers, poor sanitation, economic need to harvest, labour shortages and an aging population, poor access roads and many more which are explained in more details in other sections of the report.

Aging population/labour shortages on the blocks

Labour shortage is emerging in some smallholder blocks. There are cases where some blocks are occupied by mostly women and children or ageing parents with children working outside of their blocks with the company or other paid jobs. Poor income distribution from the head of the block also results in children refusing to work on the block to assist their parents. Contract work on block upkeep was working well but when the yield from these blocks increased, the owners did not want these contractors to come and work on their blocks. The contract work involved paying the contractors K2.00 per palm but this has since been closed. Whilst it is reported elsewhere, skip harvesting and incomplete harvesting is partly due to the lack of labour on smallholder blocks.

Law and order problems- no respect for law, elders, parents and authority

The general view of the Melanesian way of respect your elders and leaders no longer exists nowadays. There is no respect for authority/law. Drugs and alcohol abuse is common among youths and young people in the blocks. An Area Committee member for Kanari VOP looks after about 52 growers. He had encountered problems while relaying harvest toksaves to his growers. Some growers and youths are ignorant and do not want to listen to advice about the harvest programs and other oil palm related messages.

Lack of fertilizer and tools

Fertilizer has not been delivered to the smallholder growers for the last three years. Whilst this cannot be directly attributed to low productivity, smallholders viewed the non-application of fertilizer over the past three years as one of the major problems. Most of the farmers do not have enough tools to work in their blocks. These blocks with no or less tools (nets, harvest pole, wheelbarrow etc) are sharing with their neighbouring blocks. This trend tends to delay work in the blocks for upkeep, harvesting and fruit pickups.

High debt

It emerges that that the low producing blocks are often the ones with high debt and problems with loan repayments. We would need to do more to get these farmers out the cycle and get them to produce more. This number represents about more than 80 % (4473) of the total smallholder producers in the project. At the time of our discussion with the Company Smallholder Office, it was found that the smallholder growers owed K1.6 million in debts to the company. Certain criteria were introduced in trying to recoup money owed to the company. For instance, the company was selective on good credit status for replants, tools and fertilizer. Growers with debts of more than K500 were not issued fertilizer and less than K100 for tools. Based on the figure above with the majority in the low producing category, it is takes a long time to repay debts. Some growers try to avoid the debt by shifting crop to other blocks.

Economic need to produce

The need for cash to meet economic and social obligations is a key factor enticing grower to produce. These economic needs are often varied and seasonal. Key events that necessitate producing are:

community, growers and family obligations like sports, religious activities, customary obligations (feast, funeral & marriage ceremonies and compensation). The festive seasons are Easter, Christmas, New Year, Independence Day and school fees around January and February every year. Many smallholders tend to abandon and neglect their blocks and only come to harvest when there is a need for money. For instance, a grower, has his selling card cancelled (had his block abandoned for some time) and now wants to re-register his block so he can sell his FFB to the company. He sought assistance from 0PIC to register his block so he could sell his fruits and get some money to meet his social obligations (church day, pondo etc).

Needs Basis

- Papa
- Mama
- Group (community pressure/obligation):-payment options can be decided for groups with common interest where every member needs can be met.

A new development happening in the project is the intentional low production to avoid commitments from wantoks, and also pressure from landowners demanding money during the paydays. The growers normally tend to harvest about 2-3 tonnes (roughly 3-4 nets) which is considered sufficient for their basic needs. The more fruit they harvest, the more money they make and the more demand for money (external pressure) to meet those needs.

Landowner harassment
During the Oro for Oro crises, many of the settlers on the LSS blocks left their blocks due to landowner harassment. During this period, some of the LSS blocks were either sold or left with caretakers. A typical case involved one person having to buy off 26 blocks with a loan from a commercial bank. Incomplete or half payments were made with a promise to pay in full at a later stage. Since then most of the payments were not made and some of the original owners have returned to claim their blocks back. The commercial bank has also tried to take over the blocks to recoup default payments on the loans. Hence these disputes have left most of these blocks out of production. Some LSS blocks were taken over by landowners from the surrounding villages and have not been producing from these blocks on a frequent basis. In some cases, VOP growers adjacent to LSS blocks dispute and demand payments from LSS blocks and so there have been no replants. In Sorovi division, on LSS blocks, growers had problems with the traditional landowners who demanded compensation in cash and some food but the issue died out last year when the ring leader died. There are still some pockets of harassment by traditional landowners alienated from their land.

