# Annual Research Report

# 2009

**PNG Oil Palm Research Association Inc.**
Dami Research Station, P.O. Box 97, Kimbe, West New Britain Province, Papua New Guinea
Tel +675 9854009 • Fax +675 9854040 • enquiries@pngopra.org.pg

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Dami Research Station, P.O. Box 97, Kimbe, West New Britain Province, Papua New Guinea
Telephone +675 9854009 & 9854015 ◆ Facsimile +675 9854040

**Report by the Managing Director**

**September 2010**

**INTRODUCTION** (Managing Director, Ian Orrell)

2010 is a year of significant change 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 87% of the country's palm oil plantations (Table 1), and with the production from their associated smallholders process about 81% of the country's FFB (Table 2).

Table 1. Area Estimates Dec 2009 (ha)

| Project Area | Plantation | Smallholder | Total | |
|---|---|---|---|---|
| Hoskins (*NBPOL, Mosa*) | 32,228 | 23,597 | 55,825 | 42.4% |
| Popondetta (*NBPOL, Kula Group*) | 8,994 | 14,285 | 23,279 | 17.7% |
| Milne Bay (*NBPOL, Kula Group*) | 11,629 | 1,699 | 13,328 | 10.1% |
| New Ireland (*NPOL, Kula Group*) | 5,689 | 2,613 | 8,302 | 6.3% |
| Ramu (NBPOL, *RAIL*) | 7,668 | 260 | 7,928 | 6.0% |
| Bialla (*Hargy Oil Palms*) | 9,906 | 13,163 | 23,069 | 17.5% |
| TOTAL | 76,114 | 55,616 | 131,730 | |
| | 57.8% | 42.2% | | |

Table 2. FFB Production in 2009 (tonnes)

| Project Area | Plantation | Smallholder | Total | |
|---|---|---|---|---|
| Hoskins | 876,497 | 419,332 | 1,295,829 | 53.1% |
| Popondetta | 196,679 | 131,481 | 328,160 | 13.5% |
| Milne Bay | 210,711 | 10,536 | 221,247 | 9.1% |
| New Ireland | 108,440 | 16,203 | 124,643 | 5.1% |
| Ramu | 56,072 | 124 | 56,196 | 2.3% |
| Bialla | 211,416 | 200,699 | 412,115 | 16.9% |
| TOTAL | 1,659,815 | 778,375 | 2,438,190 | |
| | 68.1% | 31.9% | | |

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 has been 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 itself 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 & Criteria. The RSPO Criteria relevant to the various components of the research programme are indicated in this report. PNGOPRA's Managing Director is a member of the Steering Group of the RSPO Taskforce on Smallholders, a Member of the RSPO Greenhouse Gas Working Group, and also the facilitator of the PNG RSPO National Interpretation Working Group.

PNG's palm oil industry has invested enormously in its commitment to sustainability. It has built an enviable reputation in the world for its commitment and performance. Maintaining and developing further that reputation is essential. However a major reputational threat to PNG's palm oil sub-sector is the proposed establishment in PNG of new oil palm developments that don't follow sustainable practices, and also the large number of proposed 'oil palm' agro-forestry projects that use various legal provisions and take advantage of weak regulatory systems to acquire land in order to extract & sell timber. Currently there are up to 2.9 million hectares of such proposals at various stages in the approvals process. These projects, and their potential for massive deforestation, also pose a major threat to the PNG Government's Climate Compatible Development Plan and planned implementation of REDD+. Many of these potential projects also threaten to remove customary rights over very large tracts of land for as long as three generations. PNGOPRA is working with various regulatory authorities to help mitigate this threat through the strengthening of regulatory processes.

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 organization. This ensures that PNGOPRA is responsive and accountable to the needs of its stakeholders. The organisation is truly demand driven. The member organisations each have one representative on the PNGOPRA Board of Directors. Each Member holds voting rights within the Board that reflect the Member's financial input to the organization; this is calculated on the previous year's FFB production (the PNGOPRA Member's Levy is charged on a FFB basis). Voting rights in 2010 are presented in Table 3.

**Table 3. PNGOPRA Members Voting Rights in 2010**

| | FFB Produced | **VOTES** | |
|---|---|---|---|
| MEMBER | in 2009 | **Number** | **%** |
| New Britain Palm Oil Limited | 876,497 | **9** | 32.1 |
| Smallholders (OPIC) | 778,375 | **8** | 28.6 |
| Kula Palm Oil Ltd (ex CTP (PNG) Ltd) | 515,830 | **6** | 21.4 |
| Hargy Oil Palms Pty Ltd | 211,416 | **3** | 10.7 |
| Ramu Agri-Industries Ltd | n/a | **1** | 3.6 |
| Managing Director | n/a | **1** | 3.6 |

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 with both organizations having seats on each other's Board and management meetings. 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 2010 is K5.84 million. The Member's levy finances 89% of this expenditure and external grants 11%. The Member's levy is set at a rate of K2.00 per tonne of FFB for all growers. In 2010 PNGOPRA's expenditure is distributed as 47.8% agronomy research, 18.4% entomology research, 12.0% plant pathology research, and 21.8% management and centralised overheads.

As part of the organisational changes resulting from the PNGOPRA's strategic planning process, the Managing Director relocated to Port Moresby in late 2009 in order to begin addressing the wider sub-sector issues that were identified during the review process. A new position of Head of Research was created to take responsibility for the operational management of PNGOPRA. William Page was recruited as Head of Research and took up his appointment in May 2010; he is based at Dami Research Station in West New Britain Province.

**RESEARCH 2009** (Head of Research, Bill Page)

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 will show 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.

**Agronomy Programme**

The main task of Agronomy Section is to determine the optimum nutrient requirements for oil palm from trials and at the same time understand 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.

*Fertilizer trials*

The bulk of the work undertaken has been on fertilizer response. At each of the plantations, a number of trials have been set up in collaboration with our stakeholders (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, look into possible effects of progenies on yield responses. Later in the year, trials in NBPOL plantations in West New Britain were handed to OPRS (NBPOL) to manage.

*Spacing trials*
There are several experiments looking at: (i) the effects of different spacing arrangements on yield and (ii) yield monitoring and forecasting. The monitoring trials were closed at the end of 2009. These non-fertiliser related trials are important in providing management information to the industry.

*ACIAR Sustainability Project*
ACIAR funded project looking at sustainability of oil palm production in PNG that has started. As part of this project, Rachel Pipai will be 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.

*Other Projects*
Two other donor funded projects, Minimising nitrogen losses on volcanic soils and Mg/Cation, were closed and have been reported. A summary of Steven Nake's studies, which was part of the cation project, is given in this annual report. Another project looking into food security in smallholder farming systems is in the process of approval. This will be joint project between PNGOPRA and OPIC.

*Smallholder studies*
There has been an increased involvement in smallholder-related activities. There are smallholder fertiliser-demonstration blocks in Hoskins, food security activities in Oro, Hargy and Poliamba, collection of leaf tissues for analysis in Oro and Hargy, and 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.

*Training*
Across all sites, there is continuous involvement in training for the industry. There has been increased involvement, facilitated by OPIC, in 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.

*Technical communication*
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**

*Pest outbreaks*
Although there was a 33% drop in pest reports received during 2009 compared with 2008, it became increasingly obvious that areas infested were increasing and that as infestation reports increased that the treatment teams were struggling to keep up with the continual new reports. Although 4 outbreak reports were received from the mainland, all were monitored but none of them were recommended for treatment. Sexava were the dominant pests reported and *S. defoliaria* replaced *S. decoratus* as the dominant species. The stick insect, *E. calcarata*, was commonly recorded but mostly in association with sexava.

*Sexava studies*
Sexava nymphs were reared in outdoor cages to elucidate microclimates that influence survival of the immature stages of different species.

*Targeted trunk injection (TTI)*
All TTI carried out in oil palm during 2009 was done in West New Britain. NBPOL Smallholder Affairs Department (SHA) is responsible for undertaking the treatment of all smallholder and

plantation blocks within the NBPOL areas recommended for treatment by PNGOPRA. Hargy Oil Palm covers the same for its areas. A total of 4430 and 3145ha of outbreaks were treated in smallholder and plantation blocks respectively in West New Britain during 2009. A major concern was that second treatments were often missed by the control teams and therefore continued infestation is likely to occur

*Destructive sampling of palms*
In plantations, when replanting is due to take place, the old palms are felled mechanically and the fallen palms are windrowed before being overgrown with planted cover crop. Prior to felling, all fronds are cut and sampled for pest species. This gives an idea of where pest species are found on the palm and will help with control strategies. The work continues

*Pest Information Database (PID)*
The database is now fully functional and provides information on all pest reports. This is a useful tool for future analyses and follow-ups.

*Methamidophos Usage Database (MUD)*
This has been established to ensure full records of the insecticide usage is kept and is particularly useful for RSPO auditing purposes.

*Biological control using internal parasites*
The release of the internal parasite of sexava, *Stichotrema dallatorium,* into the wild in West New Britain continues and monitoring confirms that the spread of the parasite continues in *S. defoliaria*. There are still no returns for *S. decoratus*. Monitoring of *Stichotrema* at its origin in Oro (Northern) Province continues to show an average of 23% of *S. novaeguineae* being infected. A collaborative project between PNGOPRA and Oxford University (UK) to investigate the genetic make up of *Stichotrema dallatorium* was begun and tentative results produced. DNA has been submitted for a draft genome assembly and analyses will begin once the data is received.

*Sexava egg parasitoids*
The sexava egg parasitoids, *D.leefmansi* and *L. bicolour*, continue to be bred in the laboratory for release into outbreak areas of sexava to help reduce pest numbers. An approximate total of 1,995,100 *D.leefmansi* and 772,500 *L. bicolour* were released during the year. Studies of the variation in numbers of parasites emerging from the eggs of different species of sexava suggest that the numbers being released are underestimated.

*Stick insects*
The life cycle of stick insect pests has been delineated and monitoring continues in Oro (Northern) Province. Parasitoids were not reared during 2009.

*Wood boring beetles*
There were no reports of major beetle damage during 2009 although an isolated incident of manual control was needed at Ibana (Hargy Oil Palms). The Larger Rhinoceros Beetle (*O. entaurus*) was monitored on a bi-monthly basis on the mainland and Natural Resources Institute (UK) is trying to find a pheromone for this species as this would help with bio-control.

*Bagworm*
Bagworm infestations were very low during the year and no control was necessary as they are controlled naturally by parasitoids, predators and fungi. Collaborative work with P. Hatenschwiler (Switzeralnd) has produced a key for the main species found on oil palm.

*Finschhafen disorder (causal agent Zophiuma lobulata)*
Localised infestations of *Zophiuma lobulata* (Lophopidae) were monitored and used during PNGOPRA's research on the ecology and vector potential of this insect. No outbreaks of *Zophiuma*

were reported. An ACIAR-supported collaborative project with Charles Sturt University (CSU), Australia has been looking at the integrated Pest Management of Finschhafen disorder (FD). Work has been carried out on examining the cause of the disorder, the parasitism, fecundity and the effect of nectar availability on *Zophiuma* longevity. Data were collected on parasites that were found attacking the egg masses of *Zophiuma*, and specimens were sent to specialists for identification and publication. Additional studies by Dean Woruba, also studying at CSU on an ACIAR John Allwright Fellowship, are being undertaken to look at the potential for use of entomopathogenic fungi in controlling *Zophiuma*. Thirty-six (36) fungal samples were collected from the field which are being cultured and encouraged to sporulate in the lab by growing them on specific media. Three genera of fungi have been isolated and will be used in laboratory-based bioassays to assess those fungi which may have potential for further development in an IPM strategy for the control of *Z.lobulata*.

*Weed pests*
Mile-a-minute vine (*Mikania micrantha*) has been studied in oil palm growing areas through a project funded by DPI (ACIAR) through the Project Leader, Dr M Day (DPI, Queensland) and in collaboration with NARI Kerevat. Its distribution, growth and physical and socio-economic impacts in Papua New Guinea have been delineated. Biological control is being tested by distributing plants infected with the rust fungus *Puccinia spegazzinii.*

*Ad hoc* distribution of the gall fly *Ceccidochares connexa* continues in the oil palm growing areas for the control of Siam weed (*Chromolaena odorata*).

Chrysomelid beetles, *Calligrapha pantherina* have been released during the year in WNB in order to control the broomstick weed *Sida rhombifolia.* The release programme will continue.

A report was received from Barema Estate (Hargy Oil Palms) that Water lettuce (*Pistia stratiotes*) was blocking some of the small waterways. The leaf feeding weevil *Neohydronomus affinis* and host weed was collected from the old Agricultural Station at Kapore (WNB). A culture of the weevil is maintained at Dami, and when there are sufficient numbers of infested plants, they are returned to Barema and released into the river.

Water hyacinth (*Eichornia crassipes*) is cultured in plastic drums, and is infected with the Chevroned Waterhyacinth beetle (weevil, *Neochetina bruchi*). Host material is collected from waterways in WNB and infested plants are returned on an ad hoc basis. Monitoring of control efficacy is not undertaken.

*Insecticide trials*
Six trials were conducted in 2009 to test the efficacy of alternative insecticides to the current standard, which is methamidophos (600EC). Orthene 75%WP, Imidacloprid 200SL, Cypermethrin 2% v/v, Acetamiprid 1%v/v were the systemic insecticides available for these trials. Orthene is a good substitute for Methamidophos but is still an organophosphate. Imidacloprid has, so far, given variable results. Cypermethrin and Acetamiprid were not effective when injected into palms.

*Queen Alexandra's Birdwing Butterfly (QABB)*
Work continues on the propagation of QABB's food plant, *Pararistolochia sp.* Rules governing the import and analysis of plant material in Australia were altered by AQIS, and the *Pararistolochia* "family" material sent to the James Cook University, Townsville will not be analysed until 2010. Collaborative work with OPRS (Tissue culture laboratory) continued with emphasis on improving propagation techniques based on multiplication of known origin and food plant cutting material.

*Pollinating weevils*
Approval from DEC to release the weevils that originated from Ghana was granted during the year following the approval previously granted by NAQIA. Cultures continued to be built up in the

quarantine laboratory and their release at RAIL has been re-scheduled for 2010. Weevils continued to show high levels of nematode infection in Oro (Northern) Province.

*Training*
Entomology staff assisted at 17 OPIC field days involving 1,161 growers. Field days are an important interface between PNGOPRA staff and smallholder growers. In addition, 10 separate sessions were held at Dami for NBPOL staff on pest monitoring involving 63 people and there was also one school visit of 25 students to introduce them to the pests and the work PNGOPRA are doing. Radio programmes are scheduled through OPIC and are tailored to cover relevant topics at each session. Entomology provides expertise in the area of pest management.

**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.

*Donor projects*
Two new externally-funded projects commenced in 2009. The first is funded by the Agricultural Innovations Grant Scheme (AIGS), an AusAid beneficiary and provides funding for the development of *Trichoderma* species as biological control agents for Ganoderma. The second is funded by ACIAR and has a large component of the activities based in Solomon Islands where disease levels are high.

*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 up to 9.5 palms/ha were recorded and surveys showed an overall increase in infected palms compared with 2008. Removals of infected palms from some blocks were not completed, although at Maiwara Division 90% removal was achieved. On the PNGOPRA study blocks there was a considerable improvement in 2009 with some blocks achieving 100% removal. Nearly all study blocks in Milne Bay recorded a yield increase despite increases in disease levels except for Block 6503 which showed a decrease in production 2009. In New Ireland, the highest level of infection was 5.7 palms/ha in one Division; all other Divisions had less than 2 palms/ha. There were improvements in disease control with all Divisions achieving a higher efficiency than in previous years. In West New Britain annual disease rates decreased for most fields at Numondo. Field E5 now has a 28% infection rate, yet in Fields E1, E2 and E3 the incidence still remains below 1%. The reasons for this are still unidentified. The adjacent F fields have incidences between 3.8 and 11.8%. Disease control each quarter at Numundo has generally been efficient with only a small percentage of palms remaining in the field from the previous survey. The yield decrease observed in 2008 for MU3 at Numundo appears to have been reversed in 2009 with an average yield of 0.3 tonnes per palm.

All of the six OPRA study blocks were mapped in anticipation of replant in 2010. Disease points were located using GPS and maps generated by the newly formed GIS unit. Maps will continue to be updated until the blocks are replanted.

*Population dynamics*
There are two objectives for this work (i) to determine temporal changes in the population structure of *G. boninense* on oil palm and (ii) to determine the secondary mode(s) of disease spread. Of 104 isolates collected from neighbouring palms in 2009 from Fields E4 and E5 at Numundo, vegetative

compatibility tests showed that the majority were genetically distinct except for isolates from three pairs of adjacent palms. This result indicates a direct relationship between isolates from the three pairs of palms and possibly a common source of infection.

*Ganoderma biological control*
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.

*Trichoderma* isolates were obtained from Milne Bay in 2004 from soil samples by baiting or direct isolation. Trials were carried out using different culture media in order to assess the most suitable medium for conidia and mycelial development. Selected *Trichoderma* isolates were grown in 3 different media and the weights of conidia produced in each of the media were determined. In addition different media were tested against selected fast-growing isolates of *Trichoderma*. A higher number of conidia were produced with RBB media during stationary culture.The different *Trichoderma* isolates were tested against 4 different *Ganoderma dikaryons* isolates and SP5A consistently inhibited the growth of each *Ganoderma dikaryon* isolate to an average length of 0.1 cm and, after 1 week of incubation, the *Ganoderma* lost viability.

The growth of *Ganoderma dikaryon* #1031 on oil palm rachis tissue was tested against *Trichoderma* isolates SP5A, Bu and C. Growth of *Ganoderma* isolate #1301 was severely restricted with over 80% inhibition. However, after 2 weeks, the *Ganoderma* culture was still viable. *Trichoderma* isolates SP5A, Bu and C were each tested against *Ganoderma* isolate # 1326 on rachis blocks for two weeks. After 2 weeks incubation with *Trichoderma* cultures SP5A, Bu and C, the *Ganoderma* culture was killed and no longer viable. The *Trichoderma* cultures effectively prevented the growth of *Ganoderma* with over 90% inhibition.

The diversity of fungi on frond bases was examined in order to assess the potential for competition with *Trichoderma* cultures applied as biological control agents. Of 23 different fungi examined three isolates either out-grew or grew equally as fast as all four *Trichoderma* cultures. These fungi have the potential inhibit the growth of sprayed formulations and need to be identified for further investigations.

Several sets of field trials were undertaken in 2009. The results of these trials have not been summarised as yet but generally, variability due to weather conditions is an inhibiting factor. Trials are continuing.

*Nursery inspections*
The two quarantine nurseries at Milne Bay were inspected on a regular basis in 2009 and no major problems were reported.

*Bogia Coconut Syndrome(BCS)*
In 2008, a disorder affecting coconuts in Bogia, Madang Province was reported by CCI and in November 2008, PNGOPRA staff were invited to the first meeting of a Technical Committee to investigate the matter as a precaution against any movement of biotic agents to oil palm. A collection of samples in Madang Province was made, processed and a selection sent to New Zealand for analysis. It was concluded that the presence of phytoplasmas in coconut palms in the Madang Province has been confirmed by sequencing in 24% of samples. However, the identification of 11 sequenced samples is yet to be confirmed. The pathogenicity (or otherwise) of these phytoplasmas is also unknown and requires further investigation. Symptom expression does not correlate with the presence of phytoplasmas.

*ACIAR Ganoderma Project – The control of basal stem rot caused by Ganoderma in Solomon Islands*
The Project Proposal was finalised in early 2009 and the project officially commenced in June 2009. Partners in the Project are the University of Queensland, Australia and GPPOL in Solomon Islands. As part of the activities in 2009, the two sites selected for Ganoderma disease trials were surveyed and disease maps drawn. Samples of the progenies were also taken and sent to the University of Queensland for molecular typing.

**Smallholder Socio-economic studies**
The socioeconomics work in the oil palm has evolved and gained prominence during the past decade. In 2009, PNGOPRA created the Socio-economics section to continue the initiatives introduced and to harness the strategic partnership and support of external guidance and inputs particularly from the Curtin University of Technology in Australia. The section supports agronomy, entomology and others to develop, validate and promote appropriate innovations, approaches and knowledge systems. Focus on smallholder research is becoming more important with the rapidly changing socio-demographic context of smallholder production (population growth, generational change, land tenure issues, food security and the growing threat of HIV/AIDS), the high rates of under-harvesting amongst smallholders and conformity to RSPO Principles and Criteria.

Smallholder socio-economic research currently has several components including:
- Examining the socio-economic factors affecting productivity among smallholders.
- Improving smallholder agronomic and farm management strategies.
- Understanding smallholder livelihood strategies and their influence on smallholder production.
- Analysing recent socio-agronomic changes occurring among smallholder households
- Monitoring and evaluating smallholder interventions.
- Examining land tenure issues (e.g. customary land developments).

*Mobile Card Payment scheme*
The Socio-economic team reviewed the progress of the Mobile Card Payment scheme following concerns that the number of Mobile Cards in use in Bialla had declined to 56 from a peak of 138 Mobile Cards during the 2007 trial of the scheme. Three main reasons were found for this:
- Many Mobile Card workers (sons of leaseholders and hired labourers) were grossly overpaid with the result that leaseholders were reluctant to renew contracts when they expired. This is the key factor explaining why the scheme has not expanded.
- Limited promotion of the Mobile Card after the trial ended.
- There was some misunderstanding among the OPIC Divisional Managers and extension officers on how the Mobile Card works.

The following recommendations were made:
- Design an easily recognisable weigh docket for Mobile Card fruit to reduce the probability of data entry errors in the smallholder payment office.
- 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.
- Modify Section 4 of the Mobile Card contract to ensure that tasks for the Mobile Card worker can be allocated to specific phases (e.g. Phase 3 at the rear of the blocks were under-harvesting rates are higher).
- Implement a Mobile Card awareness program, initially on the LSS subdivisions.
- Alongside the Mobile Card awareness program, specific groups of farmers should be targeted to take up the Mobile Card.
- Apart from elderly growers, low producing blocks should be targeted to take up the Mobile Card.

- In the longer term, attention should be given to mobilising harvesting teams employed on Mobile Card contracts to target consistently low-producing VOP blocks.

*Household surveys*
In 2009, some household survey instruments were designed and updated from the earlier studies in 2000. These questionnaires were targeted at Land Settlements Schemes (LSS) and the Customary Rights Purchase Blocks (CRPB) with land shortage problems for food production and other livelihood sources. These questionnaires were field tested and training was undertaken for the two smallholder supervisory staff in the socioeconomics section and OPIC extension officers in Hoskins and Popondetta. Some surveys were completed in 2009 in the major Oil palm projects in Bialla, Hoskins and Popondetta and will be continued in 2010.

*Customary Land Use Agreement (CLUA)*
While the core of the work on the CLUA has been presented in the 2008 annual report, additional consultations and discussions have been continued in 2009 to review and update the CLUA to reflect the dynamics of customary land use dealings.

The work covered some of the following areas:

- Areas where customary land is being sold to outsiders and other villagers for oil palm development
- Areas where land disputes are common, especially on VOP and CRPB
- Talk to landowners and buyers and revisit land deals done within the last two years.

The feedback from these discussions have been continuously updated to the revised CLUA form to make it comprehensive to cover all aspects of dealing in land matters particularly on selling of village land to other villages and migrants from other parts of the country.

**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**
Agronomy Section determines the optimum nutrient requirements for oil palm from trials and at the same time undertakes activities to understand the processes which influence and regulate plant nutrient uptake and determine the long term sustainability of the system. The bulk of the work undertaken has been on fertilizer response. At each plantation, trials are carried out depending on soil types and where the gaps in our knowledge are. Some new trials, started in the last 2-3 years, look into possible effects of progenies on yield responses. In late 2009 trials in NBPOL plantations in West New Britain were handed to OPRS (NBPOL) to manage. 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 are several experiments looking at: (i) the effects of different spacing arrangements on yield and (ii) yield monitoring and forecasting. The monitoring trials were closed at the end of 2009. These non-fertiliser related trials are important in providing management information to the industry. An ACIAR funded project looking at sustainability of oil palm production in PNG that has started. Two other donor funded projects: Minimising nitrogen losses on volcanic soils and Mg/Cation, were closed in 2009. Another project looking into food security in smallholder farming systems is in the process of approval. This will be joint project between PNGOPRA and OPIC. There has been an increased involvement in smallholder-related activities and. there are smallholder fertiliser-demonstration blocks in Hoskins, food security activities in Oro, Hargy and Poliamba, collection of leaf tissues for analysis in Oro and Hargy, and 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. There is continuous involvement in training for the industry. There has been a large increase in the use of OPIC smallholder field days to extend the message of appropriate fertiliser management.

## HARGY OIL PALMS

## Trial 205: EFB x P x Mg x N Fertilizer Trial, Hargy (RSPO 4.2, 8.1)

**SUMMARY**
The application of Ammonium nitrate (AN), Triple Super Phosphate (TSP), Kieserite (KIE) did not affect yield in 2009. Despite that, AN increased yield by 2 t/ha in 2009, and response to EFB application was very little (0.1 t/ha). Leaflet N, P and Mg concentrations were significantly increased by EFB, TSP and KIE respectively. Leaflet and rachis K contents were also increased by EFB. Leaflet N concentrations dropped from an average of 2.43 % in 2008 to 2.36 % in 2009, N was applied as a treatment only in late 2007.

**METHODS**

**Trial Background Information**
The purpose of the trial is to investigate the response of oil palm to the application of EFB, and to investigate whether the uptake of phosphorus (P) and magnesium (Mg) from TSP and KIE can be improved by applying the fertilizer in conjunction with EFB. Fertilizer responses in trials can lead to more accurate fertilizer recommendations for oil palm grown on volcanic soils at Bialla. Table 1 provides background information to the trial.

**Table 1**. Trial 205 background information.

| **Trial number** | **205** | Company | Hargy Oil Palms Ltd |
|---|---|---|---|
| Estate | Hargy | Block No. | Area 9, blocks 7 & 8 |
| Planting Density | 135 palms/ha | Soil Type | Volcanic |
| Pattern | Triangular | Drainage | Freely draining |
| Date planted | 1993 | Topography | Gently sloping |
| Age after planting | 15 years | Altitude | 120 m asl |
| Recording Started | June 1997 | Previous Land-use | Oil Palm |
| Progeny | Known* | Area under trial soil type (ha) | Not known |
| Planting material | Dami D x P | Agronomist in charge | Winston Eremu |

** 16 different identified Dami DxP progenies arranged in a random spatial configuration in each plot.*

**Experimental design and treatments**

The EFB x P x Mg x N trial was set up with two rates of each fertilizer in a factorial design, replicated three times with 48 plots (Table 2). The N treatment was included in late 2007 because the palms appeared to be N deficient (based on tissue test analysis). Nitrogen was applied at a basal rate of AN at 3kg/palm in previous years. On half the number of replicates (ie. on three out of the six original replicates) the N rate was increased to 9 kg of AN/palm for 2008 only (the other replicates continued to receive 3 kg AN/palm). Post 2008 the high AN treatment will be 6 kg/palm. Extra N fertilizer was applied on replicates 2, 4 and 6; and remained the same on replicates 1, 3 and 5. Each plot has 36 palms and recordings and measurements were taken on the central 16 palms. The recorded palms consist of 16 different identified Dami DxP progenies, which have been arranged in a random spatial configuration in each plot. The number of bunches and bunch weights were recorded fortnightly on an individual palm basis and totalled for each plot, then totalled for each harvest and yield was expressed as tonne per ha per year. Leaf sampling was carried out according to standard procedures and analysed for nutrient concentrations using standard analytical procedures. Yield and its components and tissue nutrient concentration were analysed using ANOVA (General Analysis of Variance with four treatments, each applied at two rates). Basal fertilizer applied in 2009 was MOP at 2kg/palm and Borate at 150g/palm.