Caretaker disputes
Due to the Oro for Oro crisis during the early 1990s, most of the owners of the blocks moved out of their blocks. Some caretakers have been taking care of these blocks and when the owners have returned, there are disputes on the production from the blocks and then there is little or no production. Caretaker blocks can change ownership several times with disputes putting the block out of production for long periods. Caretakers tend to shift their FFB to another block to avoid debt payments. For instance, the caretaker has his own block but he is also taking care of his brother's block who decided to return to his village. Another person from SHP assisted him by paying his boat fare and then took over the block as the new owner. The elder son of the original owner returned and tried to reclaim the block. The dispute was taken to court and the original owner's son won the case. Since he is working, he gave the block to his uncle to look after. The caretaker has his own block so he asked one of his daughters to take care but they have been shifting FFB to another blocks, so he stopped and assigned contractors to harvest and they were also shifting one net to another block so he is thinking of moving one of his nephews to come over and reside

on the block and work on the block. The palms are very tall and are overdue for replanting. Not many of the ripe bunches are harvested due to tall palms. Average production is 2 tonnes per month when the average should be about 5 tonnes per month. Another caretaker block visited had very low production with no fertilizer application for the last 3-4 years. This 6 ha block is managed by the eldest son of the caretaker with sanitation on the block very poor. Skip harvesting is practiced with one harvest per month. Complete harvesting is not practical due to the labour shortage and so this block is able to do only 3-4 nets per month. This particular block has been under caretaker management for the past 31 years. The caretaker's son claims he can do all the work on the block himself, but this is clearly not the case.

In another caretaker case, it is not the caretaker's block but his wife's first husband's block, so the deceased man's brothers are always disputing the block when the caretaker's sons go in to harvest .He is waiting for his wife and son to decide on who will take ownership of the block.

Inaccessible roads
Most of the smallholder access roads are in very poor conditions. Some of the blocks can hardly harvest fruit due to the inaccessible conditions. Cyclone Guba in 2007 exacerbated this situation severing more bridges and access roads. The recovery effort put in place after the cyclone to restore essential services including roads was not comprehensive or sufficient. In the Igora division, 582 hectares were classified under "No go roads". This covers roads around Pusahambo near the main road to some LSS access roads around Isiveni and other VOP blocks around Kanari (see Appendix 2). A total of 188 blocks are being affected by the impassable access roads. The problem of inaccessible roads is also widespread in other VOP areas around the project. Most of these blocks cannot be harvested due to bad road/bridge conditions, and external funding is still required to upgrade the roads and bridges in the affected areas including monies allocated from SADP funds.

Overage palms due for replanting
In the Igora division, large numbers of LSS blocks (over 1000 hectares) are due for replant and they are too high to be harvested. On Land Tenure Conversion (LTC) blocks, the major problem (dispute) is with the traditional landowners who demand a payment of K1000, one pig and some food before replanting. This applies on every hectare which resulted in no replant on most of these blocks. If the demands are not met then the palms will grow until the crowns break then the settlers will move out of the blocks and the landowners will get their land back. This is similar in some LSS blocks preventing them from replanting. Even if they are willing to replant, the debt problem and the lack of seedlings are also posing a problem for the smallholder blocks. Feral seedlings are readily available and are being used as planting material posing a quality risk for the project.

High density plantings
High density blocks are very dark with an uneven distribution of sunlight, fronds shooting up straight, no black bunches, full of male inflorescences, planting density at 7.5 m and some 6m, and mostly ten, or more, year old palms. In the VOP blocks, most of the growers live in their village and only go their blocks to harvest. Most of the VOP blocks were developed during the Oro Expansion Project. During this project, there were high density plantings and some blocks are inaccessible to the roads. More than 70 growers from the Igora division have high density blocks with poor lining, giving very little crop after the canopies have grown bigger and preventing enough sunlight penetrating. FFB production from these blocks is negligible and harvesting in done every 2-3 months when there are enough fruit bunches to make 1-2 nets. For instance, a VOP grower desperately needs help to replant his block. He is worried because he has a K1000 loan so can't replant. He normally harvests after every three months depending on the total number of ripe bunches. He may produce only 1 net or half a net in the three months. His in-laws gave him that piece of land to plant his 2ha oil palm block. It is about 1.5ha or less and that is why he has to squeeze all the 256 seedlings into that piece of land. OPIC did some thinning exercises on the some of

seedlings but, even after thinning, the problem is still there. Now his in-laws have agreed to give him extra land to extend his block.

Skip and incomplete harvesting
2 nets per harvest is normal for 2 ha VOP blocks and 2-4 ha LSS blocks. Lengthy periods of skip-harvesting are being practiced. Most of the growers harvest once per month and the crop can be skipped for 4-5 harvest rounds. The yield coming from these growers is very low. They also partially harvest part of the block when they see that fruit bunches are enough to make 2-3 nets or more.

Land title disputes
There are still some disputes over the inheritance and transmission of titles of the leasehold blocks especially the LSS. Some growers have tried a couple of times to change the title through the Lands Office in town but did not either succeeded or the original title was misplaced by the original owner. Commonly, the process takes a very long time and growers are also requested for payments to sort out the titles.

Other productivity issues

Inter and intra-household disputes
Some large household blocks also have intra-household disputes on oil palm income distribution putting blocks out of production for extended periods.

High grower to Extension Officer ratio
There is a high ratio of growers to extension officers. In one division, we found that the extension officer is responsible for more than 400 growers when he is supposed to have around 200 growers. Most of the extension officers have more growers to cater for than is normally required. This means that they cannot respond to the growers' needs on a regular basis or in a short time.

Volunteer palms
Some farmers are beginning to plant volunteer palms as replacement for wilted palms as well as in new replants. This should not happen and is likely to compromise future yields, production and fruit quality.

Cyclone Guba
Some smallholder blocks are currently out of production due to poor access roads and also damaged roads from cyclone Guba. Some bridges and culverts were washed away during the Cyclone Guba disaster in 2007, compounding the problem of poor road access.

Delay harvesting
Harvesting can be delayed for a long time when growers have to sort out queries and irregularities with the smallholder office. Some process needs to be set up to address these issues in a timely manner so that the growers can start harvesting again.

Potential for Improvement
Although most of the problems highlighted are systemic and inherent amongst smallholders, there is a huge potential for improving smallholder production and productivity in the Higaturu project. A couple of innovative ideas have been discussed during this study, appropriate to the issues highlighted including some reassessment of current policies, standards and norms of engaging effectively with smallholders. Several propositions have been put forward during the discussions with the key stakeholders and are deliberated below.

Scheme shareholdings

A feasible option strongly advanced by the company is to embrace the concept of scheme shareholders, a category of smallholders as defined by RSPO: "Scheme smallholders, while also very diverse, are characterised as smallholders who are structurally bound by contract, by a credit agreement or by planning to a particular mill. Scheme smallholders are often not free to choose which crop they develop, are supervised in their planting and crop management techniques, and are often organised, supervised or directly managed by the managers of the mill, estate or scheme to which they are structurally linked."

Although the RSPO category is based on a permanent arrangement, under this concept, the company takes over the management of the smallholder blocks for a fixed period negotiated with the company and employs its workforce and equipment and takes a percentage of the production as payment from the smallholder blocks.

During our discussions with the growers, they were very happy with the proposed idea of the company taking over management and harvesting of the block for a fixed time to bring the block up to standard. Whilst the technical and the operational requirements will need to be worked out, the basic approach to engaging workers drawn from the company labour force or through engagement with the community youth and other interested people willing to work for the company from the surrounding blocks was clearly explained. This also included how the payments for the services to be provided by the company and the percentage of crop are to be paid to the company on a cost-recovery basis. The cost of labour, tools, equipment, fertilizers etc would be borne by the company and recovered as a percentage of the crop while the remaining balance would be paid back to the block owners. It was also explained that the title and ownership of the block would remain with the owners of the block. They can remain on the blocks and do whatever they want. The company is primarily interested in managing the oil palm and bringing it back to full production in line with plantation standards.