**Table 2**: Fertilizer and EFB treatments applied in Trial 205 in 2009

| Treatment | EFB (kg/palm/yr) | AN* (kg/palm/yr) | TSP (kg/palm/yr) | KIE (kg/palm/yr) |
|---|---|---|---|---|
| 1 | 0 | 3 | 0 | 0 |
| 2 | 0 | 6 | 0 | 0 |
| 3 | 0 | 3 | 0 | 3 |
| 4 | 0 | 6 | 0 | 3 |
| 5 | 0 | 3 | 3 | 0 |
| 6 | 0 | 6 | 3 | 0 |
| 7 | 0 | 3 | 3 | 3 |
| 8 | 0 | 6 | 3 | 3 |
| 9 | 230 | 3 | 0 | 0 |
| 10 | 230 | 6 | 0 | 0 |
| 11 | 230 | 3 | 0 | 3 |
| 12 | 230 | 6 | 0 | 3 |
| 13 | 230 | 3 | 3 | 0 |
| 14 | 230 | 6 | 3 | 0 |
| 15 | 230 | 3 | 3 | 3 |
| 16 | 230 | 6 | 3 | 3 |

* Note the high AN was reduced from 9 kg/palm in 2008

**RESULTS and DISCUSSION**

**FFB yield and its components - mean trend over time**

Fresh fruit bunch yield increased to a peak of about 43 t/ha in 2000 and then decreased progressively to 25 t/ha in 2002 and then stabilised for some years (2003-2006). From 2007 thereafter (2007, 2008 and 2009), the yields increased to above 30 t/ha (Figure 1). A positive relationship exists between the FFB yields (t/ha) and the bunch numbers per palms and subsequently the number of bunches per hectare. Therefore the increase in the FFB yield in 2000 was mainly due to an increase in number of bunches produced. Bunch number has decreased progressively from 2000 till 2002 when it began to stabilise at about 10 bunches per palm. The single bunch weight (SBW) increased progressively until 2003, when the palms were 10 years old, and is now increasing more slowly (in 2009 the SBW was around 26 kg/bunch).

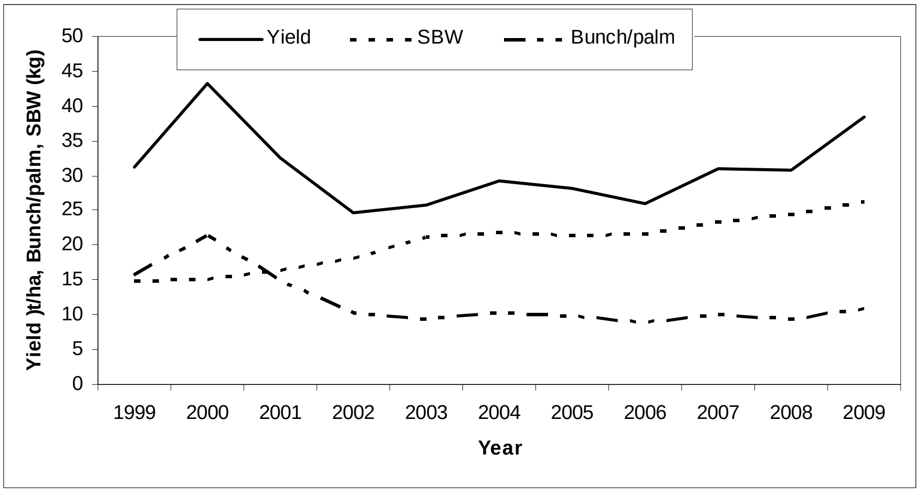



**Figure 1**: FFB yield, Bunch no/palm and SBW from 1999 to 2009.

**Effect of fertiliser treatments on FFB yield and its components in 2009**

AN and Kieserite increased yields in 2009 however were not statistically significant (Figure 2) and generally the responses were inconsistent over time. A possible reason for the inconsistency in responses was the low level of N fertilizer applied as basal applications. In late 2007 extra N fertilizer was applied on half the number of replicates – it still remains to be seen whether this will increase yield. There was no effect from the other fertilizers.

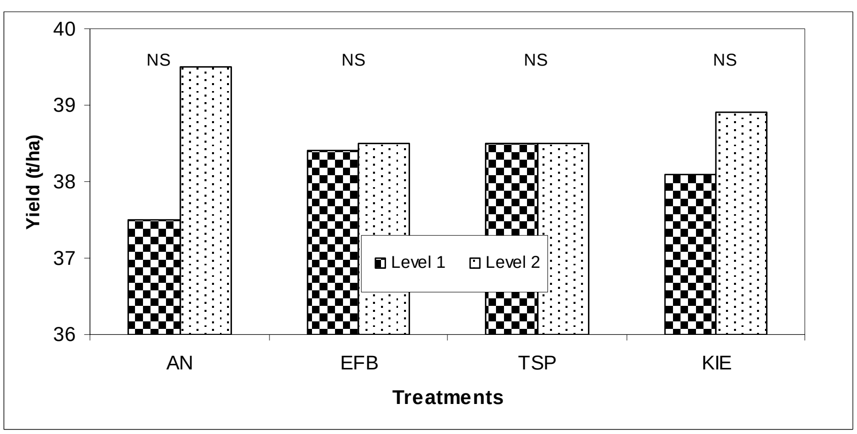



**Figure 2**. Main effect of EFB, Kieserite and TSP on FFB yield (t/ha) in 2009.

**Effect of fertilizer treatments on Tissue nutrient concentration in 2009**

The impact of fertilizer on tissue nutrient concentrations are outlined in Table 3:

- EFB increased leaflet N, K; and rachis K (EFB as a mulch breaks down and releases mineral N, P and K);
- TSP increased leaflet P and rachis P but lowered leaflet and rachis K;
- Kieserite increased leaflet Mg and P.

The effects of fertilizers on the nutrient contents were consistent for the last 3-4 years. The overall nutrient status of this trial is slightly low to adequate.

**Table 3**: Tissue nutrient concentration for Trial 205 in 2009 (figures in bold are significantly different).

| Fertilizer rate (kg/palm) | Leaflet (% dm) | | | | Rachis (% dm) | | |
|---|---|---|---|---|---|---|---|
| | **N** | **P** | **K** | **Mg** | **N** | **P** | **K** |
| AN3 | 2.36 | 0.141 | 0.60 | 0.17 | **0.30** | 0.096 | 1.51 |
| AN6 | 2.37 | 0.144 | 0.61 | 0.16 | **0.33** | 0.090 | 1.55 |
| EFB 0 | **2.34** | 0.142 | **0.59** | 0.17 | 0.32 | 0.091 | **1.47** |
| EFB 230 | **2.38** | 0.143 | **0.61** | 0.17 | 0.32 | 0.094 | **1.59** |
| TSP 0 | 2.36 | **0.140** | **0.62** | 0.17 | 0.31 | **0.078** | **1.59** |
| TSP 3 | 2.36 | **0.145** | **0.58** | 0.17 | 0.32 | **0.118** | **1.47** |
| KIE 0 | 2.36 | **0.143** | 0.60 | **0.15** | 0.32 | 0.094 | 1.53 |
| KIE 3 | 2.37 | **0.144** | 0.60 | **0.19** | 0.31 | 0.091 | 1.53 |
| **$LSD_{0.05}$** | 0.04 | 0.002 | 0.02 | 0.01 | 0.03 | 0.007 | 0.06 |
| **CV%** | 2.8 | 2.1 | 4.5 | 9.1 | 6.1 | 12.4 | 7.1 |

**Effects of fertilizer treatments on vegetative growth parameters**

AN significantly increased PCS, FP, FDM and VDM (Table 4). EFB, TSP and Kieserite also had significant effects on LAI, GF, and TDM respectively.

**Table 4.** Effect (p values) of treatments on vegetative growth parameters in 2009. P values less than 0.05 are in bold.

| Fertilizer | PCS | Radiation Interception | | | | Dry Matter Production (t/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **GF** | **FP** | **FA** | **LAI** | **FDM** | **BDM** | **TDM** | **VDM** |
| AN | **0.05** | 0.108 | **0.036** | 0.969 | 0.154 | **0.040** | 0.384 | 0.120 | **0.045** |
| EFB | 0.15 | 0.075 | 0.987 | 0.206 | **0.050** | 0.216 | 0.643 | 0.184 | 0.196 |
| TSP | 0.62 | **0.002** | 0.082 | 0.171 | 0.448 | 0.694 | 0.624 | 0.498 | 0.657 |
| KIE | 0.06 | 0.863 | 0.865 | **0.039** | 0.080 | 0.084 | 0.252 | **0.029** | 0.065 |
| CV % | 9.1 | 3.3 | 4.9 | 4.7 | 6.0 | 10.1 | 9.8 | 6.5 | 9.2 |

*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).*

## CONCLUSIONS

There were no statistically significant yield responses to inorganic fertilisers and EFB, however significant responses were seen in leaf tissue nutrient contents physiological growth parameters.

# Trial 211: Systematic N Fertilizer Trial, Navo (RSPO 4.2, 8.1)

**SUMMARY**
Trial 211 is a systematic N fertilizer 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. A 10 t/ha yield response resulted from the application of 3.7 kg/palm AN (1.25 kg N/palm) **-** an increase in 4 t/ha than in 2008. The yield response resulted from an increase in single bunch weight (kg/bunch) with increase in N rate. Bunch numbers per hectare (bunch/ha) decreased as palm mature in age. Regardless of the N fertilizer rates, an average yield of 40.6 t/ha was achieved at a rate of 2.22 AN/palm **-** a very good result. 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. Fertilizer applications and data collections are done by PNGOPRA.

**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 at 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).

| Replicate 1 | | | | | | | Replicate 2 | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| N8 | N7 | N6 | N4 | N3 | 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**: Fertilizer treatments and basal applied in Trial 211

| | LEVELS (kg $palm^{-1}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| N Fertilizer 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 fertilizers used by the plantations are applied as basal. In 2009 basal fertilizers 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 2 times a month or 26 times in a year on 14 day intervals. Leaf samples are collected on frond 17 on each selected 16 palms among the 52 measured palms in all the plots once every year. 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 on 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 with leaf sampling, using the same frond 17 on the 16 core palms in each plots in all the plots once a year. These 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 done twice a year. The height of 16 palms selected among the 52 measured palms in all the plots 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 are sent to Dami once every two weeks to be entered into the data base, 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 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 miss read. 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, pest and decease. 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 fertilizer treatment in 2009**

Results of the effects of N fertilizer rates on yield and yield components in 2009 are presented in Table 3. N fertilizer rates significantly increased yield in 2009 ($p<0.001$), and this was due to a positive significant effect on bunch numbers and single bunch weights. A significant yield difference of 4.5 t/ha (>lsd 0.05=2.53) was achieved when the rates increased from 0 to o.25 kg N/palm. Yield responses above 0.25 kg N/palm were not statistically different. The responses were also similar for the three years (2007-2009) running average. Note here that even in nil N fertilized plots, the yields were also exceptionally high at 33 t/ha.

**Table 3**. Effects of applying different N rates over yield (YLD), bunch number per hectare (BHA) and single bunch weight (SBW) in 2009 and for the last three years (2007-2009).

| | | 2009 | | | 2007-2009 | | |
|---|---|---|---|---|---|---|---|
| **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 | 33.1 | 1703 | 19.4 | 34.2 | 1817 | 18.8 |
| 0.25 | 0.74 | 37.6 | 1838 | 20.4 | 37.2 | 1903 | 19.5 |
| 0.5 | 1.48 | 38.6 | 1843 | 21.0 | 37.8 | 1915 | 19.8 |
| 0.75 | 2.22 | 40.6 | 1891 | 21.5 | 39.3 | 1961 | 20.1 |
| 1.0 | 2.96 | 41.9 | 1949 | 22.5 | 40.0 | 1988 | 20.2 |
| 1.25 | 3.70 | 43.2 | 1955 | 21.1 | 41.3 | 2004 | 20.7 |
| 1.5 | 4.44 | 42.2 | 1955 | 21.6 | 40.4 | 1999 | 20.2 |
| 1.75 | 5.18 | 44.9 | 2035 | 22.1 | 42.1 | 2052 | 20.5 |
| 2.0 | 5.92 | 43.0 | 1984 | 21.7 | 40.6 | 2010 | 20.2 |
| **mean** | | **40.6** | **1906** | **21.2** | **39.2** | **1961** | **20.0** |
| **Significant diff** | | **P<0.001** | **P<0.001** | **P<0.001** | **P<0.001** | **P<0.001** | **P<0.001** |
| **$LSD_{0.05}$** | | **2.53** | **105.6** | **0.73** | **1.82** | **79.8** | **0.62** |
| **CV%** | | **6.2** | **5.5** | **3.4** | **4.6** | **4.1** | **3.1** |

*LSD = least significant difference*
*CV % = coefficient of variation*

**Yield response over time**

A gradual and noticeable increase in yield occurred from 2003 to 2009. The response to applying N has been increasing since 2003 and in 2009 resulted in a 10 t/ha yield increase (Figure 2). The N rates more than 2kg AN have now produced more than 40t/ha.

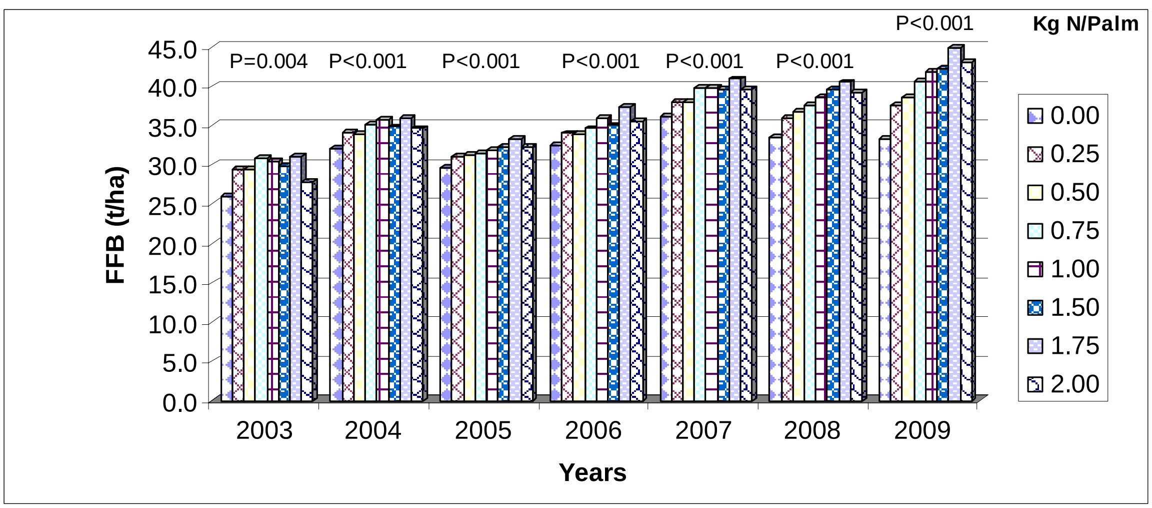



**Figure 2**: Yield response to all the rates of N (kg/palm) over time, (fertilizer N was first applied in late 2002)

**Tissue nutrient concentration for 2009**

Results of effects of N fertilizer rates on leaf nutrient contents for 2009 are presented in Table 4. Leaflet N and Rachis N increased with rates of N fertilizer at p<0.001. Leaflet P increased with N rates, whilst there were no significant effect of N rate on leaflet K, and rachis P and K.

**Table 4**. Leaf and rachis nutrient content for trial 211 in 2009

| N rate ( kg/palm) | Equivalent AN rate (kg/palm) | Leaf (% dm) | | | | | Rachis ( % dm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | | N | P | K | Mg | B | N | P | K |
| 0.00 | 0.00 | 2.25 | 0.133 | 0.66 | 0.216 | 20.9 | 0.269 | 0.063 | 1.88 |
| 0.25 | 0.74 | 2.29 | 0.133 | 0.67 | 0.206 | 20.0 | 0.275 | 0.061 | 2.04 |
| 0.50 | 1.48 | 2.37 | 0.136 | 0.66 | 0.194 | 20.3 | 0.279 | 0.062 | 2.04 |
| 0.75 | 2.22 | 2.42 | 0.138 | 0.65 | 0.190 | 20.2 | 0.291 | 0.064 | 2.05 |
| 1.00 | 2.96 | 2.45 | 0.139 | 0.66 | 0.189 | 18.2 | 0.290 | 0.065 | 2.05 |
| 1.25 | 3.70 | 2.50 | 0.140 | 0.66 | 0.180 | 18.7 | 0.296 | 0.061 | 2.06 |
| 1.50 | 4.44 | 2.46 | 0.138 | 0.64 | 0.178 | 19.1 | 0.321 | 0.064 | 2.07 |
| 1.75 | 5.18 | 2.52 | 0.141 | 0.66 | 0.175 | 18.5 | 0.311 | 0.066 | 2.06 |
| 2.00 | 5.92 | 2.54 | 0.141 | 0.66 | 0.175 | 19.0 | 0.314 | 0.064 | 2.07 |
| **Mean** | | **2.42** | **0.138** | **0.66** | **0.189** | **19.4** | **0.294** | **0.063** | **2.04** |
| **Significant difference** | | **P<0.001** | **P<0.001** | **NS** | **P<0.001** | **NS** | **P<0.001** | **NS** | **NS** |
| **$LSD_{0.05}$** | | **0.08** | **0.004** | **0.03** | **0.02** | **-** | **0.02** | **0.01** | **-** |
| **CV%** | | **3.3** | **2.8** | **4** | **9.4** | **13.8** | **7.8** | **13** | **7.4** |

**Tissue N concentration over time 2004 to 2009**

The mean leaflet N contents fell with time from 2.70 % in 2004 to 2.42 % DM in 2009 (Table 5). The low N rates (0.00, 1.25 and 1.50 kg N/palm) have fallen to below critical levels in 2009.

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

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

**Fertilizer N effects on oil palm vegetative growth**

The effect N fertilizer rates on the physiological growth parameters are presented in Table 6. About 23 new fronds were produced in 2009 (one every 16 days), indication of good growing conditions during the year. Total green fronds counted per palm averaged at 34 fronds. AN had significant effects on all the physiological growth parameters in 2009.

**Table 7**. Effects of N treatments on vegetative growth parameters in 2009

| N rate Kg/palm | Equiv- AN rate Kg/palm | Radiation Interception | | | | | Dry matter production (t/ha/yr) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | PCS | GF | FP | FA | LAI | FDM | BDM | TDM | VDM |
| 0.00 | 0 | 37.7 | 32.4 | 21.6 | 12.8 | 4.8 | 10.1 | 13.9 | 26.6 | 12.7 |
| 0.25 | 0.74 | 39.7 | 33.6 | 22.5 | 13.1 | 5.0 | 11.0 | 15.4 | 29.3 | 14.0 |
| 0.50 | 1.48 | 40.5 | 33.6 | 22.9 | 13.4 | 5.2 | 11.4 | 15.8 | 30.2 | 14.5 |
| 0.75 | 2.22 | 41.5 | 33.9 | 23.2 | 13.8 | 5.4 | 11.8 | 16.7 | 31.7 | 15.0 |
| 1.00 | 2.96 | 41.8 | 34.4 | 23.6 | 13.5 | 5.3 | 12.1 | 17.2 | 32.6 | 15.4 |
| 1.25 | 3.7 | 42.4 | 34.3 | 23.8 | 13.1 | 5.6 | 12.4 | 17.6 | 33.4 | 15.8 |
| 1.50 | 4.44 | 42.9 | 34.8 | 23.6 | 14.8 | 5.5 | 12.5 | 17.2 | 33.0 | 15.8 |
| 1.75 | 5.18 | 42.4 | 34.7 | 23.5 | 13.2 | 5.3 | 12.3 | 18.6 | 34.4 | 15.9 |
| 2.00 | 5.92 | 40.5 | 34.6 | 23.8 | 13.2 | 5.3 | 11.8 | 17.4 | 32.4 | 15.1 |
| **Mean** | | **41.0** | **34.0** | **23.2** | **13.4** | **5.3** | **11.7** | **16.6** | **31.5** | **14.9** |
| **Significance** | | **P<0.001** | **P<0.001** | **P<0.001** | **P=0.004** | **P<0.001** | **P<0.001** | **P<0.001** | **P<0.001** | **P<0.001** |
| **$LSD_{0.05}$** | | **2.0** | **1.0** | **0.7** | **0.6** | **0.3** | **0.7** | **1.2** | **1.7** | **0.8** |
| **CV %** | | **4.8** | **2.9** | **2.9** | **4.7** | **5.6** | **5.9** | **7.0** | **5.3** | **5.4** |

*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 fertilizer has significantly increased yields above 33 t/ha, an increase between 4 to 11 t/ha in 2009. Substantial yields of over 40 t/ha were realized at N rates at more than 0.7kg N/palm (equivalent of more than 2.0 kg AN/palm). Despite that, the optimum yield response of 10 t/ha achieved at N rate of 1.25 kg/palm (equivalent of 3.70kg/palm AN). The data from 2007 to 2009 also showed similar responses. Interestingly, yields from the nil fertilized plots were reasonably high (33.1 t/ha) for the last 6-7 years, however the actual FFB yields are now starting to fall as observed in 2008 and 2009.

Leaf N levels in each treatment levels had been gradually falling over the years. The results in 2009 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 fertilizer also improved the growth of the palm by increasing the radiation interception and the vegetative dry matter production of the oil palm.

**CONCLUSION**

There were significant responses in yield, tissue nutrient contents and physiological growth parameters in 2009. Leaflet N contents and yield in the low N rate plots have been falling with time.

# Trial 212: Systematic N Fertilizer Trial, Hargy (RSPO 4.2, 8.1)

**SUMMARY**
Trial 212 is a systematic Nitrogen (N) fertilizer trial purposely 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 11t/ha yield response resulted from the application of 4.44kg/palm AN (1.50 kg N/palm), a significant increase of about 7t/ha higher than the 2008 result. The yield response resulted from an increase in single bunch weight (kg/bunch) with increase in N rate. Bunch numbers per hectare (bunch/ha) decreased as palm mature in age. Regardless of the N fertilizer rates, average yield for the trial block was achieved at more than 30 t/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.

**BACK GROUND**
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. Fertilizer applications and data collections are done by PNGOPRA.

**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 at 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.)

| 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**: Fertilizer 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 fertilizers used by the plantations, but not included as treatments are applied as basal. In 2009 basal fertilizers 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 on 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. These data collected are 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. These data are 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 are sent to Dami once every two weeks to be entered into the data base, 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 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 miss read. 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, pest and decease. 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 fertilizer treatment in 2009**

The results of yield and yield component responses to N fertilizer rates are presented in Table 3. N fertilizer rates had a significant positive effects on yield and yield components in 2009 and in 2007-2009 period. The increase in yield was due to significant increases in the number of bunches and single bunch weight. A yield increase of 12 t/ha from the nil fertilized plot was obtained with application of 2.00 kg N/palm (equivalent to 5.92kg AN/palm).

**Table 3**. Trial 212: 2009 Yield (t/ha), bunches/ha) and SBW (kg/bunch) by N rate.

| | | 2009 | | | 2007-2009 | | |
|---|---|---|---|---|---|---|---|
| **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 | 23.9 | 1156 | 20.6 | 22.8 | 1175 | 19.4 |
| 0.25 | 0.74 | 23.7 | 1105 | 21.5 | 22.5 | 1127 | 20.0 |
| 0.5 | 1.48 | 30.0 | 1315 | 22.8 | 26.6 | 1279 | 20.8 |
| 0.75 | 2.22 | 30.5 | 1303 | 23.5 | 27.1 | 1258 | 21.6 |
| 1.0 | 2.96 | 31.9 | 1319 | 24.3 | 28.3 | 1261 | 22.5 |
| 1.25 | 3.70 | 32.6 | 1379 | 23.8 | 29.1 | 1348 | 21.6 |
| 1.5 | 4.44 | 35.0 | 1467 | 23.9 | 30.2 | 1370 | 22.1 |
| 1.75 | 5.18 | 34.2 | 1418 | 24.2 | 30.0 | 1351 | 22.2 |
| 2.0 | 5.92 | 36.4 | 1568 | 23.2 | 30.8 | 1428 | 21.5 |
| **Mean** | | **30.9** | **1337** | **23.1** | **27.5** | **1288** | **21.3** |
| **Significant diff** | | **P<0.001** | **P<0.001** | **P<0.001** | **P<0.001** | **P=0.001** | **P<0.001** |
| **LSD0.05** | | **3.1** | **150.7** | **1.3** | **2.1** | **107.5** | **1.0** |
| **CV%** | | **5.2** | **5.5** | **5.9** | **4.4** | **4.7** | **1.1** |

### 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 fertilized plots widened with time, a difference of 11 t/ha was recorded in 2009 (Figure 3).

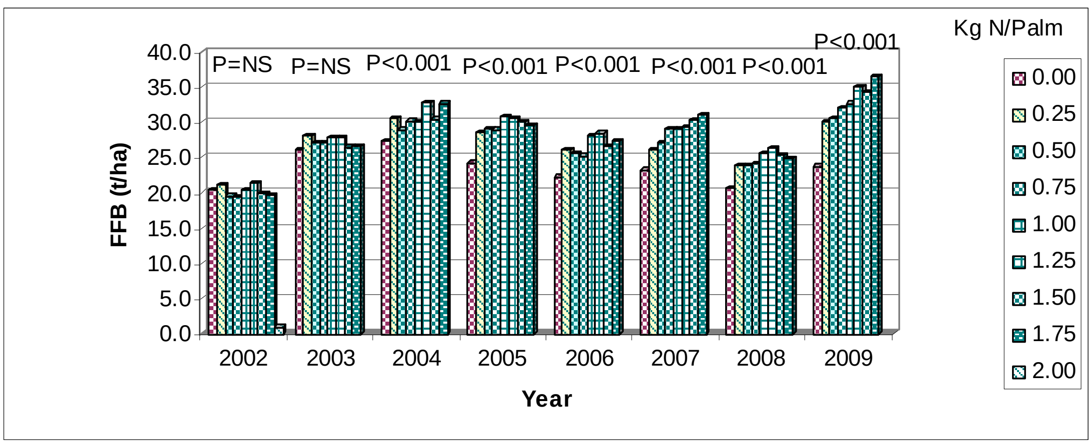



**Figure 3**. Trial 212: Yield response to all the rates of N (Kg/palm) over time (fertilizer N was first applied 2002.

### Tissue nutrient concentration

The effects of N fertilizer rates on the leaflet and rachis nutrient contents is presented in Table 4. Application of N fertilizer significantly (p<0.001) increased leaflet N and P contents but reduced K and Mg contents in the leaflets. Despite the increase in leaflet contents with N fertilizer rates, 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 contents were adequate. The N treatment did not have any significant effects on the nutrient concentration in the rachis.

**Table 4.** Tissue nutrient concentration for leaflets and rachis in 2009.

| 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 | 2.18 | 0.135 | 0.64 | 0.211 | 15.5 | 0.31 | 0.061 | 1.82 |
| 0.25 | 0.74 | 2.15 | 0.130 | 0.63 | 0.210 | 14.6 | 0.31 | 0.055 | 1.72 |
| 0.50 | 1.48 | 2.24 | 0.134 | 0.60 | 0.200 | 15.0 | 0.31 | 0.057 | 1.70 |
| 0.75 | 2.22 | 2.28 | 0.134 | 0.60 | 0.185 | 14.6 | 0.33 | 0.054 | 1.67 |
| 1.00 | 2.96 | 2.33 | 0.136 | 0.60 | 0.181 | 14.2 | 0.34 | 0.055 | 1.71 |
| 1.25 | 3.70 | 2.35 | 0.137 | 0.59 | 0.174 | 14.2 | 0.33 | 0.068 | 1.69 |
| 1.50 | 4.44 | 2.38 | 0.138 | 0.62 | 0.170 | 14.2 | 0.36 | 0.061 | 1.82 |
| 1.75 | 5.18 | 2.40 | 0.136 | 0.61 | 0.165 | 13.8 | 0.36 | 0.060 | 1.77 |
| 2.00 | 5.92 | 2.41 | 0.138 | 0.62 | 0.158 | 13.8 | 0.36 | 0.060 | 1.71 |
| **GM** | | **2.30** | **0.135** | **0.61** | **0.183** | **14.4** | **0.34** | **0.058** | **1.73** |
| **p values** | | **P<0.001** | **P<0.001** | **P=0.004** | **P<0.001** | **NS** | **NS** | **NS** | **NS** |
| **LSD0.05%** | | **0.04** | **0.003** | **0.03** | **0.014** | **1.6** | **0.03** | **0.007** | **-** |
| **CV%** | | **1.9** | **2.0** | **5.4** | **7.7** | **11.0** | **8.0** | **12.7** | **8.1** |

### Tissue N concentration over time 2004 to 2009

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

**Table 5**. Leaflet N (% DM) from 2004 to 2009

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

### Fertilizer N effects on oil palm vegetative growth

The results of effects of N fertilizer rates on the physiological growth parameters are presented in Table 6. N fertilizer 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 2009.

| 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 | 40.9 | 33.8 | | 12.6 | 6.0 | 8.8 | 12.3 | 23.4 | 11.1 |
| 0.25 | 0.74 | 42.4 | 33.8 | | 12.9 | 6.1 | 8.9 | 12.0 | 23.2 | 11.2 |
| 0.50 | 1.48 | 45.3 | 34.4 | | 13.7 | 6.6 | 9.7 | 15.1 | 27.6 | 12.5 |
| 0.75 | 2.22 | 46.8 | 34.7 | | 14.4 | 7.0 | 10.1 | 15.4 | 28.3 | 12.9 |
| 1.0 | 2.96 | 46.6 | 34.8 | | 13.9 | 6.8 | 10.1 | 15.9 | 28.9 | 12.9 |
| 1.25 | 3.70 | 49.4 | 34.1 | | 14.4 | 6.9 | 10.5 | 16.3 | 28.8 | 13.5 |
| 1.5 | 4.44 | 48.5 | 35.0 | | 14.3 | 7.0 | 10.7 | 17.3 | 31.1 | 13.8 |
| 1.75 | 5.18 | 48.6 | 34.8 | | 14.2 | 6.9 | 10.6 | 17.2 | 30.9 | 13.7 |
| 2.0 | 5.92 | 50.9 | 34.9 | | 14.4 | 7.0 | 11.3 | 18.8 | 33.4 | 14.6 |
| | **Mean** | 46.6 | 34.5 | | 13.9 | 6.7 | 10.1 | 15.6 | 28.5 | 12.9 |
| | **Significant difference:** | **<0.001** | **NS** | | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **P<0.001** | **<0.001** |
| | **$LSD_{0.05}$** | **2.4** | **-** | | **0.7** | **1.5** | **0.6** | **1.6** | **2.1** | **0.7** |
| | **CV%** | **5.3** | **4.9** | | **5.3** | **7.2** | **6.1** | **10.5** | **7.4** | **5.8** |

*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 fertilizer, yields had significantly increased above 23 t/ha, an increase between 7 to 13t/ha in 2009. Substantial yields of over 30 t/ha was realized at N rates greater than 0.7kg N/palm (equivalent of more than 2.0 kg AN/palm), with optimum yield response of 13 t/ha achieved at N rate of 2.0 kg/palm (equivalent of 5.92kg/palm AN). Similar effects were seen in 2007-2009 average yield data. Yield from the nil fertilized plots produced was on average 23.4 t/ha for the last 6-7 years. The highest yield in the nil fertilized was 27.1t/ha recorded in 2003. The leaf N levels in these plots are lower than 2.30% (deficient) for the last four years, as was expected in nil N fertilized plots. Leaf N levels at each of the treatment levels had been gradually falling over the years. The results in 2009 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 fertilizer also improved the radiation interception and dry matter production parameters of palms.

**CONCLUSION**

N fertilizers significantly increased yield and yield components, leaflet N contents and physiological growth parameters and the effects have been consistent for the last 5 years.The leaflet N contents in the leaflets have been falling with time.

# Trial 214: P (TSP) Fertilizer placement, Hargy (RSPO 4.2, 8.1)

**SUMMARY**
The P treatments have not shown any significant effects on the yields, 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 19.6t/ha in 2008 to 24.2 t/ha in 2009 but below the pretreatment yield average of 27.8t/ha in 2007.The bunch numbers per hectare (b/ha) and single bunch weights also increased in 2009. N levels in the leaflets (2.35 %) and the P levels in both leaflets (0.136 %) and rachis (0.038 %) were below the critical level.

**BACKGROUND**
Trial 214 was originally setup 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 is 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 pretreatment data and soil samples were collected in 2007. The application of treatment fertilizers were done in October 2008. Harvesting of ripe bunches and all other upkeep work is done by the plantation. Fertilizer applications and data collections are done by PNGOPRA.

**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 yet available).

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

| **Treatment code** | **P rates / placement (Kg/placement)** | **2007** | |
|---|---|---|---|
| | | **Yield (t/ha)** | **PCS (cm²)** |
| 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** |
| **Significant difference** | | **NS** | **NS** |
| **$LSD_{0.05}$** | | **4.6** | **3.0** |
| **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** |
| **LSD0.05%** | | **0.09** | **0.004** | **0.03** | **0.02** | **2.1** | **0.01** | **0.005** | **0.1** |
| **CV%** | | **3.2** | **2.7** | **4.5** | **11.9** | **12.0** | **5.5** | **12.2** | **8.1** |

**MATERIALS AND METHODS**

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

**Table 4**. Fertilizer treatments applied in Trial 214

| Fertilizer | 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 2009 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 on frond 17, on 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 on 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 with leaf sampling, using the same frond 17 on the 16 core palms in each plots in all the plots once a year. These 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 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. These data's are 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 are sent to Dami once every two weeks to be entered into the data base, 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 miss read. 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, pest and decease. This information's are 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 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.

**RESULT**

Two years after the setting of the trial and the yields with other components (Bunch number and SBW) have not shown any significant response to the treatments (Table 5). The average yield for all plots in 2008 was 19.6 t/ha and in 2009 24.2 t/ha, an increase of 4.6 t/ha. Bunch number increased slightly from an average 1127 to 1173 bunches/ha from 2008 to 2009. The average single bunch weight was 17.4kg and 20.6kg in 2008 and 2009 respectively. The highest yield was obtained from treatment 2 (1.0 kg P in the WC). The difference between high yield (WC – 1.0Kg/palm) and control (Zero) was 2.0 t/hat. The 2008-2009 data also showed no response to the treatments (Table 6).

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

| Treatment levels | P Rates Kg/palm/year | Placement | Yield (t/ha) | BHA (bunch/ha) | SBW (kg/bunch) |
|---|---|---|---|---|---|
| 1 | 0.0 | Control | 23.5 | 1190 | 19.8 |
| 2 | 1.0 | 1 - WC | 25.6 | 1211 | 21.1 |
| 3 | 1.0 | 2 - FP | 23.8 | 1131 | 21.0 |
| 4 | 2.0 | 1 - WC | 23.3 | 1095 | 21.4 |
| 5 | 2.0 | 2 - FP | 24.7 | 1240 | 19.8 |
| Mean | | | 24.2 | 1173 | 20.6 |
| Significance | | | NS | NS | NS |
| LSD0.05 | | | 5.7 | 254.6 | 1.5 |
| CV% | | | 19.9 | 18.3 | 6.3 |

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

**Table 6**. Yield (t/ha), Bunch numbers per hectare (bunch/ha) and SBW (Kg/bunch) by TSP rates (2008- 2009).

| Treatment levels | P Rates Kg/palm/year | Placement | Yield(t/ha) | BHA(bunch/ha) | SBW(kg/bunch) |
|---|---|---|---|---|---|
| | | | 2008-2009 | | |
| 1 | 0.0 | Control | 21.0 | 1135 | 18.4 |
| 2 | 1.0 | 1 - WC | 23.9 | 1212 | 19.7 |
| 3 | 1.0 | 2 - FP | 21.2 | 1109 | 19.0 |
| 4 | 2.0 | 1 - WC | 21.6 | 1112 | 19.5 |
| 5 | 2.0 | 2 - FP | 21.9 | 1184 | 18.4 |
| Mean | | | 21.2 | 1150 | 19.0 |
| Significance | | | NS | NS | NS |
| LSD0.05 | | | 4.5 | 200.3 | 1.3 |
| CV% | | | 17.5 | 14.6 | 5.8 |

The treatments did not have any significant effects on both leaflet and rachis nutrient concentration in 2009 (Table 7). Leaflet N plummeted in 2008, but increased in 2009 due to application of N as one of the basal fertilizer in 2008 (Table 8). The N levels in both the leaflet and rachis have increased in 2009. Despite that, the leaflet N is still below the adequate range, while the rachis N concentration has been increased to adequate level. All other nutrients in both leaflet and rachis (K, Mg, B) are available in adequate levels, except leaflet and rachis P which is obviously deficient, making this site a good one for the P placement trial.

**Table 7**. Tissue nutrient concentrations for leaflet N, P, K, Mg, B and rachis N, P, K in 2009.

| **Treat-Levels** | **P rates / placement (Kg/palm)** | **Leaf (%dm)** | | | | | **Rachis (%dm)** | | |
|---|---|---|---|---|---|---|---|---|---|
| | | **N** | **P** | **K** | **Mg** | **B** | **N** | **P** | **K** |
| 1 | 0.0 – Nil (Control) | 2.29 | 0.134 | 0.65 | 0.218 | 19.0 | 0.35 | 0.039 | 1.82 |
| 2 | 1.0 – Weeded Circle | 2.33 | 0.138 | 0.65 | 0.207 | 18.1 | 0.34 | 0.036 | 1.75 |
| 3 | 1.0 – Frond Pile | 2.27 | 0.137 | 0.69 | 0.218 | 18.8 | 0.33 | 0.038 | 1.73 |
| 4 | 2.0 – Weeded Circle | 2.26 | 0.137 | 0.67 | 0.200 | 17.1 | 0.36 | 0.040 | 1.74 |
| 5 | 2.0 – Frond Pile | 2.30 | 0.138 | 0.63 | 0.225 | 18.2 | 0.22 | 0.035 | 1.73 |
| **Mean** | | **2.29** | **0.137** | **0.66** | **0.213** | **18.3** | **0.35** | **0.04** | **1.75** |
| **Significant difference** | | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| **LSD0.05%** | | **0.11** | **0.004** | **0.03** | **0.03** | **0.8** | **0.01** | **0.03** | **0.1** |
| **CV%** | | **4.0** | **2.3** | **4.5** | **11.9** | **2.3** | **5.5** | **7.3** | **7.0** |

**Table 8**. Trial 214: Leaflet N (%dm) over time

| TSP Levels | P rates / placements (Kg/palm) | Leaflet N (%dm) | | |
|---|---|---|---|---|
| | | 2007 | 2008 | 2009 |
| 1 | 0.0 - Nil (control) | 2.29 | 2.09 | 2.29 |
| 2 | 1.0 - Weeded Circle | 2.39 | 2.17 | 2.33 |
| 3 | 1.0 – Frond Pile | 2.35 | 2.14 | 2.27 |
| 4 | 2.0 - Weeded Circle | 2.38 | 2.20 | 2.26 |
| 5 | 2.0 – Frond Pile | 2.32 | 2.07 | 2.30 |
| **Mean** | | **2.35** | **2.13** | **2.29** |
| **Significant Difference** | | **NS** | **NS** | **NS** |
| **$LSD_{0.05}$** | | **0.09** | **0.13** | **0.11** |
| **CV %** | | **3.2** | **5.0** | **4.0** |

**Fertilizer N effects on oil palm vegetative growth**

Similar to the other parameters, there was no significant response on the vegetative growth of the palm by the fertilizer treatments (Table 9).

*Frond production and frond number*

On average 14 new fronds were produced in 2009 (one every 26 days) a drop by 7 fronds from 2008. Total green fronds counted per palm averaged 34 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 13 year old palms (average frond area $12m^2$ and LAI of 5.6).

*Vegetative dry matter production*

Regardless of the treatments, there was an increase in Dry matter production (FDM, BDM, TDM and VDM) in 2009. 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 9 -** Effects of N treatments on vegetative growth parameters in 2009.

| 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 | 37.6 | 33.7 | 13.8 | 12.4 | 5.4 | 7.2 | 11.9 | 21.2 | 9.3 |
| 2 | 1.0 - WC | 38.9 | 34.9 | 13.8 | 12.6 | 5.7 | 7.4 | 13.3 | 23.0 | 9.8 |
| 3 | 1.0 - FP | 37.4 | 35.2 | 13.5 | 12.4 | 5.6 | 7.0 | 12.4 | 21.6 | 9.2 |
| 4 | 2.0 - WC | 40.2 | 35.8 | 14.1 | 12.8 | 5.9 | 7.8 | 11.9 | 21.9 | 10.0 |
| 5 | 2.0 - FP | 38.9 | 33.4 | 13.5 | 12.4 | 5.3 | 7.2 | 12.8 | 22.2 | 9.5 |
| | **Mean** | 38.6 | 34.6 | 13.8 | 12.5 | 5.6 | 7.4 | 12.5 | 22.0 | 9.5 |
| **Significant diff-: (P)** | | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| | **$LSD_{0.05}$** | **3.5** | **1.8** | **1.4** | **1.1** | **0.6** | **1.0** | **3.0** | **4.2** | **5.8** |
| | **CV%** | **7.6** | **4.4** | **8.8** | **7.3** | **8.7** | **11.4** | **20.6** | **16.1** | **20.6** |

*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, leaflet/rachis tissue levels and the overall vegetative growth of the palms. Despite that, the yields have increased by 4 t/ha in 2009. This increase was caused by an increase in bunch number in 2009.

Application of N as basal since the inception of the trial has improved the N levels in the leaflets, but still below the adequate range. However, the rachis N levels are reasonably high (adequate) and that should eventually be translocated to the leaflets, which may boost the N concentration in the leaflets in 2010. P level in both the leaflets and the rachis is still very low and should provide a better response from the treatments in the future.

**CONCLUSION**

The yield drop in 2008 of 19.9t/ha has picked up in 2009 to 24.2t/ha. The difference between the control and the highest yield (WC 1.0kg/palm) is only 2.0t/ha and not an effect from the treatments. Leaf N is below the critical level but has increased, while P levels in both leaflet and rachis were deficient.

# NEW BRITAIN PALM OIL : WEST NEW BRITAIN

## Trial 137: Systematic N Fertiliser Trial, Kumbango (RSPO 4.2, 8.1)

**SUMMARY**
The FFB yields and vegetative growth parameters have not shown any significant response to N treatment after 5-6 years. The yields have generally picked up in 2009 compared to 2008. The average yield for the trial block is around 30.6 t/ha which is high, which the control (0 N) yielding 29.7 t/ha. The average bunch weight and bunch number/ha for the trial in 2009 was 22.4 kg and 1362 bunches/ha respectively. Despite that, significant responses (p=0.009) were seen in leaflet N in 2009, whereby leaflet N was increased through N application. The response for K and Mg was negative, by reducing their concentration in the leaflets. It is anticipated that the response in the N leaflet will eventually be translocated to the leaflets.

**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. This trial was approved in the 1999 SAC meeting. There was a change of N source from ammonium chloride (AC) to ammonium nitrate (AN) in 2004. The soil of the trial site is freely draining pumiceous sand and gravel intermixed with finer volcanic ash. Other background information of the trial is given in Table 1. 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. This trial is similar to trial 138 at Haella and Trials 211 and 212 in Hargy Oil Palms.

**Table 1**. Basic information on Trial 137

| | | | |
|---|---|---|---|
| Trial number | 137 | Company | NBPOL |
| Date planted* | Oct 1999 | Planting density (palm $ha^{-1}$)* | 128 palm $ha^{-1}$ |
| Spacing | | Pattern | Triangular |
| LSU or MU* | Div 2 | Soil type* | Volanic sand and pumice |
| Recording started | March 2003 | Palm age (years after planting)* | 10 years |
| Topography* | Flat | Planting material | Dami D x P |
| Progeny | unknown | | |
| Drainage* | Free draining | Previous land use* | Oil Palm |
| Office in charge | S. Nake | Area under trial soil type (ha)* | Not known |

**MATERIALS AND METHODS**

**Experimental Design and Treatments**
Trials 137 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 at 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 (Table 2). Each plot has 4 measured rows of palms with 15 palms each (60 palms/plot). In trial 137 the AN fertilizer is applied in two doses per year in replicate blocks 1, 3, 5 and 7; whilst blocks 2, 4, 6 and 8 receive ten doses of AN per year. A one-way ANOVA was used to analyse: (i) yield and its components; (ii) tissue nutrient concentrations; and (iii) vegetative parameters. Yield and nutrient levels are also presented over time (since the start of the trials).

**Table 2**. Example of two replicates for the Systematic N trial design (N rate increments are at 0.25kg N/palm)

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

**Data Collection**

Yield recording is done every fortnight (14 day round) on all palms in the two central rows (Rows B & C) of each plot/treatment. Loose fruits are also collected and weighed with their respective bunches. Bunches from the palms in rows A & D are not weighed. The data is recorded onto the yield record sheets in the field and later on entered onto the computer data base using Microsoft Access and are later on converted into yield expressed in tonnes per hectare, total number of bunches harvested per hectare and the single bunch weight. 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.

**Trial maintenance and upkeep**

The two trial blocks 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

**Yield and its components response to fertilizer treatment in 2009**

There was no significant increase in yield, and the other yield components (bunch number and single bunch weight) from N treatments in 2009 (Table 3). However, the 2009 yield was on average 3.7 t/ha more than in 2008 (Figure 1), despite the continuous drop in the number of bunches per hectare (Figure 2). Similar response was observed in average data for 2007 to 2009. Despite no response, the FFB yields from the 0 N treatment yielded about 1-2 tonnes lower than the N treated plots (Table 3).

**Table 3**. Main effects of fertilizer treatments on yield and components in Trial 137

| | | 2009 | | | 2007-2009 | | |
|---|---|---|---|---|---|---|---|
| N rate | Equivalent AN rate | Yield | Bunch number | Bunch weight | Yield | Bunch number | Bunch weight |
| kg palm$^{-1}$ | kg palm$^{-1}$ | t ha$^{-1}$ | bunch ha$^{-1}$ | kg bunch$^{-1}$ | t ha$^{-1}$ | bunch ha$^{-1}$ | kg bunch$^{-1}$ |
| 0 | 0 | 29.7 | 1345 | 22.2 | 29.6 | 1510 | 19.8 |
| 0.25 | 0.74 | 31.0 | 1377 | 22.5 | 30.1 | 1508 | 20.1 |
| 0.50 | 1.48 | 30.3 | 1374 | 22.0 | 30.3 | 1547 | 19.7 |
| 0.75 | 2.22 | 31.3 | 1386 | 22.6 | 30.3 | 1516 | 20.2 |
| 1.0 | 2.96 | 30.7 | 1382 | 22.2 | 29.9 | 1524 | 19.8 |
| 1.25 | 3.70 | 31.1 | 1400 | 22.2 | 30.4 | 1549 | 19.8 |
| 1.5 | 4.44 | 30.5 | 1358 | 22.5 | 30.0 | 1527 | 19.8 |
| 1.75 | 5.18 | 29.9 | 1301 | 23.0 | 30.2 | 1504 | 20.3 |
| 2.0 | 5.92 | 30.5 | 1342 | 22.8 | 30.0 | 1501 | 20.1 |
| Significant difference: | | NS | NS | NS | NS | NS | NS |
| CV % | | 5.0 | 6.1 | 3.3 | 2.1 | 3.9 | 3.1 |

*Note: LSD not given because of no significant effects by the treatments. NS = not significant*

**Yield response over time**

The yield in the trial block increased consistently from 2004 until 2007, then plummeted in 2008 by an average of 7 t/ha. The drop in yield was suspected to be caused by a decrease in the number of bunches in the same year, but this was not really clear. Yields, however, increased from to 30.5 t/ha in 2009. Despite the continuous declining trend by the number of bunches since 2003 (Figure 2), there has been an increase in the average bunch weights over time due to maturing palms. The effect of N fertilizer on bunch number per palm or SBW is not significant for any one year. The lack of response to N fertilizer could be largely due to the high N status of the palms.

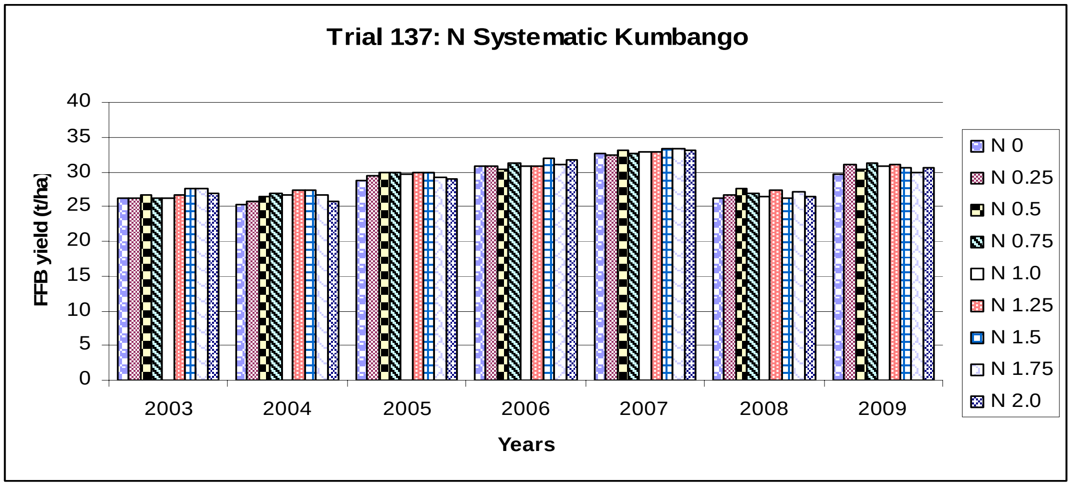



**Figure 1**. Yield response to 9 rates of N (kg/palm) over time (fertilizer N was first applied in March 2003).

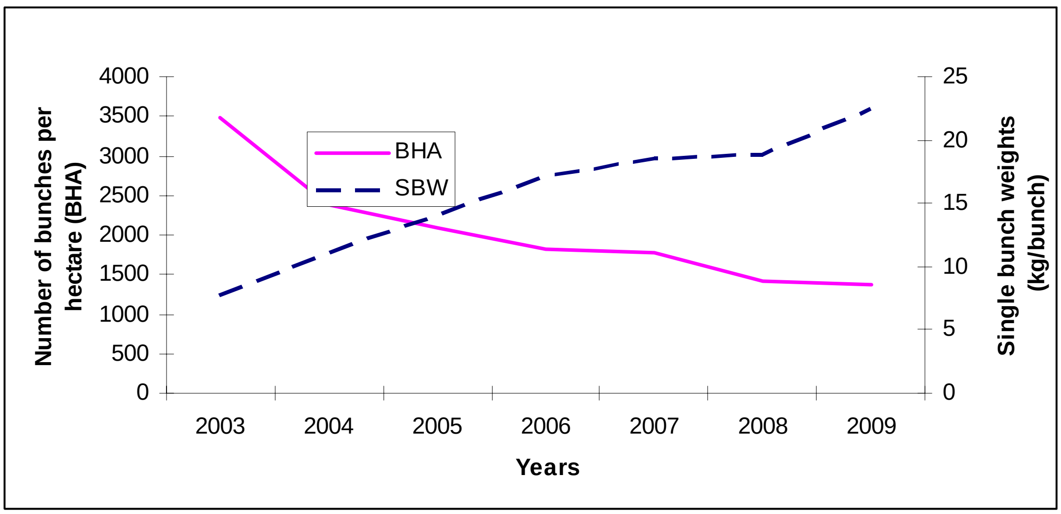



**Figure 2**. Mean trial bunch number per hectare (BHA) and SBW (kg/bunch) over time.

**Tissue nutrient concentration**

Tissue nutrient concentration was investigated for both leaflets and the rachis (Table 4 & 5 respectively). Leaflet N, K and Mg responded significantly to N fertilizer application in 2009, however, the response was positive for N leaflet levels and negative for K and Mg leaflet levels. The leaflet N levels were increased to over 2.50 %, while both leaflet K and Mg were reduced by a small amount with the application of N fertilizer (Table 4). While K leaflet levels are within the adequate range, Mg is below the adequate level (0.20 %). Leaflet N from the 0 and 0.25 kg N/palm slightly low.The average for all the N rates were within the adequate range (2.48 %). P levels have increased from an average of 0.145 % in 2008 to an average of 0.150 % in 2009, while Boron leaflet levels have been maintained within the adequate range of 16 ppm.

Rachis N was significantly (p=0.003) increased by N while there was no response on rachis P and K (Table 5). However, the average rachis N (0.30 %) was below the adequate range of 0.32 %. The rachis K seemed to be in good supply (1.40 %) while P levels are slightly low.

**Table 4**. Main effects of N fertilizer treatments on **leaflet** nutrient levels. Levels for all nutrients are expressed in % DM except B which is in ppm.

| N rate | Equivalent AN rate | 2009 | | | | | | 2004-2009 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| kg/palm | kg/palm | N | P | K | Mg | Ca | B | N | P | K | Mg | Ca | B |
| 0 | 0 | 2.41 | 0.151 | 0.83 | 0.18 | 0.82 | 16.6 | 2.56 | 0.148 | 0.84 | 0.15 | 0.86 | 15.1 |
| 0.25 | 0.74 | 2.44 | 0.151 | 0.80 | 0.18 | 0.83 | 16.7 | 2.57 | 0.148 | 0.80 | 0.16 | 0.88 | 15.3 |
| 0.50 | 1.48 | 2.48 | 0.151 | 0.78 | 0.17 | 0.83 | 16.6 | 2.57 | 0.147 | 0.79 | 0.15 | 0.88 | 14.5 |
| 0.75 | 2.22 | 2.50 | 0.149 | 0.80 | 0.16 | 0.83 | 17.3 | 2.58 | 0.147 | 0.80 | 0.15 | 0.89 | 15.1 |
| 1.0 | 2.96 | 2.49 | 0.150 | 0.79 | 0.15 | 0.83 | 16.7 | 2.57 | 0.147 | 0.78 | 0.15 | 0.90 | 15.0 |
| 1.25 | 3.70 | 2.51 | 0.151 | 0.82 | 0.16 | 0.80 | 16.9 | 2.59 | 0.148 | 0.78 | 0.15 | 0.89 | 14.9 |
| 1.5 | 4.44 | 2.49 | 0.150 | 0.80 | 0.15 | 0.83 | 17.1 | 2.57 | 0.147 | 0.78 | 0.14 | 0.91 | 14.9 |
| 1.75 | 5.18 | 2.52 | 0.151 | 0.82 | 0.15 | 0.78 | 16.6 | 2.58 | 0.148 | 0.79 | 0.14 | 0.89 | 15.1 |
| 2.0 | 5.92 | 2.51 | 0.150 | 0.81 | 0.15 | 0.79 | 17.2 | 2.58 | 0.148 | 0.80 | 0.15 | 0.90 | 15.0 |
| Mean | | 2.48 | 0.150 | 0.80 | 0.16 | 0.82 | 16.9 | 2.57 | 0.148 | 0.80 | 0.15 | 0.89 | 15.0 |
| *Significant difference* | | ***0.037*** | *NS* | ***0.017*** | ***<.001*** | *NS* | *NS* | *NS* | *NS* | ***<.001*** | ***<.001*** | *NS* | *NS* |
| *LSD 5 %* | | *0.07* | *-* | *0.03* | *0.01* | *-* | *-* | *-* | *-* | *0.02* | *0.01* | *-* | *-* |
| *CV %* | | *2.9* | *1.7* | *3.4* | *7.4* | *5.5* | *8.8* | *1.0* | *0.9* | *2.3* | *4.7* | *3.4* | *5.4* |

**Table 5**. Main effects of N fertilizer treatments on **rachis** nutrient levels. Levels for all nutrients are expressed in % DM.

| N rate | Equivalent AN rate | 2009 | | | 2004-2009 | | |
|---|---|---|---|---|---|---|---|
| kg/palm | kg/palm | N | P | K | N | P | K |
| 0 | 0 | 0.27 | 0.076 | 1.36 | 0.29 | 0.073 | 1.53 |
| 0.25 | 0.74 | 0.28 | 0.074 | 1.36 | 0.30 | 0.072 | 1.58 |
| 0.50 | 1.48 | 0.29 | 0.072 | 1.37 | 0.30 | 0.071 | 1.58 |
| 0.75 | 2.22 | 0.30 | 0.067 | 1.34 | 0.31 | 0.068 | 1.60 |
| 1.0 | 2.96 | 0.31 | 0.068 | 1.47 | 0.31 | 0.071 | 1.66 |
| 1.25 | 3.70 | 0.32 | 0.068 | 1.45 | 0.31 | 0.067 | 1.64 |
| 1.5 | 4.44 | 0.31 | 0.069 | 1.48 | 0.31 | 0.069 | 1.61 |
| 1.75 | 5.18 | 0.32 | 0.070 | 1.43 | 0.31 | 0.072 | 1.60 |
| 2.0 | 5.92 | 0.31 | 0.067 | 1.37 | 0.31 | 0.068 | 1.56 |
| Mean | | 0.30 | 0.070 | 1.40 | 0.30 | 0.070 | 1.60 |
| *Significant difference* | | 0.003 | NS | NS | 0.005 | NS | NS |
| *LSD 5 %* | | 0.03 | - | - | 0.01 | - | - |
| *CV %* | | 9.9 | 9.5 | 8.9 | 4.5 | 6.4 | 5.5 |

**Tissue N concentration over time 2004 to 2009**

Leaflet N has responded significantly to N fertiliser application over the last two years (2008 and 2009), increasing its levels in the leaflets to more than 2.50 % (Table 6). The N leaflet level from the control treatment (Zero N) has dropped to levels slightly below the adequate range. Leaflet N has decreased a little over time as the palms matured. Tissue N concentration over time also reveals the high N status of the palms, which could be the reason for a lack of yield response to applied N.