Some growers with labour problems including aged owners and also those with large or multiple blocks were very happy with this concept. Some of the growers were initially engaging contractors to do the work on their blocks with assistance from OPIC but when the company stopped the contract work, the blocks has gone back to a poor state again. This concept really appeals to those category of growers like the following example: The grower is on the area committee for Waru VOP growers, the first 4 ha is just next to his house the other 4ha is on the other side of the block so it makes it difficult for him to completely harvest his block, he has only daughters. Previously OPIC assisted him with contract harvesting but now it has stopped and he really likes the idea of the company engaging its workers to harvest from his block. There were some growers whom we visited that indicated that they were capable of handling the workload on their block when this is actually not the case. Sanitation and maintenance is poor with skip and incomplete harvesting the norm.

The key issues that arose from this line of discussion was the tenure and ownership of the blocks to engage in this scheme, the rate of percentage split and period of contractual relationship with the company under this arrangement. There are cases whereby owners try to take back the management of their blocks when they see that the blocks are in good shape and the crop volume is picking up. The contract period will have to be sufficient to appeal to the growers. Some of the growers were not on site during the visits and their children were interviewed so they said to seek their parents consent before giving their views.

Growers' fund

A growers' revolving funding mechanism can also be established so that growers are making fortnightly deductions from their blocks. This money is kept aside either by the company or through other alternative arrangements. The farmers can draw down on this money against their savings in this fund for their block requirements to fund basic needs like water tanks, house, generators as well as re-investing into developments on their blocks like fertilizer, replants, poisoning, seedling and tools etc. These savings can also be used to meet their school fees and other socio-cultural obligations during their time of need. In the long run, this is a very viable option to sustain smallholder production and reduce their debts as well as ensuring that money is available for financing tools, equipment and replanting.

Labour mobilization scheme (society or common groups)

The mobilization of labour from the surrounding smallholdings and its periphery would effectively eliminate the labour shortage problems faced by some smallholders. There are some smallholders that may not engage with the company scheme on issues of trust and percentage split, and maintain their independence. Contract harvesting in Popondetta and the Mobile Card scheme being trialed at the Bialla oil palm project are some known approaches for engaging extra labour. Community groups or affiliations like youth groups, sports, church and women are another way of engaging with the community and getting them to do work on a piece rate system for the quantity of work identified and tasked to these groups. The attractiveness of these approaches would depend on developing proper rules, guidelines and process for contractors and other participants which is supported by an administrative process established by the company.

Concluding remarks

Increased production and productivity is a great bonus to the company and the smallholders as well. For this to be realized in the medium to long term, the industry, particularly the milling company and OPIC need to seriously deliberate, debate and introduce viable and practical solutions to maximize crop production under existing smallholdings. For this to happen there is a need to have a proactive smallholder engagement strategy. The proposed scheme of smallholder interventions would have to include both the LSS and VOP as some VOPs have interest in participating as scheme smallholders with HOPL. More awareness and discussions with the smallholders would be necessary to gauge the receptiveness of the proposed scheme in the wider project context.

It is also necessary to consider other production issues as presented in this report. Poor road access and labour shortages etc. are currently a serious impediment to increasing output from the smallholders and greatly affect their loan repayment schedules. There is a need for a massive replanting program with overage and high density plantings giving very low production. Growers' debts and repayment schedules will need to be worked out in an agreeable manner since most of the growers do not have tools like harvest poles, nets and wheelbarrows. Without these tools, they can never be producing at high levels. Fertilizer distribution will need to be made obligatory, like it is done in other oil palm project areas through the signing of irrevocable orders (ilpoc). For debt recovery, it is not possible to enforce stringent debt recovery processes as growers could begin shifting crops or deliberately opt out of producing due to the lack of tools and nets. The company would need to focus on the list of high debt and low producing blocks, go to their blocks and explain to the grower and work out a production target estimate and payment schedule (target) to repay the loan, if not then the Company will assign contractors or its own workers to work on the block to repay the debts.