**Table 6**. Leaflet N (% dm) over time (2004 – 2009).

| N rate | Equivalent AN rate | Leaflet N (% DM) | | | | | |
|---|---|---|---|---|---|---|---|
| kg/palm | kg/palm | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| 0 | 0 | 2.68 | 2.68 | 2.60 | 2.48 | 2.47 | 2.41 |
| 0.25 | 0.74 | 2.67 | 2.67 | 2.59 | 2.53 | 2.49 | 2.44 |
| 0.50 | 1.48 | 2.66 | 2.66 | 2.58 | 2.51 | 2.50 | 2.48 |
| 0.75 | 2.22 | 2.65 | 2.65 | 2.57 | 2.54 | 2.51 | 2.50 |
| 1.0 | 2.96 | 2.65 | 2.65 | 2.57 | 2.52 | 2.53 | 2.49 |
| 1.25 | 3.70 | 2.64 | 2.64 | 2.61 | 2.50 | 2.55 | 2.51 |
| 1.5 | 4.44 | 2.65 | 2.65 | 2.60 | 2.52 | 2.52 | 2.49 |
| 1.75 | 5.18 | 2.67 | 2.67 | 2.60 | 2.52 | 2.54 | 2.52 |
| 2.0 | 5.92 | 2.69 | 2.69 | 2.58 | 2.49 | 2.53 | 2.51 |
| Mean | | 2.66 | 2.66 | 2.59 | 2.51 | 2.51 | 2.48 |
| Significant difference | | NS | NS | NS | NS | **0.005** | **0.037** |
| LSD (5 %) | | - | - | - | - | 0.04 | 0.07 |
| CV % | | 1.9 | 1.9 | 1.9 | 2.0 | 1.7 | 2.9 |

**Fertilizer N effects on oil palm vegetative growth**

There was no effect of N on the vegetative growth parameters (Table 7). Petiole cross section (PCS) is a primary determinant of vegetative dry matter production. The N fertilizer treatment did not have any significant effect on the PCS as well as the dry matter production. Approximately 25 new fronds were produced in 2009 (one frond every 15 days) indicating good growing conditions. Total green fronds counted per palm averaged 41 fronds which is an adequate number; however this parameter depends more or less on the level of plantation block management. Frond area (FA) and Leaf Area Index (LAI) are factors used to determine canopy size. The palms had an average LAI of 7.1 and FA of 13.5 $m^2$, again indicating good growing conditions.

**Table 7**. Main effects of fertilizer treatments on vegetative growth in 2009

| N rate (kg/palm) | PCS | HI | Radiation Interception | | | | Dry Matter Production (t/ha) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | GF | FP | FA | LAI | FDM | BDM | TDM | VDM | BI |
| 0.0 | 43.3 | 1.53 | 40.6 | 24.6 | 13.3 | 6.9 | 14.6 | 15.4 | 33.2 | 17.9 | 0.46 |
| 0.25 | 44.3 | 1.57 | 40.9 | 25.0 | 13.8 | 7.2 | 15.1 | 15.3 | 33.7 | 18.5 | 0.45 |
| 0.50 | 45.6 | 1.46 | 40.6 | 25.3 | 13.3 | 6.9 | 15.7 | 15.1 | 34.2 | 19.1 | 0.44 |
| 0.75 | 45.4 | 1.44 | 41.1 | 25.3 | 13.7 | 7.2 | 15.7 | 15.4 | 34.6 | 19.1 | 0.45 |
| 1.0 | 46.3 | 1.50 | 41.5 | 25.3 | 13.5 | 7.2 | 15.9 | 15.2 | 34.6 | 19.4 | 0.44 |
| 1.25 | 46.5 | 1.39 | 40.8 | 25.3 | 13.9 | 7.3 | 16.0 | 15.4 | 34.9 | 19.5 | 0.44 |
| 1.50 | 45.8 | 1.42 | 40.9 | 25.4 | 13.8 | 7.2 | 15.8 | 15.1 | 34.4 | 19.3 | 0.44 |
| 1.75 | 46.3 | 1.45 | 41.1 | 26.0 | 13.4 | 7.1 | 16.4 | 14.8 | 34.6 | 19.8 | 0.43 |
| 2.0 | 47.8 | 1.35 | 41.0 | 25.7 | 13.4 | 7.0 | 16.7 | 15.0 | 35.3 | 20.3 | 0.43 |
| Mean | 45.7 | 1.46 | 41.0 | 25.3 | 13.5 | 7.1 | 15.8 | 15.1 | 34.4 | 19.2 | 0.44 |
| Significance | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS |
| $LSD_{0.05}$ | - | - | - | - | - | - | - | - | - | - | - |
| CV % | 10.0 | 10.8 | 2.6 | 3.3 | 5.3 | 5.6 | 10.5 | 5.7 | 5.8 | 9.6 | 5.5 |

*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

Nitrogen is the main driver for both oil palm growth (vegetative) and yield. Surprisingly, the FFB yields and the vegetative growth of the palms from this trial showed no response to the treatments after 5-6 years. Palms receiving no N produced between 29 to 31 t/ha which were reasonably high yields and at the same time not different to yields from the palms fertilised with N. Leaflet N however increased significantly as a result of N application in 2008 and 2009. The positive response could have attributed to the plummeting leaflet N levels in all the N treatments with time (since 2006). In 2009, the N levels in all the N rates were within the adequate N range (0.45 %) except 0 and 0.25 kg N/palm treatments. N levels in the 0 and 0.25 kg N/palm were slightly low but not in the deficient range, indicating a good supply of N to the palms. This could be the reason why the positive response in the leaflet N has not been translated to a response in the yield. The palms are healthy as demonstrated by the robust vegetative growth, high radiation interception and dry matter production. Therefore, the better growing conditions could have resulted in no yield response, especially the high N status of the palms as shown from the leaflet and rachis N levels. However, with the declining leaflet N with time, a response is likely to occur in the future as the demand for N increases to maintain the increasing growth parameters of the palms as well as to sustain the more number of bunches produced.

## CONCLUSION

After 5-6 years of treatment application, there was no significant increase in FFB yield, even though there was an increase in the average bunch weight as the palms matured. The lack of response could be due to the high N status of the palms, as observed from the adequate levels of N in the leaflets. P levels are still low, but with TSP was applied at 0.5 kg/palm in the hope of bringing up the tissue P. Vegetative measurements indicate that AN had no effect on vegetative parameters.

# Trial 141: Large Fertilizer Omission Trial, Haella (RSPO 4.2, 4.3, 8.1)

**SUMMARY**

Two large scale (4 ha) fertiliser omission sites were established in 2003 on deep volcanic soils to test the theory that nutrient flow is occurring in down-hill water movement through the soil in shallow water tables. One site was located near the top of a slope quite close to native vegetation – this site was expected to experience little nutrient flow from up the hill and it was expected to see a gradual nutrient decline in the palms across the fertiliser omission plot. The other site was located at the bottom of a slope with a large area of fertilised palms up hill – this site was expected to experience nutrient flow from up-hill and see a gradient of nutrient content in the palms from the top to the bottom of the omission plot. In 2009 we saw:

- There was opposite response in yield to differences in applied or flow through nutrients
- Up-slope site – there was no difference in leaflet and rachis nutrient contents between the fertilised and unfertilised plots. This may indicate nutrient flow from outside to inside the omission plot or it may be a natural inherent nutrient gradient across the site (if the latter is the case then over time the inherent nutrient supply will be depleted inside the omission plot and yield differences should start to appear);
- Down-slope site – leaflet N and P were higher in the measured palms in the fertilised plots indicating depletion of nutrients in the unfertilised plots.

Leaflet K and rachis N, P and K did not follow a gradient from high to low in the palms in the omission plots, which is still implying that nutrient flow may not be occurring.

**Trial Background Information**

**Table 1**. Trial 141 background information.

| **Trial number** | **141 (Div II)** | **Down-slope Site** | |
|---|---|---|---|
| Estate | Haella | Company | NBPOL |
| Planting Density | 128 palms/ha | Field No. | 1322-10, Rd 6-7, Ave13-14 |
| Pattern | Triangular | Soil Type | Volcanic sand and pumice |
| Date planted | 1996 | Drainage | Free draining |
| Age after planting | 13 years | Topography | Lower slope |
| Trial established | 2003 | Altitude | ? m asl |
| Progeny | unknown | Previous Land use | Forest |
| Planting material | Dami D x P | Area under trial soil type (ha) | 176 ha |
| Trial number | **141 (Div III)** | **Up-slope Site** | |
| Estate | Haella | Field No. | 1323-10, Rd 3-4, Ave1-2 |
| Planting Density | 120 palms/ha | Soil Type | Volcanic sand and pumice |
| Pattern | Triangular | Drainage | Free draining |
| Date planted | 1997 | Topography | Up slope |
| Age after planting | 12 years | Altitude | ? m asl |
| Trial established | 2003 | Previous Land use | Forest |
| Progeny | unknown | Area under trial soil type (ha) | 100 ha |
| Planting material | Dami D x P | Agronomist | Rachel Pipai |

**METHODS**

The trial consists of a circle, of 24 palms in diameter (approximately 4ha), to which no fertilizer has been applied since 2003. Fertilizer, following company practice, has been applied to the area outside the circle. Measurements have been carried out on palms in 12 transects (1-3 palms wide) radiating from the central palm out into the fertilised area. At this stage the analysis is based on observing the difference in yield between inside the circle (no fertiliser) and outside the circle (with fertiliser). If nutrients were coming into the omission plot from outside the plot (which is the hypothesis) one would expect to see a gradation of higher to lower yields the further one moved into the fertiliser omission plot.

## RESULTS and DISCUSSION

### Average FFB Yield

Even though the number of palms recorded for yield inside and outside the N omission plot were different, it is still useful to compare the yields for N fertilised palms and unfertilised palms (Table 2). Yields in fertilised plots in the fertilised plots were lower than unfertilised plots in Division III Up-slope however the opposite was recorded in Division II Down–slope. The up-slope area did yield more then the down-slope area.

**Table 2**. Yield inside and immediately outside the omission plot in 2007, 2008 and 2009.

| | **Division III Up-slope** | | | | **Division II Down-slope** | | |
|---|---|---|---|---|---|---|---|
| | FFB yield t/ha/year | | | | FFB yield t/ha/year | | |
| | 2007 | 2008 | 2009 | | 2007 | 2008 | 2009 |
| No fertilizer* | 32.2 | 24.7 | 27.5 | | 21.0 | 20.2 | 18.7 |
| Plus fertilizer | 28.9 | 24.4 | 22.3 | | 22.5 | 20.5 | 21.3 |

* Omission plot

### Spatial distribution of yield

The yield for each individual palm on the monitored transects has been recorded. There is no trend in average yield (all transects) with distance from the centre (0) of the trials for both divisions (Figure 1). Data from individual transects (not presented) also did not show any trend.

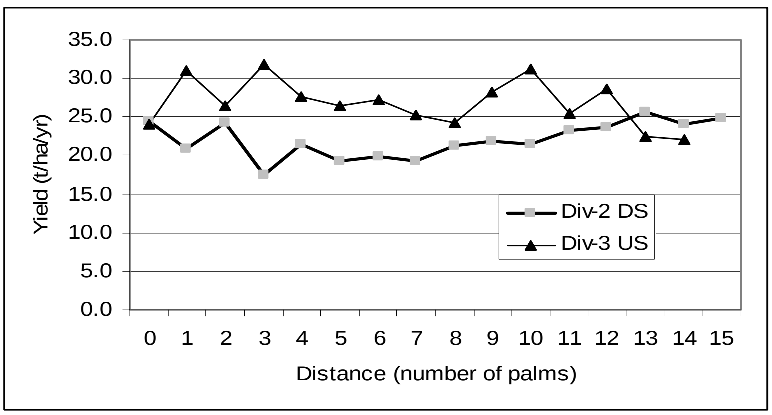



**Figure 1.** Yield distribution with palm distance from centre of the trial towards outer fertilised areas. Fertilised areas are at Distance 12-15 in Div II and 13-14 in Div III.

### Tissue nutrient analysis

Palms along the monitored transects were combined into small plots for tissue testing. Tissue test results for leaflet N, P, K, Mg and B; and rachis N, P, K were investigated. Average levels for the areas fertilised and not fertilised (omission areas) are presented in Table 3 for 2009 (6 years after trial establishment). The mean leaflet N and P contents were higher in Div III than in Div II and this was reflected in the yields, being high in Div III than in Div II.

**Table 3**. Leaflet and rachis nutrient concentration (% dm, except for B which is in ppm) in 2009, for the Up-slope and Down-slope sites for the fertilised and un-fertilised (omission plot) areas.

| | **Leaflet N** | **Leaflet P** | **Leaflet K** | **Leaflet Mg** | **Leaflet B** | **Rachis N** | **Rachis P** | **Rachis K** |
|---|---|---|---|---|---|---|---|---|
| **Div III Up-slope** | | | | | | | | |
| No fertiliser* | 2.22 | 0.137 | 0.63 | 0.17 | 20.3 | 0.25 | 0.076 | 1.38 |
| Plus fertiliser | 2.23 | 0.140 | 0.65 | 0.19 | 16.4 | 0.30 | 0.078 | 1.40 |
| **Div II Down-slope** | | | | | | | | |
| No fertiliser* | 2.06 | 0.130 | 0.64 | 0.20 | 14.3 | 0.26 | 0.07 | 1.61 |
| Plus fertiliser | 2.14 | 0.137 | 0.68 | 0.20 | 15.0 | 0.27 | 0.10 | 1.57 |

* Omission plot

**Spatial distribution of yield**

The mean leaflet N contents for all the transects are presented in figures 2 and 3 for each of the 2 divisions. In Div III, there is no particular trend in leaflet N content with distance from the centre of the palm. However in Div II, there is a trend developing that shows leaflet N contents decreasing towards the centre of the trial. There appears to be response to N fertilisers in Div II, N contents in the nil fertilised plots have fallen at Distance 1-12. There was no response in Div III and this could be due the high natural inherent soil fertility in the soils compared to Div II.

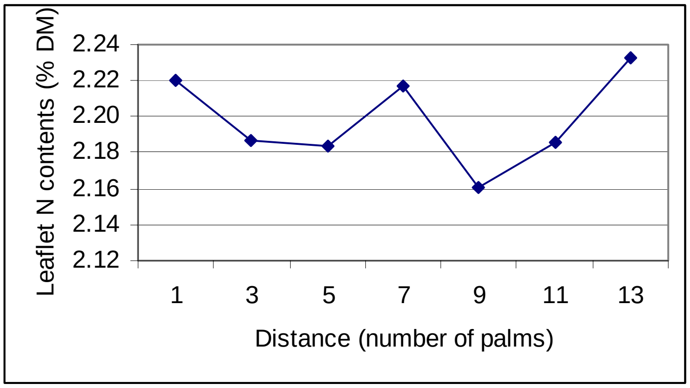



**Figure 2**. Leaflet N contents with distance from the centre of trial in Div III in 2009

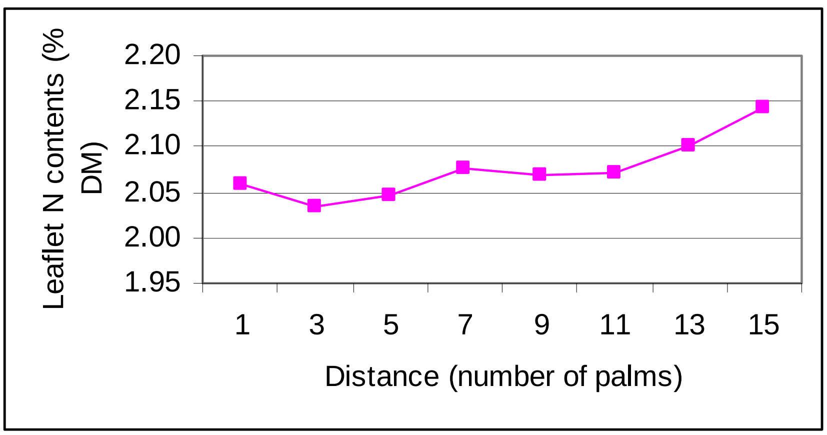



**Figure 3.** Leaflet N contents with distance from centre of trial in Div II in 2009

**CONCLUSION**

There is no indication that there is nutrient flow from outside into the plots.

# Trial 144: Magnesium and Potassium Fertilizer Response Trial, Waisisi (RSPO 4.2, 8.1)

**SUMMARY**
The impact of K and Mg fertilizers, was tested on yield and its components of bunch number and bunch weight; tissue and vegetative parameters, on a volcanic soil in a relatively young plantation (palms were planted in 2001). In 2005, the addition of high rates of Mg resulted in a small but significant yield penalty. Thereafter (2006-2009), there was no significant response. Since 2006, neither +Mg, +K nor +Mg+K treatments resulted in a yield difference compared to the control plots (no K or Mg fertilizer). Tissue test in 2009 showed both leaflet/rachis K levels and Mg leaflet levels were significantly affected by both K and Mg fertilisers. Mg fertiliser increased leaflet Mg levels, while the leaflet and rachis K were also elevated with K fertiliser application. Apart from that, combinations of both Mg and K have also increased either the Mg or K levels in the leaves respectively. Vegetative growth parameters were not affected by K and Mg fertilisers.

**BACKGROUND**

In West New Britain, the characteristic symptoms of magnesium deficiency are marked and widespread. However, fertiliser trials over the last few decades have shown little or no response to kieserite. Recent research has shown that the soils have very low cation exchange capacity (CEC) and are saturated with calcium, which competes with magnesium for cation exchange sites. It is therefore suspected that in this high rainfall environment, magnesium from soluble fertilisers like kieserite is being leached out of the soil profile before the roots can take it up. A research project to determine why magnesium nutrition is problematic, and how best to overcome the deficiency, commenced in late 2002. The project, entitled ‘Overcoming magnesium deficiency in oil palm on volcanic ash soils of PNG’, is a joint effort between PNGOPRA, the Commonwealth Scientific and Industrial Research Organisation of Australia (CSIRO), James Cook University (JCU), and the Australian Centre for International Agricultural Research (ACIAR). This field trial is part of that project. The trial has three purposes:

1. Because there was little or no response to kieserite in previous trials, we do not know how much the magnesium deficiency costs us in terms of yield. Or in other words, how much would yield increase if we could solve the problem? In this trial we have a treatment with no added magnesium and a treatment in which we supply the palm with many possible forms of magnesium (not necessarily practical options in the plantation) to ensure that we overcome the deficiency. The difference between the treatments will tell us the effect of magnesium deficiency and the potential gain in yield if we can overcome it.
2. Given the low cation exchange capacity of the soils, their high calcium contents and their low magnesium and potassium contents, it is surprising that the palms would be magnesium-deficient but not potassium-deficient. Cation nutrition is affected by interactions between the cations, so this trial is aimed at determining the effect of magnesium and potassium, alone and in combination, on symptoms and yield.
3. As the site has never received magnesium or potassium fertilisers, we will be able to follow the development of symptoms, physiological effects and yield effects with age.

**Table 1**. Trial 144 background information.

| **Trial number** | **144** | Company | NBPOL |
|---|---|---|---|
| Estate | Waisisi | Block No. | Waisisi mini estate – block A1 |
| Planting Density | 120 palms/ha | Soil Type | Volcanic ash and pumice |
| Pattern | Triangular | Drainage | Rapid |
| Date planted | 2001 | Topography | Rolling low hills |
| Age after planting | 7 | Altitude | 360 m asl |
| Recording Started | 2003 | Previous Land-use | Secondary forest |
| Planting material | Dami D x P | Area under trial soil type (ha) | 300 ha |
| Progeny | known | Agronomist in charge | Steven Nake |

## MATERIALS AND METHODS

### Treatments and Trial design

Magnesium (Mg) and Potassium (K) based fertilizers are applied at two rates (nil and plus Mg or K fertilizer) in a randomised design with 4 replicates (2 fertilizers x 2 rates x 4 replicates = 16 plots). For the plus fertilizer treatments, Kieserite and Potassium sulphate were used in addition to a slow release form of the nutrient.

*Magnesium*: applied on the soil surface with the standard Mg fertilizer Kieserite and in a slow release form as EMAG M30

*Potassium*: applied on the soil surface using Potassium sulphate ($K_2SO_4$) and in a slow release form as $K_2SO_4$ placed in inverted coconut shells to reduce leaching (see Table 2 for details of the fertilizer applications)

*Basal fertilizers* applied in 2009 were Ammonium nitrate (4.0 kg/palm), MAP (3.0 kg/palm), TSP (0.5kg/palm) and Borate (0.15 kg/palm).

To minimise chances of nutrient movement between plots, each plot of 16 palms is surrounded by 2 guard rows, the inner one treated as per allocated treatment for the plot, and the outer one untreated. No Mg or K fertilizer is applied to the block surrounding the trial. Measurements focusing on uptake of Mg and K are:

(i) Single Bunch Weight (SBW) and Bunch Number to calculate yield
(ii) Tissue nutrient concentration of Frond 17
(iii) Vegetative parameters (Petiole cross section, frond length, leaflet size etc)

**Table 2**. Fertilizer types and rates used in Trial 144.

| Nutrient | Application method | Nutrient application rate (kg/ha) | Fertilizer | Nutrient cont. of fertilizer (%) | Fertilizer application rate (kg/palm/yr) | Number of applications. |
|---|---|---|---|---|---|---|
| Mg | Surface | 50/yr | Kieserite | 17 | 2.45 | 6/yr |
| K | Surface | 50/yr | $K_2SO_4$ | 42 | 0.99 | 6/yr |
| Mg | Slow-release# | 150 | $MgCO_3$/MgO* | 46 | 2.72 | 1 |
| K | Slow-release# | 150 | $K_2SO_4^+$ | 42 | 2.98 | 1 |

* QMAG M30 + $K_2SO_4$ in inverted half coconuts # only applied at the beginning of the trial

### *Data Collection*

Similar to data collection described in Trial 137.

### *Trial maintenance and upkeep*

Similar approach described in Trial 137.

## RESULTS

### Fertiliser effects on FFB yield and its components in 2009

Six years (2009) after the inception of the trial, there continued to be no response in yield to either applied Mg or K or to the combination of these two fertilizers (Figure 1 and Table 3). In the second year of experimentation (2005) the application of Mg fertilizer significantly decreased yield by 2 t/ha (P=0.03). However, there was no difference in yield in treatments with Mg fertilizer in 2006, 2007, 2008 or 2009. Despite no response to the fertiliser treatments, the FFB yields for the trial increased dramatically in 2009 by an average of 9.1 t/ha. The average FFB yield in 2009 was 36.4 t/ha compared to 27.3 t/ha in 2008.

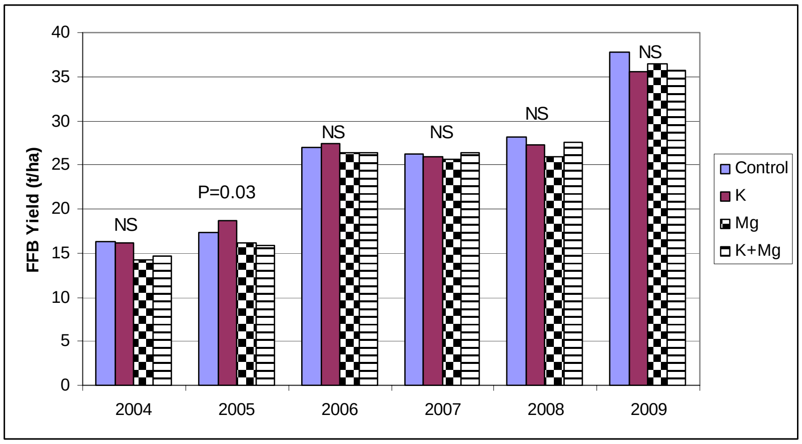



**Figure 1**. Trial 144 - FFB yield since inception of the trial in 2004.

**Table 3**. Responses in 2009 to K and Mg fertilizer on yield (FFB Yield), single bunch weight (SBW) and number of bunches (NB/ha). (K0 and Mg0= no K or Mg fertilizer; K1 or Mg1 = K and Mg fertilizer applied as per methods).

| | FFB Yield (t/ha) | | SBW (kg) | | NB (/ha) | |
|---|---|---|---|---|---|---|
| **Source** | **Mg0** | **Mg1** | **Mg0** | **Mg1** | **Mg0** | **Mg1** |
| **K0** | 37.8 | 36.5 | 18.8 | 19.4 | 2022 | 1897 |
| **K1** | 35.5 | 35.7 | 19.7 | 19.2 | 1797 | 1880 |
| **Significant difference:** | | | | | | |
| **Mg** | NS | | NS | | NS | |
| **K** | NS | | NS | | NS | |

**Fertiliser effects on tissue nutrient contents in 2009**

Leaflet K levels in plots receiving either K alone or in combination with Mg fertiliser were significantly (p=0.015) higher than the other treatments (control and Mg alone) (Table 4). Similarly, rachis K also responded significantly to K fertiliser. Despite that, rachis K was slightly below the adequate level (1.2 %). Leaflet K levels for all treatments (including control) are well within the adequate range (0.65 %). Leaflet Mg was significantly (p<0.001) higher in the Magnesium fertilizer treatments (either alone or in combination with K fertilizer). Leaflet Mg were low (<0.20 %) in the control and K fertiliser treatment (K fertilizer in the absence of Mg fertilizer may reduce the uptake of Mg). In 2007 and 2008, there was some evidence that the Mg uptake was suppressed by K fertilizer. Calcium uptake is significantly (p<0.001) reduced by the Magnesium fertilizer treatments (either alone or in combination with K fertilizer). Whether this could potentially reduce yield in the long term is unknown, currently Ca levels are high. Leaflet N and rachis N were adequate at 2.64% and 0.40% dm respectively; Leaflet P at 0.150% dm is adequate; whereas rachis P is close to acceptable at 0.08% dm. It is advised to continue with basal P application.

**Table 4**. Leaflet K, Mg and Ca, and Rachis K levels (% dm) for four treatments in 2009.

| **Fertilizer treatment** | **Leaf K** | **Leaf Mg** | **Rachis K** | **Leaf Ca** |
|---|---|---|---|---|
| Control | 0.68 | 0.16 | 0.77 | 1.06 |
| + Mg | 0.67 | 0.23 | 0.74 | 0.95 |
| + K | 0.70 | 0.14 | 1.02 | 1.10 |
| + Mg + K | 0.72 | 0.20 | 0.92 | 0.91 |
| **Significant difference:** | | | | |
| **Mg** | NS | **<0.001** | NS | **<0.001** |
| **K** | **0.015** | NS | **0.004** | NS |
| **MgxK** | NS | NS | NS | 0.05 |
| **LSD** | 0.03 | 0.04 | 0.18 | 0.04 |
| **CV%** | 3.9 | 13.0 | 18.9 | 3.3 |

**Tissue nutrient content over time (2004-2009)**

Fertilizer treatments were first applied in 2003 and already by the 2004 sampling there were some changes in K and Mg nutrient contents in the leaflet and rachis. The leaflet K levels were reduced over time – this is expected as the palms mature, but the trend remained the same. Unlike 2008, rachis K levels were increased by K fertiliser in 2009 (see Figures 2 and 3).