Road access would need to be greatly improved although this remains the responsibility of the provincial and national governments. Whilst some SADP funds are earmarked for this purpose, it would need to be prioritized for are severely affected areas with a large number of growers present and high potential for new or infill expansion. Labour shortages can be effectively addressed through mobilizing labour or through the scheme smallholder production approach. Land and caretaker disputes can be effectively addressed through the engagement of a fulltime OPIC lands officer. The responsibilities for settling disputes of ownership, transmission of titles need to be addressed quickly to get these blocks back to production in the shortest time possible. With several options available, systems-wide options of assessing throughput from various interventions or a combination of these options would greatly enhance the efforts to sustain, promote and increase smallholder production.

Appendices

Appendix 1: Meeting and Places

25/8/10 – Meeting in Mike Jackson's Office, General Manager, Higaturu Oil Palm Limited
25/08/10 – Meeting in Smallholders office, present: Steven Sipolo, Brian Cazalet
25/08/10 – OPIC Office: Present:
Leo Ruki, Project Manager, OPIC Popondetta
Graydon Hanguru, Field Manager, OPIC Popondetta
Alex Kimana, divisional manager Igora, OPIC Popondetta
Epano Kaima, Divisioinal Manager Sorovi, OPIC Popondetta
Alex Jima, Divisional manager, Illimo, OPIC Popondetta
John Asiri, Divisional Manager, Saiho, OPIC Popondetta
26/08/10 – Meeting with growers in Sorovi division: present: Mackenzie Genau, Senior Extension Officer, Francis Kimeto, extension officer, Company smallholder officer for Sorovi, 7 grower households
27/08/10 –Meeting with Igora Division officers. Present: Alex Kimana, divisional manager, SEO-Bernard Piskaut, Bito Mula, EO's-Jack Alu, Walter Ben & Julius Isoro
31/08/10 – Meeting with growers in Igora and Isiveni LSS and VOP
01/09/10 – Meeting with Company lands officer Copeland Sumani
06/09/10 – Meeting in Mike Jackson's office. Present: Mike Jackson, Ratnam Somoo, Brian Cazalet

Appendix 2: Damaged and poor access roads

No go roads in Igora Division LSS and VOPs.

No Go Roads	***No of blocks***	***Hectares***
Isigahambo road	4	16
Pusahambo VOP	4	16
Igora road 11	2	16
Igora road J	3	12
Isiveni Ope road	4	18
Isiveni Ope road 3	11	28
North Sangara	2	4
Senari road	49	98
Waru/Dopos road	4	8
Tafish road	16	44
Hondahare road	30	60
Giririta road	91	182
Jajau F/road 3	4	8
Kanari field road (23 x 46 ha)	23	46
Jajau m/road (10 x 20 ha)	10	20
Total	**188 blocks**	**582 hectares**

APPENDIX 1 – RSPO PRINCIPALS AND CRITERIA

The Roundtable on Sustainable Palm Oil (RSPO)
PNG National Implementation Working Group (PNG NIWG)
Principles and Criteria

PRINCIPLE 1: Commitment to transparency

Criterion 1.1
Oil palm growers and millers provide adequate information to other stakeholders on environmental, social and legal issues relevant to RSPO Criteria, in appropriate languages & forms to allow for effective participation in decision making.
Criterion 1.2
Management documents are publicly available, except where this is prevented by commercial confidentiality or where disclosure of information would result in negative environmental or social outcomes.

PRINCIPLE 2: Compliance with applicable laws and regulations

Criterion 2.1
There is compliance with all applicable local, national and ratified international laws and regulations.
Criterion 2.2
The right to use the land can be demonstrated, and is not legitimately contested by local communities with demonstrable rights.
Criterion 2.3
Use of the land for oil palm does not diminish the legal rights, or customary rights, of other users, without their free, prior and informed consent.

PRINCIPLE 3: Commitment to long-term economic and financial viability

Criterion 3.1
There is an implemented management plan that aims to achieve long-term economic and financial viability.