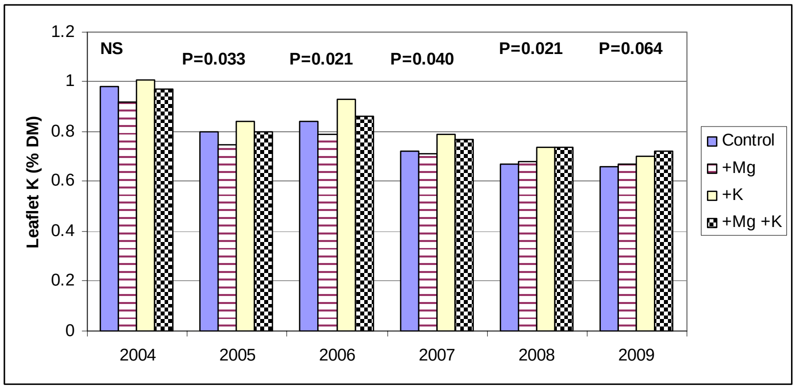



**Figure 2**. Leaflet K (% dm) in trial 144 over time (2004 to 2009)

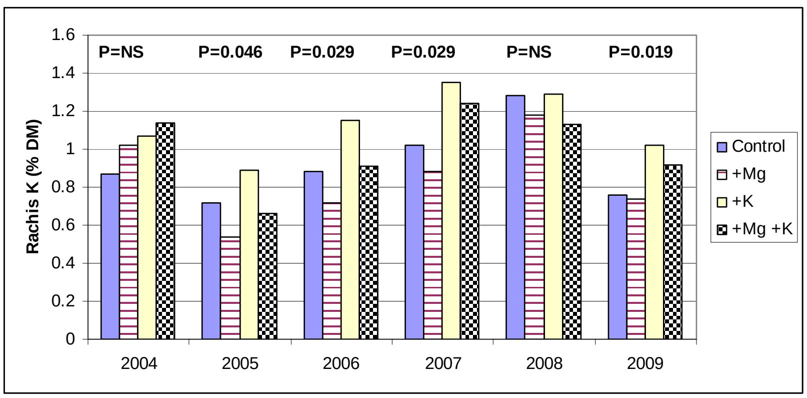



**Figure 3**. Rachis K (% dm) in trial 144 over time (2004 to 2008)

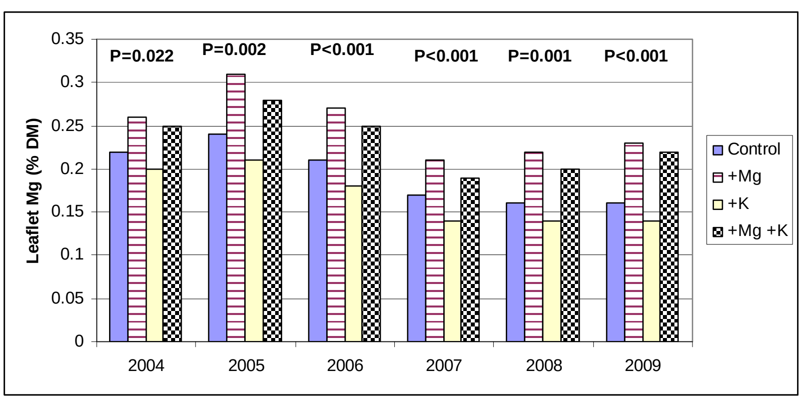



**Figure 4**. Leaflet Mg (% dm) in trial 144 over time (2004 to 2009).

The effect of Mg fertiliser on Leaflet Mg was more pronounced in all the years compared to the other treatments (Figure 4). In the control treatment and the K alone treatment (in the absence of Mg fertilizer) the levels of leaflet Mg have now dropped below the adequate level of 0.20 % dm. Only in the treatments where Mg fertilizer was applied were the levels adequate (above 0.20 % dm).

**Fertilizer effects on oil palm vegetative growth**

Similar to the 2008 result, there continued to be no significant effects of the fertilizer treatments on the growth parameters measured in 2009. The mean value for each parameter, the level of significance and the co-efficient of variation are presented in Table 5.

*Frond production and frond number*

Close to 26 new fronds were produced in 2009 (one every 14 days) – this is normal for this age palm. Total green fronds counted per palm averaged 41.6 fronds which is an adequate number. The number of green fronds are expected to decline as palms mature.

*Frond and canopy size*

The two assessments of canopy coverage, 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) have increased slightly in 2009 and were within adequate limits for palms in this age group (average frond area 11.4 $m^2$ and LAI of 5.7).

*Vegetative dry matter production*

Petiole cross section (PCS) is a primary determinant of vegetative dry matter production. PCS in 2009 increased to an average of 35.6$cm^2$ and was not influenced by the Mg or K fertilizer treatments. 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 2008 and the increments were not related to the fertilizer treatments (Table 5).

**Table 5**. Summary of fertilizer effect on vegetative growth parameters in 2009.

| | PCS | Radiation Interception | | | | Dry Matter Production (t/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | GF | FP | FA | LAI | FDM | BDM | TDM | VDM |
| Mean | 35.6 | 41.6 | 25.7 | 11.4 | 5.7 | 11.8 | 19.1 | 34.4 | 15.3 |
| P value | 0.502 | 0.470 | 0.884 | 0.514 | 0.391 | 0.691 | 0.435 | 0.533 | 0.678 |
| CV% | 7.0 | 2.8 | 2.0 | 6.8 | 7.4 | 7.2 | 6.1 | 5.3 | 6.6 |

*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

Unlike the previous years, there continued to be no yield response to Mg and K fertilizers applied either alone or applied in combination. Despite that, the FFB yields have increased substantially by more than 9 t/ha in 2009. The fertiliser response in 2005 by the FFB yield could have been caused by other co-variants. Similarly, the physiological parameters in 2009 did not respond significantly to the fertiliser treatments. However, the parameters measured indicated a relatively robust growth by the palms in 2009. Even though there was not significant response on the vegetative growth, the responses in 2009 have been very positive. The radiation interception was enhanced and the dry matter production was increased in 2009. As opposed to the yield and the vegetatative growth of the palms, the Mg and K leaflet and rachis levels responded well to the Mg and K fertilisers.

## CONCLUSION

After 6 years, there was no impact of either Mg or K based fertilizer on the oil palm production (FFB yields in t/ha). However, the overall trial yields have increased from 27 t/ha in 2008 to more than 36 t/ha in 2009. Mg fertiliser increased leaflet Mg levels, while the leaflet and rachis K were also elevated with K fertiliser application. Apart from that, combinations of both Mg and K have also increased either the Mg or K levels in the leaves respectively. Leaflet Mg and K levels have plummeted below adequate in the zero Mg and K fertilizer treatments in 2009.

# Trial 145: Magnesium Source Trial, Walindi (RSPO 4.2, 8.1)

**SUMMARY**
This trial compares four types of Magnesium fertilizer ($MgSO_4$, MgO, $MgCO_3$ and a mixture of MgO / $MgCO_3$) applied at 2 rates (standard rate and a double standard rate, where the standard rate is equivalent to 2kg/palm of $MgSO_4$). The trial was established in late 2004. There was no increase in yield observed between the zero control and the Mg fertilizer treatments (either at the standard or double standard rate). The application of Mg fertilizer did not result in higher leaflet Mg levels. The application of the four different types of Mg fertilizer also had no effect on the vegetative parameters measured (such as PCS, frond production, and LAI).

**BACKGROUND**
Magnesium deficiency is common in oil palm on the young volcanic ash soils of West New Britain (WNB). Kieserite is currently used to correct the deficiency. However, Kieserite is highly soluble and has the potential to be rapidly lost by leaching due to high rainfall and saturation of the soil cation exchange capacity with Ca. By using magnesium fertilizers with lower solubility than kieserite, it is envisage that the roots will have more chances of accessing the magnesium before it is lost by leaching. The trial is part of the ACIAR-funded Mg project. The purpose of the trial is to compare the effects highly soluble and less soluble magnesium fertilizers on oil palm growth and yield.

**Table 1**. Trial 145 background information.

| **Trial number** | **145** | Company | NBPOL |
|---|---|---|---|
| Estate | Walindi | Block No. | MU-1311-09 |
| Planting Density | 120 palms/ha | Soil Type | Volcanic ash |
| Pattern | Triangular | Drainage | Rapid |
| Date planted | 1999 | Topography | Slight inclination |
| Age after planting | 9 | Altitude | 30 m asl |
| Recording Started | 2004 | Previous Land-use | Replanted oil palm |
| Planting material | Dami D x P | Area under trial soil type (ha) | 750 ha |
| Progeny | unknown | Agronomist in charge | Steven Nake |

**MATERIALS AND METHOD**

***Experimental Design and Treatments***
Magnesium based fertilizer is applied as four sources (Kieserite, and the QMAG products Magnesite FO1, EMAG M30 and EMAG 45), at two rates (standard and 2 times standard) and compared to a control which receives no Mg fertilizer, in a randomised design with four replicates. The current industry standard for kieserite in WNB is around 2 kg kieserite per palm per year. The other fertilizers are applied at an equivalent magnesium rate (Table 2). All treatments are applied twice annually and spread on the surface. Basal fertilizer applied in 2008: Ammonium nitrate (3.0 kg/palm); TSP 0.5 kg/palm; MOP 0.5kg/palm; and Borate 0.15 kg/palm. Each plot consists of 36 (6 x 6) palms with the inner 16 (4 x 4) being the recorded palms. Trenches have been dug around each plot to prevent root poaching.

**Table 2**. Fertilizer types and rates used in Trial 145.

| Treatment number | Product | Main component | Mg content (%) | Mg application rate (kg/palm/yr) | Fertilizer rate per application (g/palm) |
|---|---|---|---|---|---|
| 1 | Kieserite | $MgSO_4$ | 17 | 0.34 | 1000 |
| 2 | " | " | " | 0.68 | 2000 |
| 3 | Magnesite FO1 | $MgCO_3$ | 26 | 0.34 | 654 |
| 4 | " | " | " | 0.68 | 1308 |
| 5 | EMAG M30 | $MgCO_3$ / MgO | 46 | 0.34 | 370 |
| 6 | " | " | " | 0.68 | 739 |
| 7 | EMAG45 | MgO | 56 | 0.34 | 304 |
| 8 | " | " | " | 0.68 | 607 |

***Data Collection***

Similar to data collection described in Trial 137. Statistical analysis: 4 sources of Mg fertilizer by two rates plus a control equals 9 treatment plots x 4 replicates in a randomised block design was analysed using a Two Way ANOVA. One of the treatments, the nil fertilizer control, was duplicated 4 times in each block. This design has enabled the control treatment to be estimated at twice the accuracy of the other 8 treatments.

***Trial maintenance and upkeep***

Similar approach described in Trial 137.

**RESULTS**

**Yield in 2009**

At this stage in the trial (fourth year) there are no differences ($p>0.05$) between the Mg fertilizer treatments and the control (Control 32.7 t/ha and average of all Mg treatments is 33.6 t/ha). Similarly, the impact of Mg fertilizer on Bunch Number and single bunch weight was also not significant.

**Table 3**. Average FFB (t/ha), bunch number per hectare and single bunch weight for each treatment in 2009

| Fertilizer type | Yield (t/ha) | Bunch number (Bunch/ha) | SBW (kg) |
|---|---|---|---|
| Control | 32.7 | 1550 | 21.2 |
| Kieserite Standard | 32.9 | 1540 | 21.4 |
| " 2 x Standard | 33.3 | 1585 | 21.0 |
| EMAG45 Standard | 33.7 | 1605 | 21.1 |
| " 2 x Standard | 34.1 | 1603 | 21.3 |
| FO1 Standard | 35.1 | 1684 | 20.8 |
| " 2 x Standard | 31.8 | 1433 | 22.4 |
| EMAG M30 Standard | 34.8 | 1571 | 22.1 |
| " 2 x Standard | 32.7 | 1503 | 21.7 |
| **Significant difference:** | **NS** | **NS** | **NS** |
| **CV%** | **10.6** | **10.9** | **6.5** |

**Yield over time**

Since the first treatment application in 2004, there have been no trends in yield from the different Mg fertilizer treatments (Figure 1). In Figure 1, only the Standard rate of Mg fertilizer is presented (Mg equivalent to 2kg/palm of Kieserite; the double rate of Mg fertilizer had the same result). Despite the insignificant response, the FFB yields increased to more than 32 t/ha in 2009.

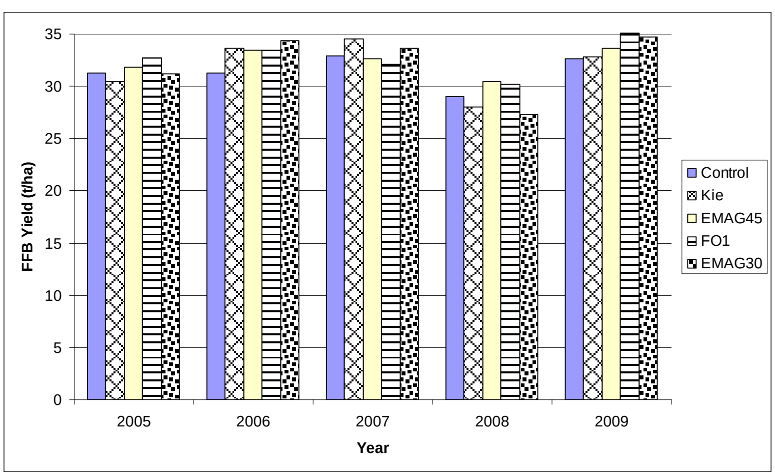



**Figure 1**. Yield achieved from 2005 to 2009 as a result of different Mg fertilizer treatments (including the zero Mg control)

**Tissue nutrient analysis**
Leaflet and rachis Mg levels have been tested in Frond 17 since 2003 (2003 was the year before treatments were applied). There has been no change in leaflet or rachis Mg levels since 2003 in any of the treatments (Table 4). However, there were large differences between years in leaflet and rachis Mg, this could be due to different timings of sampling or differences in laboratory readings between years.

**Table 4**. Yearly leaflet and rachis Mg levels (% dm) since 2003.

| Mg fertiliser | Level | Leaflet Mg (%dm) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| **Control** | **0** | **0.17** | **0.17** | **0.22** | **0.19** | **0.13** | **0.15** | **0.19** |
| **Kieserite** | **1** | **0.17** | **0.15** | **0.22** | **0.18** | **0.14** | **0.16** | **0.19** |
| **Kieserite** | **2** | **0.16** | **0.17** | **0.22** | **0.19** | **0.14** | **0.16** | **0.19** |
| **EMAG45** | **1** | **0.17** | **0.16** | **0.22** | **0.18** | **0.14** | **0.17** | **0.19** |
| **EMAG45** | **2** | **0.17** | **0.16** | **0.21** | **0.18** | **0.14** | **0.16** | **0.20** |
| **FO1** | **1** | **0.18** | **0.17** | **0.23** | **0.19** | **0.15** | **0.17** | **0.20** |
| **FO1** | **2** | **0.18** | **0.16** | **0.22** | **0.19** | **0.15** | **0.17** | **0.20** |
| **EMAG M30** | **1** | **0.17** | **0.17** | **0.22** | **0.19** | **0.14** | **0.17** | **0.20** |
| **EMAG M30** | **2** | **0.16** | **0.15** | **0.21** | **0.18** | **0.14** | **0.17** | **0.19** |
| Significant diff.: | | | | | | | | |
| Treatment | | | | | NS | | | |

The other tissue nutrient levels are presented in Table 5. All the major nutrient levels were adequate to high (Table 5).

**Table 5**. Mean leaflet and Rachis nutrient levels for trial 145 in 2009. Values in brackets are leaflet and rachis levels for 2008.

| Nutrient | Leaflet (% dm) | Rachis (% dm) |
|---|---|---|
| Nitrogen | 2.48 (2.57) | 0.34 (0.43) |
| Phosphorus | 0.151 (0.148) | 0.13 (0.15) |
| Potassium | 0.76 (0.83) | 1.6 (2.1) |
| Calcium | 0.72 (0.72) | - |
| Boron | 15.2 (25) ppm | - |

**Fertilizer Mg effects on oil palm vegetative growth**
The Mg fertilisers did not have a significant effect on the vegetative growth of the palms (radiation interception and dry matter production in 2009 (Table 6).

*Frond production and frond number*
An average of 27 new fronds were produced in 2009 (one every 13-14 days) which is indicating good growing conditions – normally we would expect a new frond to form every 17 to 20 days. Total green fronds counted per palm averaged 39 fronds which is an adequate number.

*Frond and canopy size*
The two assessments of canopy coverage, Frond area (based on leaflet length and width) and LAI (Leaf Area Index, calculated from Frond area, frond number and palms per ha) were also within adequate limits for palms in this age group (average frond area $14m^2$ and LAI of 6.7).

*Vegetative dry matter production*
Petiole cross section (PCS) is a primary determinant of vegetative dry matter production. PCS did not vary across Mg treatments and was not significantly different from the control (no Mg fertilizer applied). 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) were also not related to Mg fertilizer type or to the control (Table 6).

**Table 6**. Effect of treatments on vegetative growth parameters in 2009.

| Mg fertilizer | Level | PCS | Radiation Interception | | | | Dry Matter Production (t/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | GF | FP | FA | LAI | FDM | BDM | TDM | VDM |
| Control | 0 | 54.3 | 38.9 | 26.6 | 14.2 | 6.6 | 18.3 | 17.8 | 40.1 | 22.3 |
| Kieserite | 1 | 58.2 | 39.2 | 26.9 | 13.6 | 6.4 | 19.9 | 17.9 | 42.1 | 24.1 |
| Kieserite | 2 | 57.6 | 38.8 | 26.2 | 14.6 | 6.8 | 19.1 | 19.0 | 42.4 | 23.4 |
| EMAG45 | 1 | 53.6 | 38.9 | 26.1 | 14.9 | 7.0 | 17.8 | 18.8 | 40.6 | 21.9 |
| EMAG45 | 2 | 53.5 | 38.4 | 26.8 | 14.2 | 6.5 | 18.2 | 18.2 | 40.5 | 22.3 |
| FO1 | 1 | 56.1 | 39.4 | 26.5 | 14.4 | 6.8 | 18.9 | 19.1 | 42.0 | 23.1 |
| FO1 | 2 | 50.9 | 40.0 | 27.0 | 14.1 | 6.8 | 17.5 | 17.6 | 38.9 | 21.3 |
| EMAG M30 | 1 | 59.3 | 39.0 | 26.5 | 15.0 | 7.0 | 20.0 | 19.0 | 43.2 | 24.3 |
| EMAG M30 | 2 | 68.0 | 38.7 | 26.1 | 14.0 | 6.5 | 22.3 | 17.9 | 44.7 | 26.8 |
| **Significant diff.:** | | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| **$LSD_{0.05}$** | | - | - | - | - | - | - | - | - | - |
| **CV%** | | **17.7** | **3.2** | **3.1** | **7.1** | **8.0** | **17.8** | **9.9** | **11.7** | **16.5** |

*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

All parameters measured have not showed any response to the type and rates of the different sources of Mg fertilisers applied. The results indicated that it did not matter what source and rate of Mg fertiliser was applied, the same response is obtained for FFB yield, tissue nutrient levels and the vegetative growth. The growth parameters measured have indicated that the palms are growing well. The Mg levels in the leaflets were all within the adequate level (2.0 %) while levels of other major nutrients such as N, P and K were all adequately available, thus the healthy palm growth coupled with adequate levels of all leaf tissue nutrients could be reason for the no response.

## CONCLUSION

In the fifth year of trial, there continued to be no positive response in yield resulting from any of Mg fertilizer applications (either as Mg type or rate applied). It has not been possible to demonstrate a leaflet or rachis Mg level difference from the different treatments, nor an effect of the treatments on the vegetative parameters, such as Petiole Cross Section, Frond Production or Leaf Area Index.

**Acknowledgements**

- ACIAR support for funding the trial is grateful acknowledged (Project SCMN/2000/046)
- Queensland Magnesia Pty Ltd for supporting the project with the supply of Mg based fertilizers (FO1, EMAG M30 and EMAG 45)

# Trial 146: Magnesium Fertilizer Type and Placement Trial, Kumbango (RSPO 4.2, 8.1)

**SUMMARY**
In this trial the application method for three different Mg fertilizers (Kieserite, FO1 (MgCO3) and EMAG45 (MgO)) were compared to a zero control (no Mg fertilizer) and a positive control (all three Mg fertilizers). The application methods compared were: surface applied; open trench; covered trench and fertilizer placed in inverted coconuts. There were no differences in yield (and its components of bunch number and SBW) in 2009. While Mg fertiliser type did not have any effect on the tissue nutrient levels and the vegetative growth parameters, Placement of Mg fertiliser showed significant effects on the leaflet Mg levels and the PCS. Nutrient concentrations in the leaflet and rachis for N, P, K and Boron all indicate adequate nutrition at this stage.

**BACKGROUND**
Mg deficiency symptoms persist in West New Britain, despite applications of kieserite. It is suspected that the cation exchange capacity of the soil is swamped with Ca, preventing Mg from being retained. It was proposed that adding Mg fertiliser in concentrated zones, or with barriers to leaching, or as less soluble sources might solve the problem of competition with Ca and loss by leaching. Therefore this trial was established to determine if the placement and type of Mg fertilisers influences response of palms in an area that appears to be Mg-deficient. The background information is shown in Table 1.

**Table 1**. Trial 146 background information.

| **Trial number** | **146** | Company | NBPOL |
|---|---|---|---|
| Estate | Kumbango | Block No. | MU 1121-03A |
| Planting Density | 135 palms/ha | Soil Type | Volcanic ash/pumice |
| Pattern | Triangular | Drainage | Rapid |
| Date planted | 1999 | Topography | Flat |
| Age after planting | 9 | Altitude | 60 m asl |
| Recording Started | 2004 | Previous Land use | Oil palm |
| Planting material | Dami D x P | Area under trial soil type (ha) | 460 ha |
| Progeny | unknown | Agronomist in charge | Steven Nake |

**MATERIALS AND METHOD**

***Experimental Design and Treatments***
Three sources of Magnesium based fertilizer (Kieserite; MgO (EMAG45); and $MgCO_3$ (Magnesite FO1)) were applied in four different placements (spread on the surface; in an Open Trench; in a Covered Trench; and in inverted coconuts). Two controls were included: the first being a zero (no fertilizer) control and the second being a positive control with all fertilizer types applied (Table 2).

Placement of fertilizer consisted of spreading twice annually on the surface; and three treatments with a high concentration, equivalent to 8 years of annual applications, applied in year 1 of the trial and applied in: (i) an open trench, (ii) a trench covered with plastic, and (iii) placed in inverted coconut shells. Each treatment (3 sources x 4 placements + 2 controls) was replicated four times, and treatments were applied to plots in a randomised block design (Figure 1). Each plot consists of 36 (6x6) palms with the inner 16 (4x4) being the recorded palms.

Trenches have been dug around each plot to prevent root poaching. In 2009, Ammonium Nitrate (3 kg/palm) TSP (0.5 kg/palm), MOP (1.0 kg/palm), and borate (0.15 kg/palm) were applied as basal fertilizers.

**Table 2**. Fertilizer types, rates applied and placement for Trial 146.

| Treatment no. | Fertilizer type | Placement | Mg appl. rate (kg/palm) | Mg content of fert. (%) | Fert. appl. rate (kg/palm/yr) | Number of appl. |
|---|---|---|---|---|---|---|
| 1 | Kieserite | Surface | 0.34 | 17 | 2 | 2/yr |
| 2 | Kieserite | Open Trench | 2.72 | 17 | 16 | Yr 1 only |
| 3 | Kieserite | Covered | | | | |
| | | Trench | 2.72 | 17 | 16 | Yr 1 only |
| 4 | Kieserite | Coconuts | 2.72 | 17 | 16 | Yr 1 only |
| 5 | $MgCO_3$ | Surface | 0.34 | 26 | 1.3 | 2/yr |
| 6 | $MgCO_3$ | Open Trench | 2.72 | 26 | 10.5 | Yr 1 only |
| 7 | $MgCO_3$ | Covered | | | | |
| | | Trench | 2.72 | 26 | 10.5 | Yr 1 only |
| 8 | $MgCO_3$ | Coconuts | 2.72 | 26 | 10.5 | Yr 1 only |
| 9 | MgO | Surface | 0.34 | 56 | 0.6 | 2/yr |
| 10 | MgO | Open Trench | 2.72 | 56 | 4.9 | Yr 1 only |
| 11 | | Covered | | | | |
| | MgO | Trench | 2.72 | 56 | 4.9 | Yr 1 only |
| 12 | MgO | Coconuts | 2.72 | 56 | 4.9 | Yr 1 only |
| 13 | Zero control | | 0 | | 0 | |
| 14 | Positive control | | | | | |
| | Kieserite | Surface | 0.34 | 17 | 2.0 | 2/yr |
| | M30** | Open Trench | 3.40 | 46 | 7.4 | Yr 1 only |

* Trench with plastic cover. ** A mixture of $MgCO_3$ and MgO

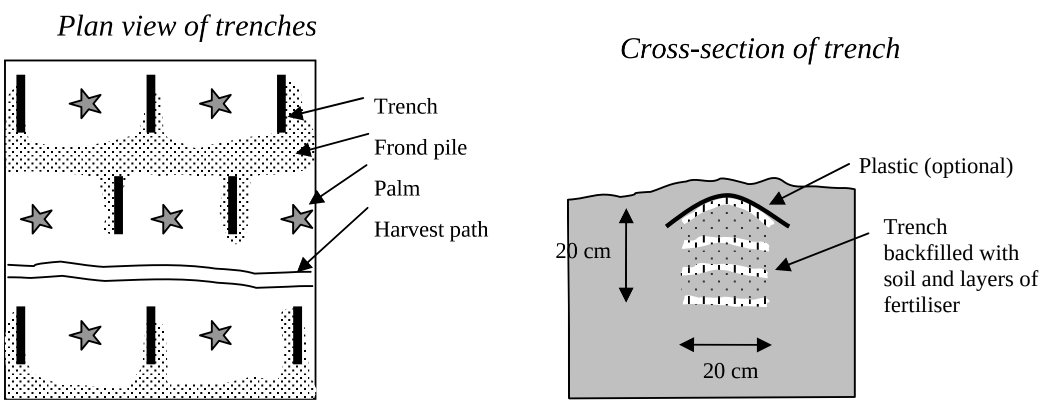



**Figure 1**. Location and cross-section of trenches containing fertiliser

***Data Collection***

Similar to data collection described in Trial 137.

***Trial maintenance and upkeep***

Similar approach described in Trial 137.

## RESULTS

**Effects of Mg fertiliser type and placement on FFB yield and components in 2009**

There were no significant responses in yield or its components to either the type of Magnesium based fertilizer applied or to the placement of the fertilizer in 2009 (Table 3).

**Table 3.** Significance (p values) of main effects in 2009 for Magnesium based fertilizer type and placement on FFB yield and its components. The two controls (nil Mg, combined sources of Mg) were not included in this statistical analysis.

| | FFB yield | BN/ha | SBW (kg) |
|---|---|---|---|
| Fertilizer type | 0.485 | 0.920 | 0.165 |
| Placement | 0.404 | 0.753 | 0.971 |
| Source x Placement | 0.606 | 0.627 | 0.445 |

The average yield achieved in 2009 was 29.9 t/ha, and represented an increase of 4.4 t/ha from 2008. The yields obtained from the treatment combinations and the two control treatments (Zero and Positive control) are shown in Table 4. There were no significant effects on Single Bunch Weight (mean 22.3kg), or Bunch Number (mean 1347/ha), the results for these are not presented. The bunch weights increased as expected but the bunch number per hectare declined in 2009.

**Table 4**. Effect of Mg source and placement on FFB yield (t/ha) in 2009.

| Fertilizer type | Placement | | | | | |
|---|---|---|---|---|---|---|
| | Zero control | Surface | Open Trench | Covered Trench | Coconuts | Positive control |
| Nil | 32.4 | | | | | |
| Kieserite | | 31.2 | 29.7 | 30.3 | 30.3 | |
| $MgCO_3$ | | 31.5 | 30.9 | 29.5 | 28.0 | |
| MgO | | 30.2 | 28.3 | 28.7 | 30.2 | |
| Combined | | | | | | 30.1 |

The yields from the zero control (no Mg fertiliser) are reasonably high and similar to the postive control and the other Mg fertilised treatments. Therefore, it is clear that there is no difference in the yield between the Zero Control (no Mg fertilizer), the Mg fertilizer treatments and the Positive Control (high rates of two sources of Mg fertilizer).

**Treatment effects on tissue nutrient concentration in 2009**

Mg type fertiliser did not have any significant effect on leaflet Mg. Placement of Mg fertiliser and the interaction between Mg source and placement had significant effects on leaflet Mg levels (Table 4). Surface placement method had increased the leaflet Mg levels up to the adequacy level (0.20 % dm). Leaflet Mg levels from the other 3 placement methods were all below the adequacy level (Table 6).

**Table 5**. Significance (p values) of fertiliser effects in 2009 for Magnesium based fertilizer type and placement leaflet Mg levels. The two controls (nil Mg, combined sources of Mg) were not included in this statistical analysis.

| | Leaflet Mg | lsd |
|---|---|---|
| Fertilizer type | 0.144 | - |
| Placement | 0.002 | 0.013 |
| Source x Placement | 0.059 | 0.022 |

**Table 6**. Effect of Mg fertiliser placement on leaflet Mg in 2009

| Placement | Leaflet Mg (% dm) |
|---|---|
| **Surface** | **0.20** |
| **Open Trench** | **0.18** |
| **Covered Trench** | **0.18** |
| **Coconuts** | **0.18** |
| CV % | 8.2 |

**Table 7**. Effect of Mg source and placement (interaction) on leaflet Mg (% dm) in 2009.

| Fertilizer type | Placement | | | | | |
|---|---|---|---|---|---|---|
| | Zero control | Surface | Open Trench | Covered Trench | Coconuts | Positive control |
| Nil | 0.20 | | | | | |
| Kieserite | | 0.19 | 0.17 | 0.18 | 0.20 | |
| $MgCO_3$ | | 0.21 | 0.17 | 0.18 | 0.18 | |
| MgO | | 0.21 | 0.20 | 0.19 | 0.18 | |
| Combined | | | | | | 0.19 |

Leaflet K responded significantly (p=0.032) to placement of Mg, whereas Ca was not influenced by Mg product type or placement. The overall nutrient status in the leaflets and rachis is presented in Table 8. The nutrient concentrations in the leaflet and rachis were all in the adequate range.

**Table 8**. Mean leaflet and Rachis nutrient levels for trial 146 (2009).

| Nutrient | Leaflet (% dm) | Rachis (% dm) |
|---|---|---|
| Nitrogen | 2.45 | 0.28 |
| Phosphorus | 0.149 | 0.11 |
| Potassium | 0.76 | 1.56 |
| Boron | 15.5 ppm | - |

**Fertilizer Mg effects on oil palm vegetative growth**

*Frond production and frond number*

Total green fronds counted per palm averaged 38-39 fronds which is an adequate number (Table 9). As palms mature, the number of green fronds decrease. Mg fertilizer (type and/or placement) applications had no significant effects on either parameter measured.

*Frond and canopy size*

The two assessments of canopy coverage, Frond area (based on leaflet length and width) and LAI (Leaf Area Index calculated from Frond area, frond number and palms per ha) indicate that the canopy has good cover. Neither, Frond Area or LAI was affected by the type and placement of Mg fertilizer applied (Table 9).

*Vegetative dry matter production*

Petiole cross section is a primary determinant of vegetative dry matter production. The PCS was significantly affected by the treatment interaction. The PCS for the Mg treatments was 48.5 $cm^2$ (Table 9). 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) were also not related to Mg fertilizer type or placement (Table 9).

**Table 9**. Mean value of vegetative parameters in 2009 as measured or calculated presented as the mean value for treatments (Mg source x placement); zero control (no Mg fertilizer) and positive control (two sources of Mg fertilizer)

| | Treatment mean | Zero Control | Positive control | Notes |
|---|---|---|---|---|
| PCS | 48.5 | 50.0 | 44.8 | Normal petiole cross section |
| GF | 39.4 | 38.4 | 38.6 | Adequate total number of fronds |
| FA | 14.2 | 13.7 | 13.6 | |
| LAI | 7.2 | 6.7 | 6.7 | Adequate LAI |
| FDM | 7.6 | 7.9 | 7.1 | |
| BDM | 13.8 | 14.3 | 13.8 | |
| TDM | 23.7 | 24.8 | 23.2 | |
| VDM | 10.0 | 10.4 | 9.4 | |

*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 yields have increased to close to 30 t/ha in 2009. While the bunches per hectare dropped in 2009, the single bunch weights continued to increase to over 22 kg per bunch, therefore the increase in yield could have resulted from the increasing bunch weights. The drop in the number of bunches is expected to happen as palms mature. Leaflet Mg was still slightly below the adequacy level in some treatments. The yields, Mg levels and vegetative growth parameters from the zero control treatment have been reasonably good, indicating good growing condition for the palms.

## CONCLUSION

In 2009, placement of Mg fertiliser significantly influenced the Leaflet Mg levels, while its also had an impact on the growth of the PCS. Placing of any Mg source of fertiliser on the surface increased Mg levels to the adequacy level (2%dm). The Mg fertilizer type, after 5 years continued to showed no differences in yield (or in bunch number or SBW); nutrient levels in leaflets or rachis; or in vegetative parameters such as PCS, Frond Production or LAI. The average yield for the trial was 29.9 t/ha.

**Acknowledgements**

- ACIAR support for funding the trial is grateful acknowledged (Project SCMN/2000/046)
- Queensland Magnesia Pty Ltd for supporting the project with the supply of Mg based fertilizers (FO1, EMAG M30 and EMAG 45)

# Trial 139: Palm Spacing Trial, Kumbango (RSPO 8.1)

**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. From 2003 to 2009 there were no differences in yield attributed to the different plantings. Although no significant, in 2009 there was a small difference in yield, with the Wide avenue spacing yielding slightly less compared to the Standard avenue spacing (30.0 vs 28.5 t/ha). The yields increased by about 4 t/ha in the trial in 2009. There is no difference between spacing treatments in leaflet and rachis nutrient concentrations and the vegetative growth of the palms.

**BACKGROUND**
The purposes of this trial are 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 (ie 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.

**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 fertilizers applied in 2009: AN 1.5kg/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 5$^{th}$ 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**
Similar to data collection described in Trial 137.

**Trial maintenance and upkeep**
Similar approach described in Trial 137.

## RESULTS

### Spacing treatment effect on yield in 2009

The spacing treatment in 2009 had not significant effect on the yield, bunch number and the single bunch weight (Table 3). The Wide avenue spacing was 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 2009

| Avenue width | Yield t/ha | Bunch number per hectare | Single bunch weight |
|---|---|---|---|
| Standard | 30.0 | 1301 | 23.0 |
| Intermediate | 29.0 | 1276 | 22.7 |
| Wide | 28.5 | 1269 | 22.5 |
| **Significant difference** | **NS** | **NS** | **NS** |
| **LSD** | **-** | **-** | **-** |
| **CV%** | **5.8** | **5.6** | **1.2** |

### Spacing treatment effect on yield over time

Yield increased from 16.0 t/ha in 2003 to 32 t/ha in 2007 and decreased dramatically in 2008 to below 25 t/ha and increased to over 28 t/ha in 2009. The observed yield loss in 2008 was caused by the substantial drop in bunch numbers the same year. The single bunch weight has increased to an average of 22 kg/bunch in 2009 (Figure 1 and 2).

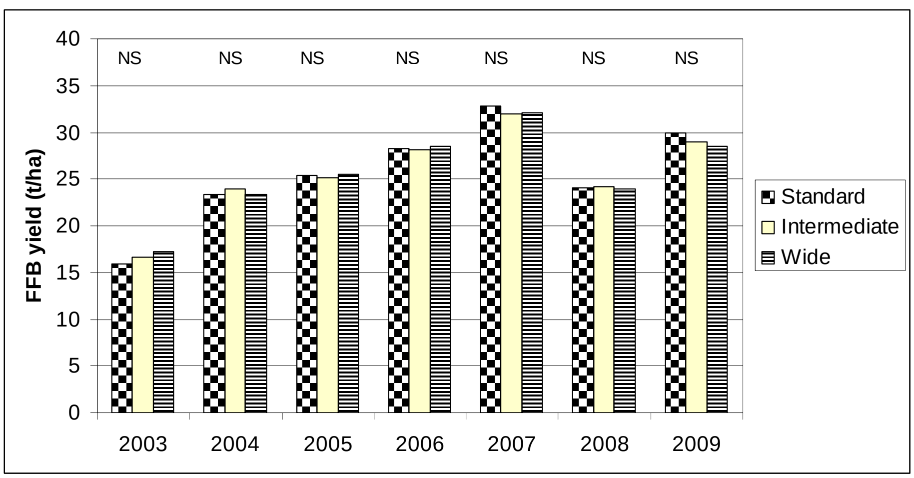



**Figure 1**. The impact of Avenue width on yield (keeping planting density the same) for Trial 139.

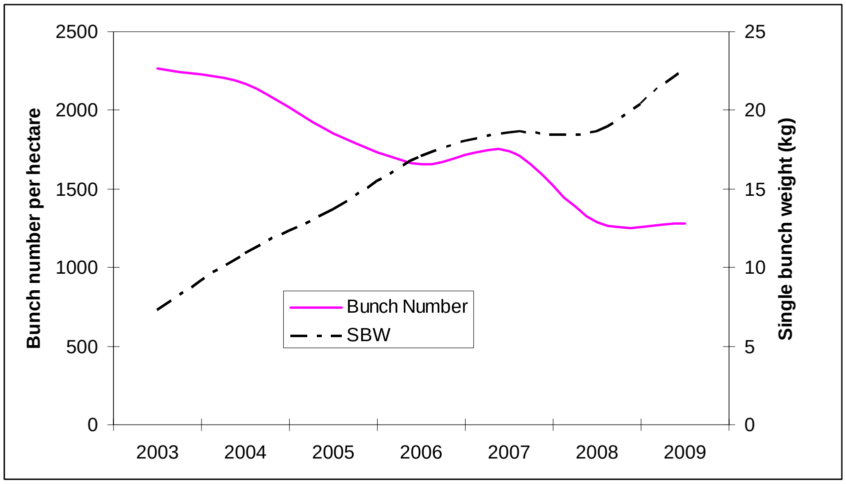



**Figure 2**. Mean trial bunch number per hectare (BHA) and SBW (kg/bunch) over time.

**Spacing treatment effect on tissue nutrient levels**

There were no differences in the nutrient status of the different spacing treatments in 2009 (Table 4). Leaflet continued to drop from 2.60 % dm in 2006 to 2.42 % dm in 2009. Rachis N increased from last year (0.25 to 0.40 for rachis N). Leaflet P, K and Mg were either adequate or near adequate. Leaflet B levels were adequate. Rachis N, P and K were all well over the adequate level.

**Table 4**. Leaflet and rachis nutrient status for three different Avenue widths in 2009

| Avenue Width | Leaflet nutrient concentration (% dm) | | | | | Rachis nutrient concentration (% dm) | | |
|---|---|---|---|---|---|---|---|---|
| | N | P | K | Mg | B | N | P | K |
| **Standard** | **2.42** | **0.144** | **0.64** | **0.19** | **16.7** | **0.40** | **0.11** | **1.91** |
| **Intermediate** | **2.41** | **0.142** | **0.65** | **0.18** | **15.8** | **0.41** | **0.12** | **2.02** |
| **Wide** | **2.42** | **0.143** | **0.66** | **0.18** | **16.8** | **0.39** | **0.11** | **1.89** |
| **Significance:** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| **CV %** | **2.1** | **2.0** | **3.2** | **6.2** | **5.5** | **6.6** | **3.9** | **6.3** |

**Spacing treatment effect on tissue vegetative growth**

The spacing effect had no significant effect on all the vegetative growth parameters in 2009 (Table 5), thus the means for each of the growth parameters were given instead of individual treatment.

*Frond production and frond number*

Close to 25 new fronds were produced in 2009 (one every 14 days) – this is normal for this age palm. Total green fronds counted per palm averaged 40 fronds which is an adequate number. The number of green fronds is expected to decline as palms mature.

*Frond and canopy size*

The two assessments of canopy coverage, 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) have increased slightly in 2009 and were within adequate limits for palms in this age group (average frond area 13 $m^2$ and LAI of 6.8).

*Vegetative dry matter production*
Petiole cross section (PCS) is a primary determinant of vegetative dry matter production. PCS in 2009 increased to an average of 45 $cm^2$. 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 2008 and the increments were not related to the spacing treatments (Table 5).

**Table 5**. Effects of the different Avenue widths on vegetative growth in 2009

| | Radiation interception | | | | | Dry matter production (t/ha) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | **PCS** | **FA** | **GF** | **FP** | **LAI** | **FDM** | **BDM** | **TDM** | **VDM** |
| **Mean** | **45.3** | **13.3** | **40.1** | **24.5** | **6.8** | **15.1** | **12.3** | **30.4** | **18.2** |
| **Significance** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** |
| **lsd** | **1.61** | - | - | - | - | - | - | - | - |
| **CV%** | **1.6** | **2.1** | **4.5** | **3.7** | **5.4** | **4.8** | **5.8** | **3.4** | **4.4** |

*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

At the lowest spacing (8.6 x 8.6 x 8.6), the avenue width is the widest but the width of the inter-rows are reduced to give the same density (128 palms/ha) as the other two treatments. Therefore at the lowest inter-row width, the palms are closely grown and competition for sunlight, nutrients, water and other necessary factors for growth and production are much higher than the other two spacing treatments. As a result, yields, nutrient concentrations in the fronds and the vegetative growth of the palms were reduced with reduction in spacing, although not significant. For example, yields dropped from 30 t/ha in the standard spacing (narrow avenue) to 28 t/ha in the closest spacing (widest avenue).

## CONCLUSION

At this stage in the trial, as palms are reaching maturity, there is still little differences in yield between planting palms at a standard avenue width of 8.2m compared to wider avenues of 9.5 and 10.6m (whilst keeping density the same). The Standard avenue treatment yielded 30 t/ha and the Wide avenue treatment yielded 28.5 t/ha.

# CTP MILNE BAY ESTATE

## Trials 502 and 511: Nitrogen, phosphorus, potassium and EFB trials, Waigani (RSPO 4.2, 8.1)

**SUMMARY**
Two trials, 502 and 511, with the same treatments, were established in 1994/95 in the Waigani estate at CTP 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 the response to N, P, K fertilizers in a factorial combination, with and without EFB. EFB was included to test whether it can be used to replace or supplement inorganic fertilizer. 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 however in Trial 502 and 14 plots in Trial 511 while the fields await replant.

- In Trial 502, following were responses observed in 2009:
- After two years of experiment in Trial 511, although small, there has been a significant response in yield and tissue nutrient concentration in both low and high yielding plots. The yield and tissue levels continued to be monitored in 2010 so the yield response could be observed further in 2010. As of 2009:
- Average yield in low yielding plots changed significantly from 12.2 t/ha in 2007 to 25.7t/ha in 2009. A very large yield difference of 12.5 t/ha.
- No significant yield difference was observed as an average in the high yielding plots, but there was a significant yield drop from 19.0 t/ha in 2007 to 13.7 t/ha in 2009 in plots that do not receive SOA. A significant drop in yield of 5.3 t/ha.
- Leaf N, P and K significantly increased in low yield plots. Leaf N rose from deficient level (2.17) in 2007 to adequate level (2.51) in 2009. Rachis N level increased from 0.27 in 2007 to 0.38 in 2009.
- In high yielding plots, only Leaf K, rachis N, rachis K

The trials are due for replant in 2011 so there will be another year of observing yield and tissue concentration in 2010 before both trials are being felled.

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

**Materials and methods**
General ANOVA was used to analyse the effects of different treatments on yield and tissue nutrient concentrations in both trials.

Trials 502 and 511 are factorial fertilizer 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 fertilizers 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 fertilizers are applied in 3 doses per year.

**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 | 21 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 | 19 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.*

**Table 2**. Amount of fertilizer 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:
(a) 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);
(b) when 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, a new plan was followed (Table 3).

**Table 3**: New fertilizer treatments in Trial 511

| | | Current fertiliser applied (kg/palm) | | | Proposed fertiliser 2008 (kg/palm) | | |
|---|---|---|---|---|---|---|---|
| Plot | YLD04 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 fertilized with highest fertilizer 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 fertilized 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 make ensure that the trial is maintained at good field standard.

**DATA COLLECTION AND ANALYSIS**

The effects of fertilizers on yield and its components, leaf tissue nutrient concentrations and physiological growth parameters are discussed in this report. Leaf tissue samples (leaflets and rachis) are collected from frond 17 out 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 fertilizer treatments on FFB yield its components are presented in Tables 4 and 5 respectively. SOA significantly increased SBW in 2009, and FFB yield and SBW in 2007-2009. MOP and EFB had similar effects to SOA in 2009 and 2007-2009. TSP did not have any effect on yield and yield components in both 2009 and 2007-2009. MOP and EFB had a significant interaction on SBW in 2009 and 2007-2009 and on FFB yield in 2007-2009. MOP increased SBW (not presented) and FFB yields; however the weights were further increased in the presence of FFB (Table 6).

The significant effects on FFB yield reported annually since 1998 appears to have stopped in 2009 and this could be due to nil fertilizer applications in 2008 and or the fall in crop experienced in 2008 and remained low in 2009. Mean ffb yield in 2007 was 27 t/ha, in 2008 was 20 t/ha and 20 t/ha again in 2009. Although there was a slight fall in leaflet N and rachis K concentrations, the fall in yield in 2008 was experienced throughout the plantations in Milne Bay and other provinces as well (Figure 1). The fall in crop was mostly due to fall in the number of bunches produced per ha, 991 bunches/ha in 2007, 760 bunches/ha in 2008 and 726 bunches/ha in 2009. The SBW remained at around 27 kg.

**Table 4.** Effect (p values) of treatments on FFB yield and its components for 2009 and 2007 to 2009 (3 years averaged data). P values less than 0.05 are presented in bold.

| | 2009 | | | 2007 to 2009 | | |
|---|---|---|---|---|---|---|
| **Source** | **Yield** | **BN** | **SBW** | **Yield** | **BN** | **SBW** |
| SOA | 0.263 | 0.752 | **<0.001** | **0.006** | 0.596 | **<0.001** |
| TSP | 0.330 | 0.250 | 0.843 | 0.689 | 0.180 | 0.921 |
| MOP | 0.341 | 0.852 | **<0.001** | **0.013** | 0.497 | **<0.001** |
| EFB | 0.180 | 0.946 | **<0.001** | **<0.001** | 0.194 | **<0.001** |
| SOA.TSP | 0.315 | 0.370 | 0.455 | 0.067 | 0.208 | 0.589 |
| SOA.MOP | 0.813 | 0.823 | **0.011** | 0.562 | 0.691 | 0.168 |
| TSP.MOP | 0.385 | 0.352 | 0.065 | 0.663 | 0.828 | **0.021** |
| SOA.EFB | 0.760 | 0.827 | 0.586 | 0.671 | 0.459 | 0.328 |
| TSP.EFB | 0.590 | 0.593 | 0.664 | 0.882 | 0.991 | 0.826 |
| MOP.EFB | 0.060 | 0.285 | **<0.001** | **0.001** | 0.077 | **<0.001** |
| | | | | | | |
| CV% | | | | | | |

**Table 5**. Main effects of treatments on FFB yield (t/ha) and its components for 2008 and 2006 to 2008 (three years averaged data). P values less than 0.05 are presented in bold.

| | | 2009 | | | | 2007 to 2009 | | |
|---|---|---|---|---|---|---|---|---|
| | | **Yield (t/ha)** | **BN (bunches/ha)** | **SBW (kg)** | | **Yield (t/ha)** | **BN (bunches/ha)** | **SBW (kg)** |
| SOA 0 | | 19.5 | 755 | **25.7** | | **21.2** | 578 | **25.5** |
| SOA 1 | | 20.0 | 698 | **28.6** | | **22.6** | 569 | **28.2** |
| SOA 2 | | 22.3 | 728 | **30.6** | | **24.7** | 600 | **29.2** |
| SOA 3 | | 21.6 | 725 | **29.5** | | **23.6** | 581 | **28.5** |
| *$lsd_{0.05}$* | | | | 1.265 | | 1.924 | | 1.020 |
| TSP 0 | | 20.3 | 705 | 28.6 | | 22.9 | 571 | 27.8 |
| TSP 1 | | 21.4 | 748 | 28.7 | | 23.2 | 593 | 27.9 |
| | | | | | | | | |
| MOP 0 | | 19.2 | 715 | **26.6** | | **21.1** | 561 | **26.2** |
| MOP 1 | | 21.3 | 735 | **29.0** | | **23.4** | 584 | **28.1** |
| MOP 2 | | 20.8 | 708 | **29.4** | | **23.3** | 585 | **28.4** |
| MOP 3 | | 22.0 | 748 | **29.4** | | **24.4** | 597 | **28.8** |
| *$lsd_{0.05}$* | | | | 1.265 | | 1.924 | | 1.020 |
| EFB 0 | | 20.1 | 725 | **27.5** | | **21.7** | 571 | **26.6** |
| EFB 1 | | 21.6 | 728 | **29.8** | | **24.4** | 593 | **29.1** |
| *$lsd_{0.05}$* | | | | 0.895 | | 1.360 | | 0.721 |
| GM | | 20.8 | 726 | 28.6 | | 23.0 | 582 | 27.8 |
| SE | | 4.472 | 145.1 | 1.752 | | 2.665 | 64.63 | 1.413 |
| C.V.% | | 21.5 | 20.0 | 6.1 | | 11.6 | 11.1 | 5.1 |

**Table 6**. Effect of MOP and EFB on FFB yield (t/ha) in 2007 to 2009 (three year average data).

| MOP by EFB 2007 to 2009 | | |
|---|---|---|
| | EFB 0 | EFB 1 |
| MOP 0 | 17.4 | 24.9 |
| MOP 1 | 22.3 | 24.4 |
| MOP 2 | 22.2 | 24.4 |
| MOP 3 | 24.8 | 23.9 |
| *P=0.008, Sed = 1.332, d.f =30* | | |

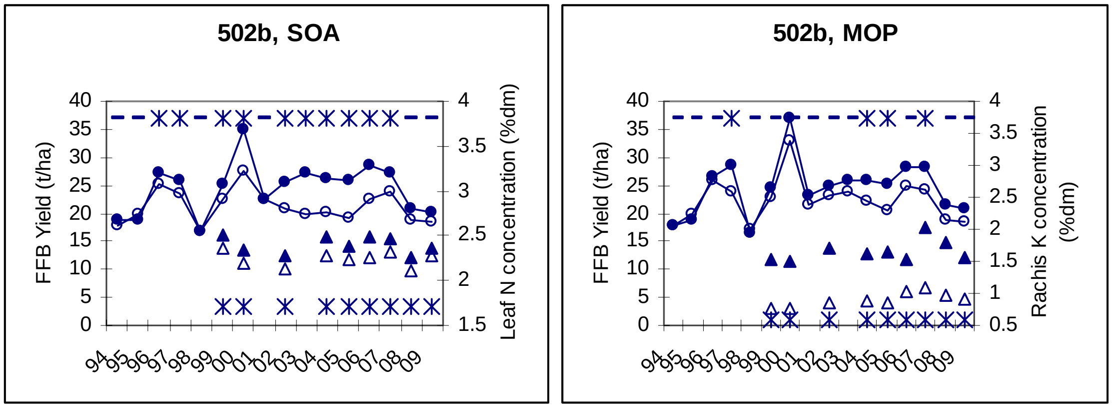



**Figure 1**. Main effects of SOA and MOP on yield and tissue nutrient concentration over the duration of the trial. Lines are FFB yields and triangles are tissue concentrations. Full symbols represent the maximum level of application, and empty symbols zero application. Symbols along the top of the graph indicate significance of the main effect on yield, and along the bottom indicate significance of the main effect on tissue concentration. Stars indicate significance (p<0.05) and dashes non-significance.

## LEAF TISSUE NUTRIENT CONCENTRATIONS

Effect of fertilizers on leaf tissue nutrient contents are presented in Tables 7 and 8. Fertilizer applications ceased in 2007, however their effects on leaf tissue nutrient concentrations are still noticed in 2009. SOA significantly increased leaflet Ash and N, and rachis N, P and K concentrations. TSP increased leaflet and rachis P concentrations. MOP significantly affected leaflet ash, K, Mg, Ca and B, and rachis Ash, K and P concentrations. EFB significantly affected leaflet ash, K, Mg and Ca, and rachis Ash and K contents.

There were significant interactions between MOP and EFB on the cation concentrations in the tissues. Two interactions tables are not presented, however, results indicated that;

a) 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 2007-2009.
b) 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 2009**.** p values less than 0.05 are indicated in bold.

| | Leaflet nutrient contents (% DM) | | | | | | | | | Rachis nutrient contents (% DM) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Source | Ash | N | P | K | Mg | Ca | Cl | B (ppm) | | Ash | N | P | K |
| SOA | **<0.001** | **<0.001** | 0.144 | 0.085 | 0.535 | 0.366 | 0.217 | 0.523 | | 0.224 | **<0.001** | **<0.001** | **0.036** |
| TSP | 0.413 | 0.787 | **0.013** | 0.481 | 0.779 | 0.667 | 0..790 | 0.861 | | 0.909 | 0.810 | **<0.001** | 0.411 |
| MOP | **0.009** | 0.289 | 0.413 | **<0.001** | **<0.001** | **0.022** | 0.909 | **<0.001** | | **<0.001** | 0.936 | **0.010** | **<0.001** |
| EFB | **0.001** | 0.884 | 0.569 | **<0.001** | **<0.001** | **<0.001** | 0.457 | 0.115 | | **0.046** | 0.431 | 0.543 | **<0.001** |
| SOA.TSP | 0.843 | 0.055 | 0.174 | 0.327 | 0.171 | 0.942 | 0.763 | 0.517 | | 0.225 | 0.440 | 0.376 | 0.551 |
| SOA.MOP | 0.436 | 0.112 | 0.075 | **0.020** | 0.517 | 0.323 | 0.987 | 0.138 | | 0.810 | 0.896 | 0.693 | 0.560 |
| TSP.MOP | 0.451 | 0.715 | 0.163 | 0.475 | 0.066 | 0.438 | 0.771 | 0.639 | | 0.283 | 0.832 | 0.159 | 0.315 |
| SOA.EFB | 0.315 | **0.005** | 0.643 | 0.493 | 0.117 | 0.423 | 0.521 | 0.444 | | 0.473 | 0.701 | 0.736 | 0.250 |
| TSP.EFB | 0.184 | 0.520 | 0.058 | 0.070 | 0.065 | 0.148 | 0.156 | 0.205 | | 0.550 | 0.606 | 0.158 | 0.916 |
| MOP.EFB | **0.034** | 0.314 | 0.521 | **<0.001** | **<0.001** | **<0.001** | 0.136 | **0.008** | | 0.086 | 0.597 | **0.017** | **<0.001** |
| CV% | | | | | | | | | | | | | |

**Table 8.** Trial 502, 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 (% DM)** | | | | | | | | | **Rachis nutrient concentrations (%DM)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** | **Cl** | **B (ppm)** | | **Ash** | **N** | **P** | **K** |
| SOA 0 | **13.2** | **2.29** | 0.150 | 0.60 | 0.38 | 0.82 | 0.48 | 15.1 | | 4.9 | **0.319** | **0.205** | **1.49** |
| SOA 1 | **13.1** | **2.28** | 0.148 | 0.60 | 0.38 | 0.82 | 0.51 | 14.3 | | 4.6 | **0.300** | **0.175** | **1.26** |
| SOA 2 | **13.6** | **2.30** | 0.147 | 0.60 | 0.36 | 0.80 | 0.49 | 14.6 | | 4.6 | **0.322** | **0.162** | **1.31** |
| SOA 3 | **14.3** | **2.37** | 0.149 | 0.57 | 0.37 | 0.84 | 0.50 | 15.0 | | 4.6 | **0.357** | **0.143** | **1.28** |
| *$LSD_{0.05}$* | *0.490* | *0.0429* | | | | | | | | | *0.0260* | *0.032* | *0.169* |
| TSP 0 | 13.6 | 2.31 | **0.147** | 0.60 | 0.38 | 0.82 | 0.50 | 14.8 | | 4.7 | 0.323 | **0.147** | 1.36 |
| TSP 1 | 13.5 | 2.31 | **0.150** | 0.59 | 0.37 | 0.82 | 0.50 | 14.7 | | 4.7 | 0.325 | **0.196** | 1.31 |
| *$LSD_{0.05}$* | | | *0.002* | | | | | | | | | ***0.0267*** | |
| MOP 0 | 14.1 | 2.29 | 0.150 | **0.52** | **0.46** | **0.86** | 0.50 | **16.6** | | **3.9** | 0.328 | **0.148** | **0.90** |
| MOP 1 | 13.2 | 2.31 | 0.147 | **0.61** | **0.36** | **0.81** | 0.50 | **14.2** | | **4.7** | 0.325 | **0.181** | **1.34** |
| MOP 2 | 13.5 | 2.30 | 0.148 | **0.62** | **0.35** | **0.81** | 0.49 | **13.** | | **5.0** | 0.325 | **0.164** | **1.53** |
| MOP 3 | 13.3 | 2.33 | 0.149 | **0.62** | **0.33** | **0.80** | 0.50 | **14.5** | | **5.0** | 0.320 | **0.193** | **1.57** |
| *$LSD_{0.05}$* | *0.490* | | | *0.0278* | *0.0287* | *0.0395* | | *1.274* | | *0.296* | | *0.0189* | *0.169* |
| EFB 0 | 13.9 | 2.31 | 0.148 | **0.55** | **0.40** | **0.85** | 0.50 | 15.1 | | **4.6** | 0.320 | 0.169 | **1.21** |
| EFB 1 | 13.2 | 2.31 | 0.149 | **0.64** | **0.35** | **0.79** | 0.49 | 14.4 | | **4.8** | 0.328 | 0.174 | **1.47** |
| *$LSD_{0.05}$* | 0.346 | | | *0.0197* | *0.0203* | *0.0279* | | | | *0.209* | | | *0.119* |
| GM | 13.5 | 2.31 | 0.148 | 0.59 | 0.37 | 0.82 | 0.50 | 14.7 | | 4.7 | 0.324 | 0.171 | 1.34 |
| SE | 0.678 | 0.0595 | 0.0041 | 0.0386 | 0.0398 | 0.0547 | 0.464 | 1.764 | | 0.410 | 0.0360 | 0.070 | 0.234 |
| C.V.% | 5.0 | 2.6 | 2.8 | 6.5 | 10.6 | 6.7 | 9.3 | 12.0 | | 8.7 | 11.1 | 21.6 | 14.6 |

**PHYSIOLOGICAL GROWTH PARAMETERS**

The effects of fertilizers on physiological growth parameters are presented in Tables 9 and 10. SOA significantly increased FL, PCS, FA, LAI, FDM, TDM and VDM. MOP increased FL and FA only. EFB significantly increased FL, PCS, FA, LAI, FDM, BDM, TDM and VDM. TSP did not have any effect on any of the growth parameters. None of the fertilizers had any effect on BI and BI was very low (mean=0.36) implying VDM production was greater than BDM production.