PRINCIPLE 4: Use of appropriate best practices by growers and millers

Criterion 4.1
Operating procedures are appropriately documented and consistently implemented and monitored.
Criterion 4.2
Practices maintain soil fertility at, or where possible improve soil fertility to, a level that ensures optimal and sustained yield.
Criterion 4.3
Practices minimise and control erosion and degradation of soils.
Criterion 4.4
Practices maintain the quality and availability of surface and ground water.
Criterion 4.5
Pests, diseases, weeds and invasive introduced species are effectively managed using appropriate Integrated Pest Management (IPM) techniques.
Criterion 4.6
Agrochemicals are used in a way that does not endanger health or the environment. There is no prophylactic use of pesticides, except in specific situations identified in national Best Practice guidelines. Where agrochemicals are used that are categorised as World Health Organisation Type 1A

or 1B, or are listed by the Stockholm or Rotterdam Conventions, growers are actively seeking to identify alternatives, and this is documented.

Criterion 4.7

An occupational health and safety plan is documented, effectively communicated and implemented.

Criterion 4.8

All staff, workers, smallholders and contractors are appropriately trained.

PRINCIPLE 5: Environmental responsibility and conservation of natural resources and biodiversity

Criterion 5.1

Aspects of plantation and mill management, including replanting, that have environmental impacts are identified, and plans to mitigate the negative impacts and promote the positive ones are made, implemented and monitored, to demonstrate continuous improvement.

Criterion 5.2

The status of rare, threatened or endangered species and high conservation value habitats, if any, that exist in the plantation or that could be affected by plantation or mill management, shall be identified and their conservation taken into account in management plans and operations.

Criterion 5.3

Waste is reduced, recycled, re-used and disposed of in an environmentally and socially responsible manner.

Criterion 5.4

Efficiency of energy use and use of renewable energy is maximised.

Criterion 5.5

Use of fire for waste disposal and for preparing land for replanting is avoided except in specific situations, as identified in the ASEAN guidelines or other regional best practice.

Criterion 5.6

Plans to reduce pollution and emissions, including greenhouse gases, are developed, implemented and monitored.

PRINCIPLE 6: Responsible consideration of employees and of individuals and communities affected by growers and mills

Criterion 6.1

Aspects of plantation and mill management, including replanting, that have social impacts are identified in a participatory way, and plans to mitigate the negative impacts and promote the positive ones are made, implemented and monitored, to demonstrate continuous improvement.

Criterion 6.2

There are open and transparent methods for communication and consultation between growers and/or millers, local communities and other affected or interested parties.

Criterion 6.3

There is a mutually agreed and documented system for dealing with complaints and grievances, which is implemented and accepted by all parties.

Note PNG NIWG sees 6.2 and 6.3 as linked

Criterion 6.4

Any negotiations concerning compensation for loss of legal or customary rights are dealt with through a documented system that enables indigenous peoples, local communities and other stakeholders to express their views through their own representative institutions.

Criterion 6.5

Pay and conditions for employees and for employees of contractors always meet at least legal or industry minimum standards and are sufficient to provide decent living wages.

Criterion 6.6

The employer respects the right of all personnel to form and join trade unions of their choice and to bargain collectively. Where the right to freedom of association and collective bargaining are restricted under law, the employer facilitates parallel means of independent and free association and bargaining for all such personnel.

Criterion 6.7

Children are not employed or exploited. Work by children is acceptable on family farms, under adult supervision, and when not interfering with education programmes. Children are not exposed to hazardous working conditions.

Criterion 6.8

Any form of discrimination based on race, caste, national origin, religion, disability, gender, sexual orientation, union membership, political affiliation, or age is prohibited.

Criterion 6.9

A policy to prevent sexual harassment and all other forms of violence against women and to protect their reproductive rights is developed and applied.

Criterion 6.10

Growers and mills deal fairly and transparently with smallholders and other local businesses.

Criterion 6.11

Growers and millers contribute to local sustainable development wherever appropriate.

PRINCIPLE 7: Responsible development of new plantings

Criterion 7.1

A comprehensive and participatory independent social and environmental impact assessment is undertaken prior to establishing new plantings or operations, or expanding existing ones, and the results incorporated into planning, management and operations.

Criterion 7.2

Soil surveys and topographic information are used for site planning in the establishment of new plantings, and the results are incorporated into plans and operations.

Criterion 7.3

New plantings since November 2005 have not replaced primary forest or any area required to maintain or enhance one or more High Conservation Values.