**Table 9.** Trial 502, main effects (p values) of fertilizer treatments on vegetative growth parameters in 2009. P values less than 0.05 are shown in bold.

| Source | | | Radiation interception | | | Dry matter production | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FL | PCS | FP | FA | LAI | FDM | BDM | TDM | VDM | BI |
| | | | | | | | | | | |
| SOA | **<0.001** | **<0.001** | 0.332 | **0.026** | **<0.001** | **<0.001** | 0.097 | **<0.001** | **<0.001** | 0.596 |
| TSP | 0.084 | 0.198 | 0.071 | 0.133 | 0.573 | 0.561 | 0.518 | 0.999 | 0.597 | 0.334 |
| MOP | **0.0221** | 0.564 | 0.240 | **0.007** | 0.158 | 0.298 | 0.191 | 0.082 | 0.250 | 0.497 |
| EFB | **<0.001** | **<0.001** | 0.857 | **0.007** | **<0.001** | **0.006** | **0.003** | **<0.001** | **0.003** | 0.344 |
| SOA.TSP | 0.448 | 0.928 | 0.808 | 0.057 | 0.290 | 0.816 | 0.061 | 0.097 | 0.720 | 0.354 |
| SOA.MOP | 0.216 | **0.046** | 0.206 | 0.852 | 0.855 | **0.040** | 0.837 | 0.225 | 0.040 | 0.234 |
| TSP.MOP | 0.249 | 0.304 | 0.347 | 0.069 | 0.106 | 0.801 | 0.171 | 0.136 | 0.692 | 0.675 |
| SOA.EFB | **0.029** | 0.162 | 0.279 | 0.762 | 0.211 | 0.135 | 0.266 | **0.049** | 0.109 | 0.519 |
| TSP.EFB | 0.820 | 0.179 | 0.613 | 0.355 | 0.273 | 0.219 | 0.855 | 0.275 | 0.210 | 0.532 |
| MOP.EFB | 0.945 | 0.206 | 0.952 | 0.236 | 0.104 | 0.543 | **0.016** | **0.011** | 0.380 | 0.220 |
| | | | | | | | | | | |
| CV% | | | | | | | | | | |

*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**. Trial 502, main effects of fertilizer treatments on the vegetative growth parameters in 2009. P values less than 0.05 are shown in bold

| Source | | | Radiation interception | | | Dry matter production (t/ha/yr) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FL | PCS | FP | FA | LAI | FDM | BDM | TDM | VDM | BI |
| | | | | | | | | | | |
| SOA 0 | **596.0** | **47.2** | 21.8 | **13.7** | **5.40** | **13.9** | 9.8 | **26.3** | **16.5** | 0.37 |
| SOA 1 | **621.5** | **52.6** | 21.7 | **14.2** | **5.83** | **15.4** | 10.2 | **28.5** | **18.2** | 0.36 |
| SOA 2 | **631.9** | **57.4** | 21.9 | **14.3** | **6.04** | **16.9** | 11.3 | **31.3** | **20.0** | 0.36 |
| SOA 3 | 631.0 | **55.3** | 22.9 | **14.0** | **5.90** | **17.0** | 10.9 | **31.0** | **20.1** | 0.35 |
| *LSD0.05* | 10.21 | 3.115 | | 0.461 | 0.243 | 1.415 | | 1.964 | 1.558 | |
| | | | | | | | | | | |
| TSP 0 | 623.1 | 53.8 | 21.6 | 14.2 | 5.81 | 15.6 | 10.7 | 29.3 | 18.6 | 0.37 |
| TSP 1 | 616.6 | 52.4 | 22.6 | 13.9 | 5.77 | 15.9 | 10.4 | 29.3 | 18.9 | 0.35 |
| *LSD0.05* | | | | | | | | | | |
| | | | | | | | | | | |
| MOP 0 | **613.6** | 51.8 | 21.7 | **13.5** | 5.67 | 15.2 | 9.8 | 27.7 | 18.0 | 0.35 |
| MOP 1 | **623.9** | 53.3 | 22.9 | **14.2** | 5.75 | 16.5 | 10.7 | 30.2 | 19.5 | 0.35 |
| MOP 2 | **627.8** | 53.5 | 22.1 | **14.2** | 5.80 | 15.9 | 10.6 | 29.5 | 18.9 | 0.36 |
| MOP 3 | **614.9** | 53.9 | 21.5 | **14.3** | 5.94 | 15.6 | 11.2 | 29.7 | 18.5 | 0.38 |
| *LSD0.05* | 10.21 | | | 0.461 | | | | | | |
| | | | | | | | | | | |
| EFB 0 | **609.6** | **50.6** | 22.0 | **13.8** | **5.63** | **15.1** | **9.8** | **27.7** | **17.8** | 0.35 |
| EFB 1 | **629.9** | **55.6** | 22.1 | **14.3** | **5.95** | **16.5** | **11.3** | **30.9** | **19.6** | 0.37 |
| *LSD0.05* | 7.22 | 2.202 | | 0.326 | 0.172 | 1.000 | 0.903 | 1.389 | 1.102 | |
| | | | | | | | | | | |
| GM | 619.9 | 53.1 | 22.1 | 14.0 | 5.79 | 15.8 | 10.5 | 29.3 | 18.7 | 0.36 |
| SE | 14.14 | 4.313 | 2.076 | 0.638 | 0.337 | 1.959 | 1.769 | 2.720 | 2.158 | 0.0496 |
| C.V.% | 2.3 | 8.1 | 9.4 | 4.5 | 5.8 | 12.4 | 16.8 | 9.3 | 11.5 | 13.8 |

*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

There was no effect of fertilizer on yield in 2009. Higher yields were obtained in the presence of SOA and MOP for 2007-2009 Effects of MOP on cation contents in the leaf tissues and DM production were enhanced with the addition of EFB.

## RESULTS AND DISCUSSIONS (PART 2 – TRIAL 511)

The results from the 14 selected plots were analysed and were used to answer the following questions. The following terms in Table 11 are defined for data interpretation.

**Table 11**. 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 |

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 13.7 t/ha in 2009 (Figure 2). 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.

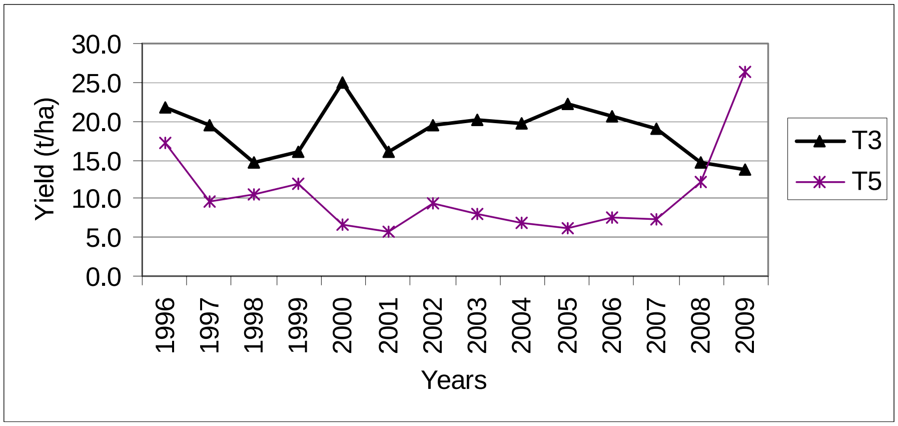



**Figure 2**. Yield trend in T3 and T5 plots from 1996 to 2009. Fertiliser treatments changed in 2008.

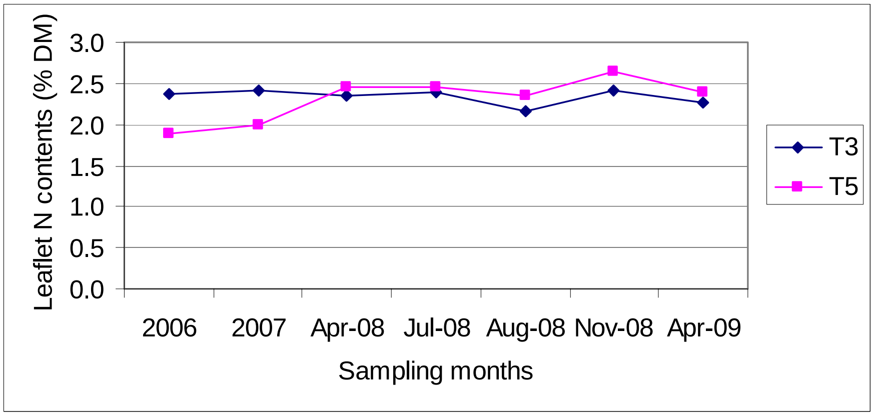



**Figure 3**. Leaflet N concentrations (% DM) in T3 and T5 plots.

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 (Figure 3). Similar trend was seen with leaflet P, leaflet K and rachis K contents in T5 plots (Figures 4, 5 and 6).

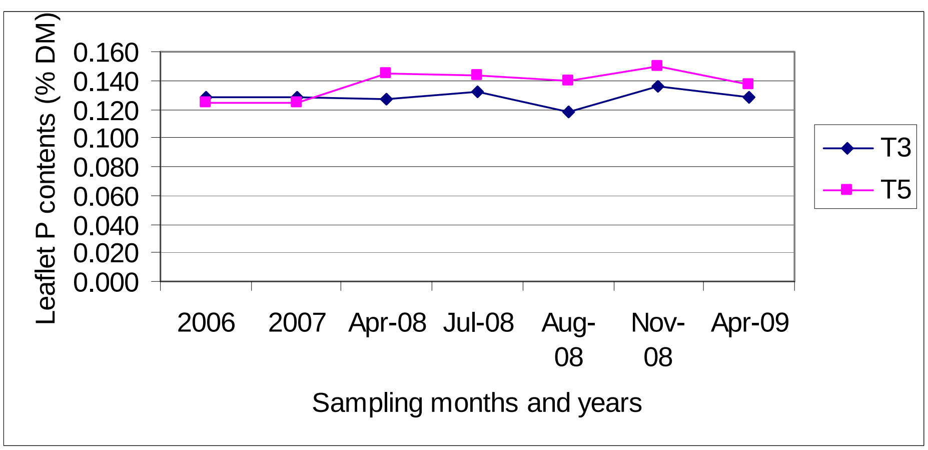



**Figure 4.** Leaflet P concentrations in T3 and T5 plots.

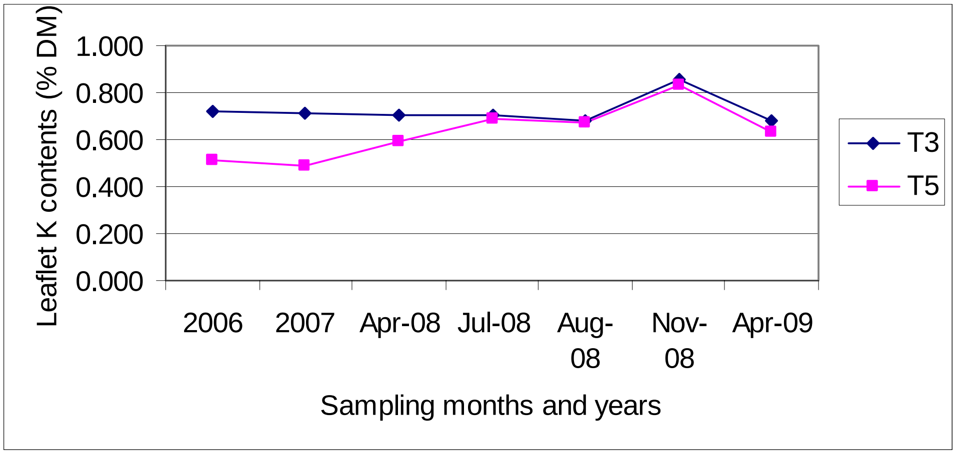



**Figure 5**. Leaflet K concentrations in T3 and T5 plots.

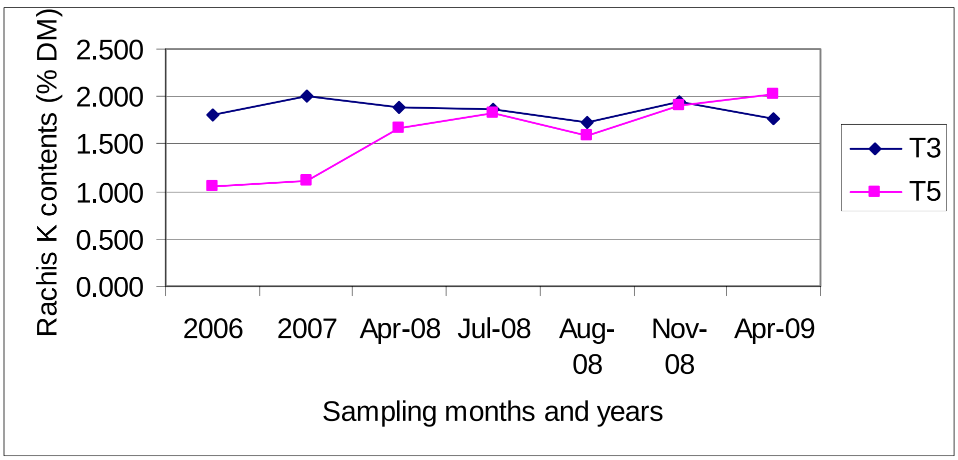



**Figure 6**. Rachis K concentrations in T3 and T5 plots.

FFB yield in T4 plots decreased in 2008 however rebound to just above 25 t/ha in 2009 (Figure 7). 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 slightly fell in 2009.

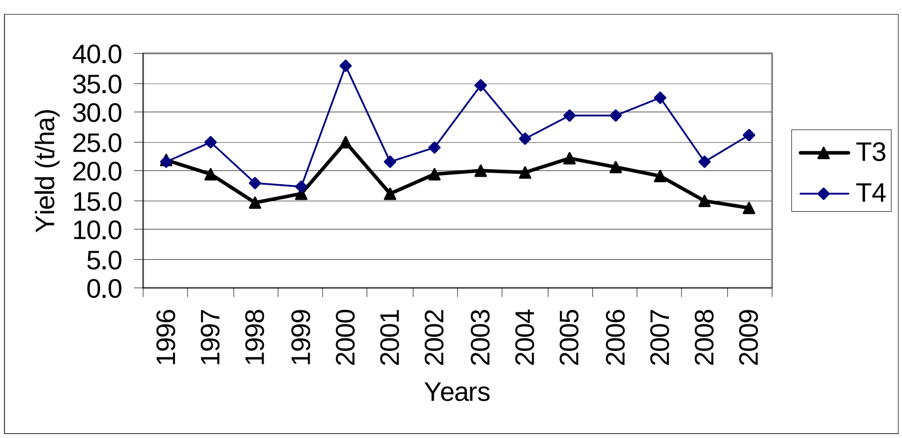



**Figure 7**. Yield trend in T3 and T4 plots from 1996 to 2009. Fertiliser treatments changed in 2008

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 8). 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.

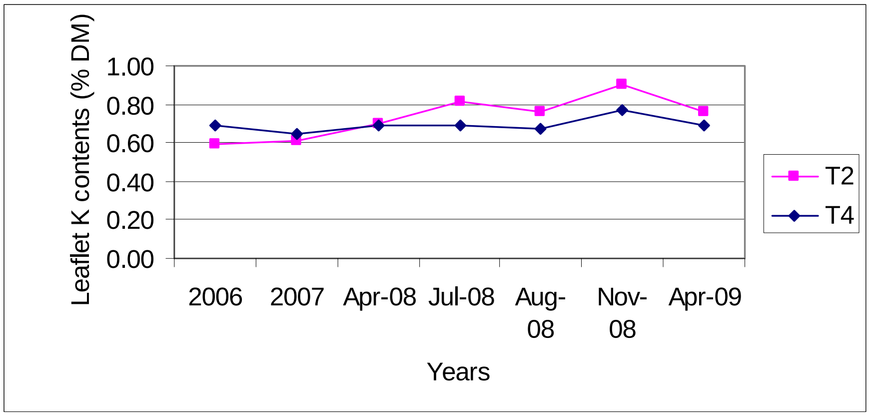



**Figure 8**. Leaflet K concentrations in T2 and T4 plots.

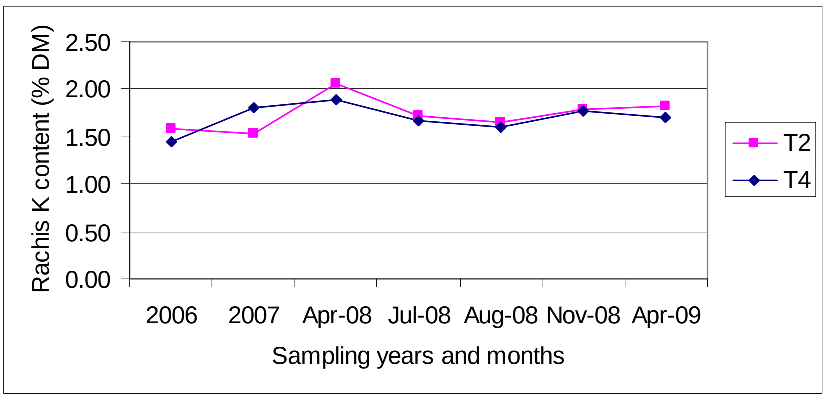



**Figure 9**. Rachis K concentrations in T2 and T4 plots.

Even after K addition was stopped in T2 and T4 plots, it appears rachis K contents are sufficient and above 1.50 % DM (Figure 9)

Addition of N and P in T2 plots in 2008 improved leaflet P concentrations (Figure 10). The fall in P contents in April 09 happened in both T2 and T4 and therefore cannot be due to P depletion. In T4 plots where P fertiliser was not applied in 2008, the P contents were still high (>0.140 % DM) throughout the sampling months. This implies sufficient reserves in the soil to maintain the levels.

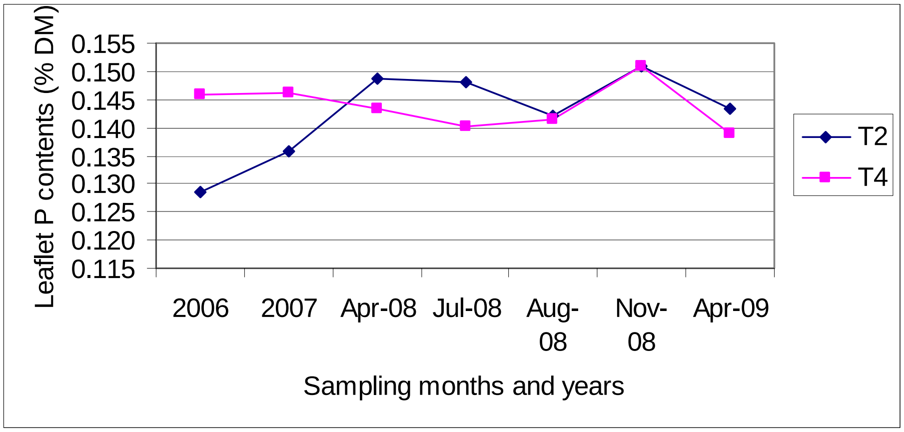



**Figure 10**. Leaflet P concentrations in T2 and T4 plots

**CONCLUSION**

Responses to addition of fertilizers especially N fertilizers had immediate effect on yield (within a year) and leaf nutrient contents. Addition of N fertilisers to N deficient palms improved the utilisation of K in the palms immediately. Yield and leaf tissue nutrient contents responses to stopping of fertiliser applications are yet to be seen.

# Trial 504: Nitrogen by Potassium trial, Sagarai (RSPO 4.2, 8.1)

**SUMMARY**
Trial 504 was established in the Sagarai estate of the CTP Milne Bay Estate plantation, to test the response in oil palm to N and K fertilizer. 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 of SOA (0, 2.0, 4.0 and 6.0 kg/palm) and 4 rates of MOP (0, 2.5, 5.0 and 7.5 kg/palm). FFB yield, frond 17 nutrient concentration and vegetative growth parameters responded well to the fertilizer treatments, especially to SOA as the N source. N drives production in this estate. Over the last few years the response to K fertilizer has been increasing. Highest yields of 26.6 t/ha was still obtained from a combination of N and K fertilizer. In 2009 the optimum combination of N and K was 4 to 6 kg of SOA/palm (0.8 to 1.2kg N/palm) in combination with MOP at 5 kg/palm (2.25 kg K/palm).

## METHODS

### Trial Background Information

**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 | 17 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 | Agronomist in charge | Rachel Pipai |

### 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). Fertilizer was first applied in 1994. Fertilizers are applied in 3 doses per year. TSP at 0.5 kg/palm was applied as a basal in 2009.

**Table 2**. Types of treatment fertilizer 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.

Trial data was analyzed using standard two way analysis of variance procedures.

### Data Collection

Yield recording (weighing of bunches) is done on a fortnightly basis (14 days). 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.

## RESULTS and DISCUSSION

### Yield and other components response to fertilizer 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. The effect of the treatments, especially SOA in increasing yield has been consistent over the last seven years. The yield difference between the maximum and zero level of SOA application widened in 2005 and 2006, and continued into 2007. The effect of K fertilizer on yield, although significant from 2004 to 2007, is less marked compared to N fertilizer. The combination of both fertilizers resulted in the highest yields highlighting the importance of N and K nutrition on this soil type.

In 2009, SOA had a significant effect on FFB yield and SBW ($p<0.001$). SOA significantly increased FFB yield above 20 t/ha and this positive response resulted from a significant increase in both the number of bunches and the single bunch weight. MOP also had an impact on yield ($p<0.001$) and this was brought about by a positive effect on the number of bunches produced and the SBW.

**Table 3**. Effect (p values) of treatments on FFB yield and its components for 2009 and 2007 to 2009 (3 years averaged data). P values less than 0.05 are presented in bold.

| | 2009 | | | 2007 to 2009 | | |
|---|---|---|---|---|---|---|
| **Source** | **Yield** | **BN** | **SBW** | **Yield** | **BN** | **SBW** |
| SOA | **<0.001** | 0.095 | **<0.001** | **<0.001** | **<0.001** | **<0.001** |
| MOP | **0.008** | 0.083 | 0.181 | **<0.001** | **0.002** | **0.034** |
| SOA.MOP | 0.505 | 0.684 | 0.052 | 0.404 | 0.156 | 0.158 |
| CV % | | | | | | |

**Table 4**. Main effects of treatments on FFB yield (t/ha) and its components for 2009 and 2007 to 2009 (three years averaged data). P values less than 0.05 are presented in bold.

| | 2009 | | | | 2007-2009 | | |
|---|---|---|---|---|---|---|---|
| | **Yield (t/ha)** | **BN (b/ha)** | **SBW (kg)** | | **Yield (t/ha)** | **BN (b/ha)** | **SBW (kg)** |
| SOA0 | **18.7** | 785 | **23.8** | | **20.4** | **898.2** | **22.8** |
| SOA1 | **21.9** | 855 | **25.8** | | **23.6** | **961.7** | **24.7** |
| SOA2 | **23.4** | 860 | **27.6** | | **25.3** | **970.3** | **26.3** |
| SOA3 | **24.0** | 882 | **27.5** | | **26.3** | **1022.4** | **26.0** |
| $LSD_{0.05}$ | 2.277 | | 1.017 | | 1.445 | 48.2 | 0.829 |
| MOP0 | **20.2** | 802 | 25.6 | | **21.9** | **909.3** | **24.4** |
| MOP1 | **21.3** | 820 | 26.1 | | **23.7** | **953.1** | **25.0** |
| MOP2 | **24.1** | 900 | 26.7 | | **25.4** | **994.2** | **25.6** |
| MOP3 | **22.4** | 859 | 26.2 | | **24.6** | **996.0** | **24.9** |
| $LSD_{0.05}$ | *2.277* | | | | 1.445 | 48.2 | 0.829 |
| | | | | | | | |
| GM | 22.0 | 845 | 26.2 | | 23.9 | 963.1 | 25.0 |
| SE | 3.201 | 113 | 1.430 | | 2.032 | 67.76 | 1.165 |
| CV % | 14.6 | 13.4 | 5.5 | | 8.5 | 7.0 | 4.7 |

Combinations of both SOA and MOP produced the highest yields (Table 5). The highest FFB yield of 27.6 t/ha was obtained when 2.0 kg of SOA /palm was applied together with 5.0 kg of MOP/palm for 2007-2009 period.

**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 – 2009*** | | | | |
|---|---|---|---|---|
| | MOP0 | MOP1 | MOP2 | MOP3 |
| SOA0 | 17.3 | 16.9 | 20.8 | 19.7 |
| SOA1 | 20.0 | 19.9 | **26.2** | 21.5 |
| SOA2 | 20.6 | 22.7 | **25.7** | 24.4 |
| SOA3 | 22.8 | **25.6** | 23.7 | 24.1 |
| ***SOA by MOP – 2007 to 2009*** | | | | |
| | MOP0 | MOP1 | MOP2 | MOP3 |
| SOA0 | 18.6 | 18.9 | 22.6 | 21.7 |
| SOA1 | 21.2 | 23.7 | 25.5 | 24.0 |
| SOA2 | 22.6 | 25.3 | **27.6** | 25.6 |
| SOA3 | 25.2 | 27.0 | 25.8 | 27.2 |

**Table 6**. Effect (p values) of treatments of frond 17 nutrient concentration. P values < 0.05 are shown in bold.

| Source | **Leaflet nutrient concentrations** | | | | | | | | **Rachis nutrient concentrations** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Cl** | **B (ppm)** | | **Ash** | **N** | **P** | **K** |
| SOA | **0.022** | **<0.001** | 0.643 | 0.102 | 0.133 | 0.467 | **0.034** | | **<0.001** | **0.012** | **<0.001** | **<0.001** |
| MOP | **0.006** | 0.668 | 0.854 | **<0.001** | **<0.001** | **<0.001** | **<0.001** | | **<0.001** | 0.477 | **<0.001** | **<0.001** |
| SOA.MOP | 0.856 | 0.537 | 0.452 | 0.537 | 0.143 | 0.845 | 0.480 | | 0.484 | 0.095 | 0.415 | 0.876 |
| | | | | | | | | | | | | |
| CV % | | | | | | | | | | | | |
| | | | | | | | | | | | | |

**Table 7.** Main effects of treatments on frond 17 nutrient concentration. P values < 0.05 are shown in bold. All units expressed in % dry matter.

| | **Leaflet nutrient concentrations** | | | | | | | | **Rachis nutrient concentrations** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **Cl** | **B (ppm)** | | **Ash** | **N** | **P** | **K** |
| SOA0 | **10.2** | **2.30** | 0.155 | 0.67 | 0.37 | 0.47 | 9.8 | | 4.3 | **0.276** | **0.255** | **1.37** |
| SOA1 | **10.3** | **2.32** | 0.153 | 0.66 | 0.36 | 0.46 | 9.5 | | 3.9 | **0.272** | **0.192** | **1.19** |
| SOA2 | **10.5** | **2.43** | 0.154 | 0.65 | 0.35 | 0.48 | 9.9 | | 3.7 | **0.301** | **0.159** | **1.11** |
| SOA3 | **10.7** | **2.48** | 0.155 | 0.62 | 0.36 | 0.48 | 10.2 | | 3.4 | **0.289** | **0.135** | **1.01** |
| $LSD_{0.05}$ | 0.333 | 0.0713 | | | | | | | 0.292 | 0.0186 | 0.0239 | 0.130 |
| MOP0 | **10.8** | 2.36 | 0.154 | **0.57** | **0.40** | **0.41** | 10.7 | | 2.7 | 0.290 | **0.146** | **0.61** |
| MOP1 | **10.4** | 2.39 | 0.155 | **0.65** | **0.36** | **0.49** | 9.7 | | 3.9 | 0.284 | **0.192** | **1.21** |
| MOP2 | **10.2** | 2.40 | 0.154 | **0.69** | **0.34** | **0.50** | 9.4 | | 4.4 | 0.287 | **0.198** | **1.42** |
| MOP3 | **10.3** | 2.38 | 0.154 | **062** | **0.34** | **0.50** | 9.5 | | 4.4 | 0.276 | **0.205** | **1.44** |
| $LSD_{0.05}$ | 0.333 | | | 0.0367 | 0.0131 | 0.0304 | 0.4708 | | 0.292 | | 0.0239 | 0.130 |
| GM | 10.4 | 2.38 | 0.154 | 0.65 | 0.36 | 0.47 | 9.8 | | 3.8 | 0.284 | 0.185 | 1.17 |
| SE | 0.469 | 0.1002 | 0.0041 | 0.0516 | 0.0185 | 0.0427 | 0.6620 | | 0.410 | 0.0261 | 0.0336 | 0.182 |
| CV % | 4.5 | 4.2 | 2.7 | 7.9 | 5.1 | 9.0 | 6.7 | | 10.7 | 9.2 | 18.1 | 15.6 |
| | | | | | | | | | | | | |

**Fertilizer effects on Frond 17 nutrient concentrations**

N and K fertilizer 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.