Criterion 7.4

Extensive planting on steep terrain, and/or on marginal and fragile soils, is avoided.

Criterion 7.5

No new plantings are established on local peoples' land without their free, prior and informed consent, dealt with through a documented system that enables indigenous peoples, local communities and other stakeholders to express their views through their own representative institutions.

Criterion 7.6

Local people are compensated for any agreed land acquisitions and relinquishment of rights, subject to their free, prior and informed consent and negotiated agreements.

Criterion 7.7

Use of fire in the preparation of new plantings is avoided other than in specific as identified in the ASEAN guidelines or other regional best practice.

PRINCIPLE 8: Commitment to continuous improvement in key areas of activity

Criterion 8.1

Growers and millers regularly monitor and review their activities and develop and implement action plans that allow demonstrable continuous improvement in key operations.

APPENDIX 2 – RSPO PRINCIPALS AND CRITERIA ADDRESSED BY PNGOPRA RESEARCH

RSPO Principles and criteria addressed by each PNGOPRA study during 2010

NB: Principle 3 is not included below as it is not directly covered by PNGOPRA research although results may contribute to the production of management plans

Principle	1		2			4								5						6											7							8
Criteria	1	2	1	2	3	1	2	3	4	5	6	7	8	1	2	3	4	5	6	1	2	3	4	5	6	7	8	9	10	11	1	2	3	4	5	6	7	1
AGRONOMY RESEARCH																																						
Intercropping trials							x	x						x						x																		x
Fertiliser response trials							x	x			x																											x
Spacing/Thinning/Cover Crop Trials							x	x																														x
Smallholder leaf sampling							x	x																														x
Smallholder fertiliser/BMP demonstrations							x	x		x	x		x							x																		x
Sustainability Project	x						x	x	x				x	x					x																			x
Smallholder block assessments						x	x	x	x	x	x		x	x																								x
Smallholder food security project							x						x	x						x																		x
PALMSIM collaboration with Wageningen							x	x																														x
Agronomy training	x												x																									x
ENTOMOLOGY RESEARCH																																						
Oil Palm Pest Reports										x																												x
PestRecs and TTI levels in 2010										x	x																											x
Pest frequency and distribution										x																												x
Pest Treatment										x	x																											x
Rainfall										x																												x
Insecticide trials										x	x																											x
Rearing of "sexava" and stick insects										x																												x
Sexava survival and reproduction										x																												x
Destructive Palm Sampling										x																												x
Economic monitoring (FFB production)										x																												x
Pest Information Database (PID)						x				x																												x
Methamidophos Usage Database (MUD).						x				x	x																											x
Biological control of insect pests of oil palm	x									x																												x
Sexava egg parasitoids.										x																												x
Pollinating weevils																																						x
Other pests										x																												x
QABB studies															x																							x
Evironmental monitoring project									x																													x
Reference and reprints and insect collections																																						x
Training and field days	x												x																									x
Quarantine related issues														x																								x
Pest Lists										x																												x
PLANT PATHOLOGY RESEARCH																																						
Epidemiology of basal stem rot						x				x																												x
Biological control of Ganaderma										x																												x
Screening for Ganoderma resistance										x																												x
Mitochondrial DNA of Ghana weevils																																						x
Quarantine										x																												x
Publications, conferences and travel	x												x																									x
Disease reports										x																												x
Training	x												x																									x
SOCIO-ECONOMICS RESEARCH																																						
Smallholder engagement strategy													x								x																	x
Mobile Card																					x			x					x	x								x
Clan Land Usage Agreement (CLUA)	x		x	x	x									x						x	x		x												x			x
Household socioeconomic surveys																				x	x																	x
Smallholder food security project							x						x	x						x																		x
Training, field days and radio programs	x												x																									x
Industry support and stakeholder liaison	x												x																									x
Ramu field study	x				x															x	x										x				x			x
Higaturu Smallholder production assessment	x				x		x	x					x							x	x										x				x			x
Totals	11	0	1	1	3	4	11	9	3	23	7	0	13	7	1	0	0	0	1	8	6	0	1	1	0	0	0	0	1	1	2	0	0	0	3	0	0	49