Leaflet concentrations of K were increased by increasing rates of MOP; in the rachis both P and K levels were increased with higher MOP rates.
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 (9.8 ppm) were low
- N fertilizer 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.

There is little difference in yield between SOA and MOP fertilized plots however the gap between fertilized plots and the control (nil fertilized plots) widened after 2001 (Figure 1). The gap in 2009 was 7 t/ha. There was a fall in crop in 2008 however there are indications of recovery in 2009.

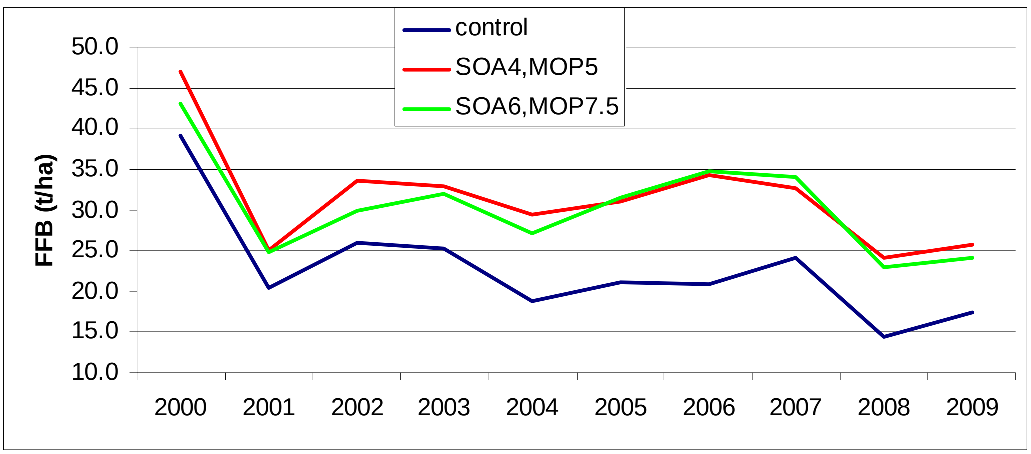



**Figure 1**. Yield trend from 2000 to 2009 for various SOA-MOP combinations

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, remobilizing K reserves in the rachis. Response to N limited by availability of K.

**Table 8**. Trial 504 Effect of SOA and MOP on rachis K concentrations in 2009

| | MOP0 | MOP1 | MOP2 | MOP3 |
|---|---|---|---|---|
| SOA0 | 0.89 | 1.40 | 1.62 | 1.57 |
| SOA1 | 0.63 | 1.20 | 1.46 | 1.46 |
| SOA2 | 0.48 | 1.15 | 1.32 | 1.49 |
| SOA3 | 0.43 | 1.08 | 1.29 | 1.22 |

**Fertilizer effects on vegetative growth parameters in 2009**

Tables 9 and 10 present the fertilizer effects on vegetative growth parameters. Increasing rates of SOA had a positive and significant effect on the petiole cross section, frond area, Leaf Area Index (LAI), dry matter production and bunch index. The addition of K also had beneficial impact on increasing the petiole cross section, frond area and dry matter production, however K fertilizer had no effect on frond length, frond production, frond size and bunch index. The mean bunch index was 0.33.

**Table 9**. Effect (p values) of treatments on vegetative growth parameters in trial 504, for 2009. Significant effects ($p<0.05$) are shown in bold.

| | | | Radiation interception | | | Dry matter production | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Source | FL | PCS | FP | FA | LAI | FDM | BDM | TDM | VDM | BI |
| SOA | 0.233 | **<0.001** | 0.399 | **0.024** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **<0.001** | **0.027** |
| MOP | 1.000 | **0.020** | 0.634 | **0.016** | 0.068 | 0.187 | **0.020** | **0.012** | 0.123 | 0.098 |
| SOA.MOP | 0.359 | 0.402 | 0.319 | **0.013** | 0.755 | 0.273 | 0.459 | 0.410 | 0.284 | 0.351 |
| CV % | | | | | | | | | | |

*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, for 2009. Significant effects ($p<0.05$) are shown in bold.

| | | | Radiation interception | | | Dry matter production | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FL | PCS | FP | FA | LAI | FDM | BDM | TDM | VDM | BI |
| SOA0 | 649.7 | **54.0** | 24.9 | **13.8** | **5.22** | **18.0** | **9.8** | **31.0** | **21.1** | **0.31** |
| SOA1 | 650.5 | **57.5** | 25.3 | **14.2** | **5.61** | **19.5** | **11.6** | **34.6** | **23.0** | **0.33** |
| SOA2 | 641.0 | **59.2** | 25.7 | **14.2** | **5.66** | **20.4** | **12.4** | **36.5** | **24.0** | **0.34** |
| SOA3 | 640.4 | **58.1** | 25.3 | **14.3** | **5.71** | **19.7** | **12.7** | **36.1** | **23.3** | **0.35** |
| *$LSD_{0.05}$* | | 2.041 | | 0.342 | 0.248 | 1.036 | 1.195 | 1.823 | 1.168 | 0.0240 |
| MOP0 | 645.6 | **55.2** | 25.3 | **13.8** | 5.36 | **18.8** | **10.8** | **32.8** | 22.0 | 0.33 |
| MOP1 | 645.3 | **57.4** | 25.4 | **14.2** | 5.68 | **19.5** | **11.2** | **34.2** | 23.0 | 0.32 |
| MOP2 | 645.6 | **58.4** | 25.0 | **14.2** | 5.57 | **19.5** | **12.6** | **35.7** | 23.1 | 0.35 |
| MOP3 | 645.1 | **57.8** | 25.6 | **14.4** | 5.59 | **19.8** | **11.9** | **35.3** | 23.4 | 0.33 |
| *$LSD_{0.05}$* | | 2.041 | | 0.342 | | | 1.195 | 1.823 | | |
| GM | 645.4 | 57.2 | 25.3 | 14.2 | 5.55 | 19.4 | 11.6 | 34.5 | 22.9 | 0.33 |
| SE | 12.73 | 2.870 | 1.399 | 0.480 | 0.349 | 1.456 | 1.681 | 2.563 | 1.643 | 0.0338 |
| CV % | 2.8 | 5.0 | 5.5 | 3.4 | 6.3 | 7.5 | 14.5 | 7.4 | 7.2 | 10.1 |

*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 fertilizer, applied as SOA, was the main driver of production in this trial. N treatments resulted in higher concentrations of N in the rachis and leaflets, increased size of rachis PCS (petiole cross section), higher dry matter production of fronds and subsequent higher yields. The higher yield of palms in the N treatments was brought about by more and heavier bunches.

K fertilizer, 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 were 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, 8.1)

**SUMMARY**
A new NxK trial at Maiwara, MBE. Treatments were first applied in May 2007. There were no differences in yield resulting from the different fertiliser application, however there are some apparent differences showing in the tissue analysis (K fertiliser increased the rachis K level).

**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 fertilizer 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 | 7 | 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 |

**RESULTS**

*Yield*
Two analyses were undertaken for 2008 – the first one was for the 2008 data alone and secondly we used 2006 yield as the co-variate for the 2008 analysis (we cannot use 2007 as the co-variate year because treatments were imposed half way during the year).

The regression equation for Yield in 2008 was:

$$Yield_{2008} = 16.1 + 9.5\,N - 1.6\,N^2 + 4.1\,K - 0.2\,K^2 - 2.3\,N.K \quad R^2=0.44$$

(note in the above equation N and K refer to units of nutrient applied in kg/palm)

The only parameter which was significant was the intercept (parameter a) at P=0.009. All other parameters were not significant indicating that at this stage in the trial there is little impact of the fertilisers on yield. It was hoped to use the pre-treatment data as a co-variate to improve the relationship for the effect of fertiliser on yield. The use of co-variates means that the differences across the field in the pre-treatment data can be allowed for in the 2008 treatment data.

The regression equation for Yield in 2008 whilst using Yield 2006 as a co-variate was:

$$Yield_{2008} = 11.4 + 7.8\,N - 1.7\,N^2 + 3.1\,K - 0.3\,K^2 - 1.5\,N.K \quad R^2=0.45$$

(note in the above equation N and K refer to units of nutrient applied in kg/palm)

In this case none of the parameters were significant (all had a $P > 0.05$) and the $R^2$ (coefficient of variation) had not improved indicating that using 2006 yield data did not improve the explanation of yield outcomes in 2008.

*Tissue nutrients*

The same regression procedures as for yield were applied to the tissue data and in this first full year of treatments there were few significant effects. Only Rachis K was influenced by the fertiliser treatments (r2 = 0.80) with the parameter for K having a P value of 0.03. Certainly the zero input K treatment had a low Rachis K content (RK = 0.78 %dm) and much lower then the K fertiliser treatments (RK > 1.2 %dm).

We expect that these results will continue to differentiate between no or low fertiliser inputs and the higher fertiliser treatments in future years.

**DISCUSSION**

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

# Trial 517: New K placement trial at Maiwara Estate (RSPO 4.2, 8.1)

**SUMMARY**
A new K placement trial was set up at Maiwara, MBE. Treatments were first applied in May 2007. The trial aims to identify the best placement option for MOP fertilizer. The trial consists of four treatments for the placement of MOP (all at 7.5kg/palm) where each treatment is replicated four times:

- spread over frond tips and frond pile
- spread over weeded circle
- spread on the edge of weeded circle
- broadcast over the whole block

(Note: one high treatment plot and two zero treatment plots were included as plots because three plots were left over in the trial design of trials 516 and 517).

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

**INTRODUCTION**
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 fertilizer treatments were applied in May 2007. Site details are presented in Table 1.

**Table 1.** Trial 517 back ground 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 | 8 | 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 2009: 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).

Trial 517 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 poor uptake from 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) broad-cast. Three additional plots were available and two of these did not receive any K fertiliser, and the third plot has a higher rate of 12k g/palm MOP. These three plots are not part of the analysis but are used to provide additional information especially when interpreting tissue K levels.

One way Anova is used for trial analysis.

**RESULTS AND DISCUSSION**

Analysed yield data for 2009 and 2007-2009 are presented in Table 2. Yield data for the nil fertilised and the highest MOP rate plots are also presented. 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 is 27.5 t/ha in 2009.

**Table 2.** Trial 517 main effects of fertilizer placement treatments on FFB yield (t/ha) and its components for 2009 and 2007 to 2009 (three years averaged data).

| | | **2009** | | | | **2007-2009** | | |
|---|---|---|---|---|---|---|---|---|
| | | **Yield (t/ha)** | **BN (bunches/ha)** | **SBW (kg)** | | **Yield (t/ha)** | **BN (bunches/ha)** | **SBW (kg)** |
| | | | | | | | | |
| Nil fertilizer | | 28.2 | 1606 | 17.5 | | 26.2 | 1707.1 | 15.5 |
| Highest MOP rate | | 26.9 | 1422 | 18.9 | | 26.6 | 1736.3 | 15.6 |
| | | | | | | | | |
| Edge of weeded circle | | 27.1 | 1445 | 18.8 | | 27.0 | 1677 | 16.3 |
| Weeded circle | | 26.5 | 1500 | 17.8 | | 26.3 | 1676 | 15.9 |
| Broadcast | | 29.2 | 1547 | 18.9 | | 27.4 | 1750 | 15.9 |
| Frond tips and piles | | 27.3 | 1519 | 18.0 | | 27.2 | 1763 | 15.6 |
| | | | | | | | | |
| *P values* | | *0.377* | *0.814* | *0.297* | | *0.655* | *0.606* | *0.800* |
| | | | | | | | | |
| GM | | 27.5 | 1503 | 18.4 | | 27.0 | 1717 | 15.9 |
| SE | | 2.160 | 152.8 | 0.971 | | 1.228 | 116.9 | 1.000 |
| C.V.% | | 7.8 | 10.2 | 5.3 | | 4.6 | 6.8 | 6.3 |

Analysed leaf tissue nutrient content data are presented in Table 3. Again, just as with the yield data, there is still no responses to the different fertiliser placement The mean rachis K concentration in nil fertiliser plot was 1.10 % DM and was much lower than the treated plots which had a mean of 1.39 % DM. The highest MOP fertilised plot has rachis K concentration of 1.62 % 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 %.

| | Leaflet nutrient concentrations | | | | | | | | Rachis nutrient concentrations | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** | **Cl** | **B (ppm)** | **Ash** | **N** | **P** | **K** |
| Nil fertilizer | 11.7 | 2.36 | 0.138 | 0.52 | 0.35 | 0.80 | 0.48 | 12 | 4.21 | 0.255 | 0.108 | 1.10 |
| Highest MOP rate | 11.7 | 2.25 | 0.135 | 0.61 | 0.32 | 0.83 | 0.64 | 10 | 5.24 | 0.290 | 0.098 | 1.62 |
| Edge of weeded circle | 11.4 | 2.31 | 0.137 | 0.58 | 0.33 | 0.80 | 0.58 | 10.4 | 4.5 | 0.282 | 0.108 | 1.28 |
| Weeded circle | 11.9 | 2.31 | 0.138 | 0.60 | 0.34 | 0.77 | 0.59 | 10.8 | 4.8 | 0.260 | 0.117 | 1.44 |
| Broadcast | 12.0 | 2.33 | 0.137 | 0.56 | 0.34 | 0.82 | 0.60 | 10.7 | 4.8 | 0.282 | 0.121 | 1.39 |
| Frond tips and piles | 12.1 | 2.32 | 0.139 | 0.60 | 0.31 | 0.80 | 0.58 | 11.7 | 4.9 | 0.267 | 0.110 | 1.46 |
| P values | 0.574 | 0.937 | 0.490 | 0.367 | 0.482 | 0.060 | 0.866 | 0.110 | 0.623 | 0.449 | 0.882 | 0.363 |
| GM | 11.9 | 2.32 | 0.138 | 0.59 | 0.33 | 0.80 | 0.59 | 10.9 | 4.7 | 0.273 | 0.114 | 1.39 |
| SE | 0.716 | 0.0631 | 0.0023 | 0.0344 | 0.0298 | 0.0241 | 0.0416 | 0.745 | 0.392 | 0.0231 | 0.0260 | 0.147 |
| C.V.% | 6.0 | 2.7 | 1.7 | 5.9 | 9.0 | 3.0 | 7.0 | 6.8 | 8.3 | 8.5 | 22.7 | 10.5 |

The results of physiological growth parameters measured in 2009 are presented in Table 4. There is no effect of fertiliser placement on vegetative growth parameters in 2009.

**Table 4**. Trial 517, main effects of treatments on vegetative growth parameters in 2009.

| | | | Radiation interception | | | Dry matter production (t/ha/yr) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FL | PCS | FP | FA | LAI | FDM | BDM | TDM | VDM | BI |
| Nil fertilizer | 590.3 | 36.4 | 23.2 | 11.0 | 5.84 | 13.0 | 14.3 | 30.3 | 16.1 | 0.47 |
| Highest MOP rate | 596.0 | 37.8 | 25.2 | 11.5 | 6.63 | 14.6 | 13.8 | 31.6 | 17.8 | 0.44 |
| Edge of weeded circle | 588.7 | 35.4 | 23.4 | 11.0 | 5.70 | 12.8 | 13.7 | 29.5 | 15.7 | 0.46 |
| Weeded circle | 597.9 | 35.8 | 23.4 | 11.2 | 5.80 | 12.9 | 13.4 | 29.2 | 15.8 | 0.46 |
| Broadcast | 602.0 | 35.7 | 24.1 | 11.1 | 5.77 | 13.2 | 14.7 | 31.1 | 16.3 | 0.47 |
| Frond tips and piles | 583.6 | 34.3 | 23.9 | 10.6 | 5.45 | 12.6 | 14.0 | 29.7 | 15.6 | 0.47 |
| P values | 0.640 | 0.924 | 0.573 | 0.464 | 0.635 | 0.872 | 0.537 | 0.481 | 0.815 | 0.870 |
| GM | 593.1 | 35.3 | 23.7 | 11.0 | 5.68 | 12.9 | 14.0 | 29.9 | 15.9 | 0.47 |
| SE | 22.1 | 3.356 | 0.833 | 0.544 | 0.412 | 1.036 | 1.267 | 1.769 | 1.152 | 0.0285 |
| C.V.% | 3.7 | 9.5 | 3.5 | 5.0 | 7.3 | 8.0 | 9.1 | 5.9 | 7.3 | 6.1 |

*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

The trial is still in the early stages to show any responses to treatments.

# Trial 513: Spacing and Thinning Trial, Padipadi (RSPO 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. Background 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 | 5 | 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. Fertilizer application will follow normal plantation practice for an immature fertilizer 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 and 2009 (Table 2).

**Table 2.** Trial 513 Main effects of density treatments on FFB yield (t/ha) and its components for 2009 and 2008 to 2009 (two years averaged data). P values less than 0.05 are presented in bold.

| | | 2009 | | | | 2008-2009 | | |
|---|---|---|---|---|---|---|---|---|
| **Density Treatment** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** |
| 128 | | 29.0 | **3174** | 9.1 | | 24.1 | **2796** | 8.5 |
| 135 | | 30.2 | **3365** | 8.9 | | 25.5 | **3020** | 8.3 |
| 143 | | 31.6 | **3586** | 8.8 | | 27.4 | **3187** | 8.6 |
| 128 (192) | | 28.3 | **2958** | 9.6 | | 23.6 | **2689** | 8.7 |
| 135 (203) | | 27.2 | **3014** | 9.0 | | 22.6 | **2755** | 8.1 |
| 143 (215) | | 28.8 | **3083** | 9.4 | | 23.6 | **2845** | 8.2 |
| $lsd_{0.05}$ | | | 379.3 | | | | 288.4 | |
| sig | | | **0.032** | | | | **0.026** | |
| Grand Mean | | 29.2 | 3197 | 9.1 | | 24.5 | 2882 | 8.4 |
| SE | | 2.669 | 208.5 | 0.384 | | 2.481 | 158.5 | 0.516 |
| CV % | | 9.1 | 6.5 | 4.2 | | 10.1 | 5.5 | 6.1 |

(..) previous density

**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

The difference in yield between planting density treatments was due only to the bunch number produced per hectare not to bunch weight (all treatments produced similar bunch weights).

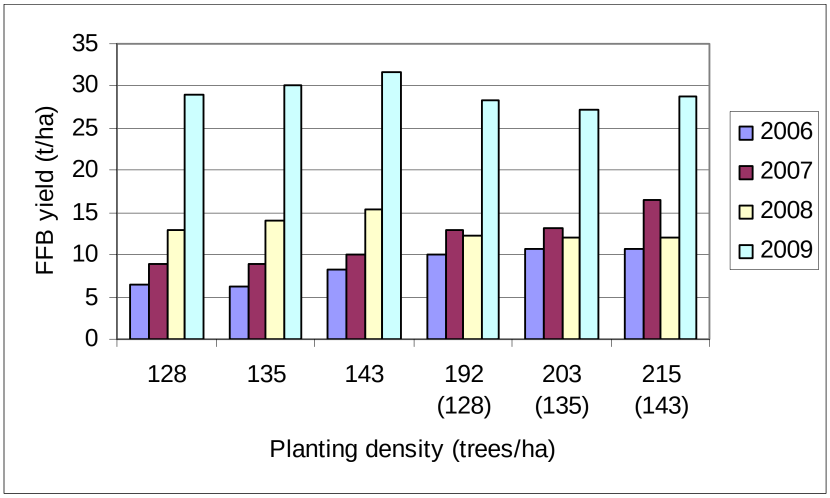



**Figure 1**. Trial 513: FFB yield for the pre-thinning years (2006 and 2007) and the post-thinning year (2008 - 2009). Note 1. the planting density in brackets refers to post-thinning
Note 2. in 2006 harvest commenced in April (yield only for April to December)
Note 3. post-thinning in 2008 harvest commenced in April (yield only for April to December)

Of greatest interest is whether any one treatment had a higher yield over the period pre-thinning plus post-thinning. Treatments 1 and 2 (planted at 128 and 135 palms/ha) had a significantly lower yield compared to treatments 3, 4 and 5 (respectively planted at 143; 192 and thinned to 128; and planted at 203 and thinned to 135 palms/ha) compared to treatment 6 (planted at 215 and thinned to 143 palms/ha) (Figure 2).

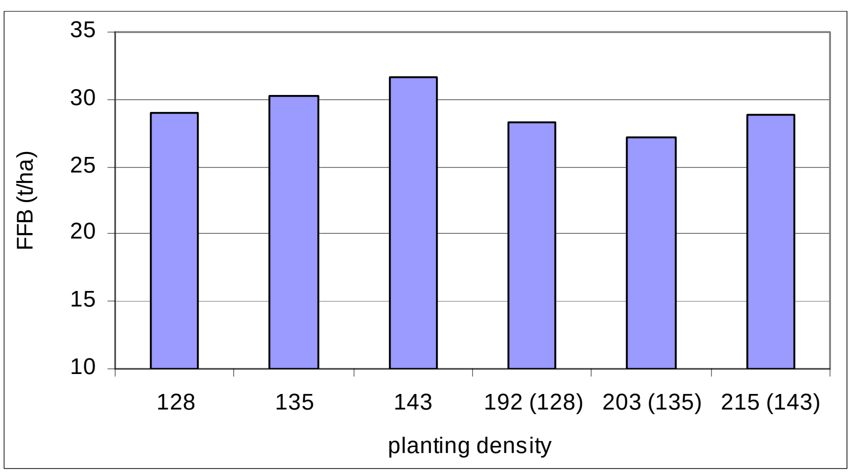



**Figure 2**. Total yield for six planting density treatments commencing pre-thinning (April 2006) to the end of 2008 (thinning took place in February 2008). Note 1. The planting density in brackets refers to post-thinning

The trial should continue until full maturity to determine whether the yield in the high planting density plots (original planting at 143 palms/ha and the treatment planted at 215 and then thinned to 143 pa/ms/ha) can maintain their current yield advantage compared to the lower density plantings.

Leaf tissue nutrient contents were reasonably above optimum levels except for rachis K content which was at 0.87 %. K could be limiting in this environment due to no proper fertilizer applications.

**Table 3**. Trial 513: Leaf tissue nutrient content

| | | Leaflets nutrient concentrations (% DM) | | | | | | | | | Rachis nutrient concentrations (% DM) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Plots | | Ash | N | P | K | Mg | Ca | B (ppm) | Cl | | Ash | N | P | K |
| | | | | | | | | | | | | | | |
| 1 | | 11.32 | 2.59 | 0.157 | 0.63 | 0.37 | 0.75 | 14 | 0.48 | | 4.01 | 0.38 | 0.076 | 0.87 |
| 6 | | 12.08 | 2.59 | 0.156 | 0.59 | 0.28 | 0.8 | 14.7 | 0.46 | | 3.88 | 0.41 | 0.09 | 0.91 |
| 14 | | 10.19 | 2.59 | 0.151 | 0.65 | 0.29 | 0.72 | 13.6 | 0.28 | | 3.76 | 0.47 | 0.085 | 0.83 |
| | | | | | | | | | | | | | | |
| Mean | | 11.20 | 2.59 | 0.15 | 0.62 | 0.31 | 0.76 | 14.10 | 0.41 | | 3.88 | 0.42 | 0.084 | **0.87** |

**CONCLUSION**

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

# CTP HIGATURU OIL PALM

**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) Urea.S at Heropa; (iv) Mg.K source at Mamba; and (v) N.P at Sangara and Ambogo.
*Outcome:*

- N.P.K.Mg trial – only K increased yield as rachis K level of 0.46 for the control indicates that K is limiting yield production in this area.
- SOA.EFB – EFB increased yields by 2 t/ha but no effect of N as yet.
- Urea.Sulphur – no positive yield response as it is only the first year after treatments.
- Urea.TSP (mature) – established in late 2006 and no treatment outcomes as yet.
- Urea.TSP (immature) – established in late 2007 and Urea increased yield by 1 t/ha.

**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 (36t/ha) and yield increased with increasing rate of N up to 1.68 kg N per palm (32 to 38 t/ha, control only 15 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

**Synopsis of 2009 PNG OPRA trial results and recommendations**

| Trial | Palm Age | Yield t/ha | Yield Components | Tissue (% dm) | Vegetative | Notes |
|---|---|---|---|---|---|---|
| 324 Sangara<br>N type x rate<br>Soil: Volcanic ash | 12 | N type (NS)<br>N rate 32.2 to 38<br>Control 15.3 | N rate B/ha 1554 to 1813 (NS)<br>N rate SBW 21 (NS) | N type LN 2.51 (NS)<br>N rate LN 2.42 to 2.58<br>RN 0.29 to 0.34<br>LP 0.147; RP 0.157<br>LK 0.72; RK 1.77<br>LMg 0.19, LB 10 | N rate PCS 42 to 47<br>LAI 5.54 (NS) | Highest yield: 1.68 kg N/palm)<br><br>B low |
| 326 Sangara<br>SOA, EFB (factorial)<br>Soil: Volcanic ash | 9 | SOA 33.5 (NS)<br>EFB 32-34.5 | SOA B/ha 1493 (NS)<br>SOA SBW 22.5 (NS) | EFB LK 0.77 (NS)<br>RK 1.28 to 1.77<br>LN 2.60; RN 0.31<br>LP 0.149; RP 0.09<br>LMg 0.21, LB 15ppm | PCS 45 (NS)<br>FP 24 (NS)<br>LAI 6.6 (NS) | Responses commenced in leaf nutrient contents |
| 329 Mamba<br>SOA, TSP, MOP, KIE (factorial)<br>Soil: Volcanic ash | 11 | SOA 26.5 (NS)<br>TSP 26.5 (NS)<br>MOP 21.8 to 24.4 (S)<br>KIE 26.5 (NS) | MOP B/ha 899 (NS)<br>MOP SBW 25-26.8 (S) | SOA LN 2.66 (NS)<br>RN 0.27 (NS)<br>TSP LP 0.164 (NS)<br>RP 0.07 to 0.09<br>MOP LK 0.62 to 0.84<br>RK 0.46 to 1.45<br>KIE LMg 0.16 to 0.33<br>LB 11 | MOP PCS 56.5 (NS)<br>LAI 6.6- 6.83 (S)<br>Kie LAI 6.9 (NS) | Tissue: K required<br>N high<br><br>B low<br><br>LAI high |
| 330 Heropa (ex Grassland)<br>Urea, Elemental S<br>Soil: Sandy alluvium | 8 | Urea 8.2 (NS)<br>S (NS) | B/ha 511 (NS)<br>SBW 15.8 (NS) | Urea LN 2.35-2.51 (S)<br>RN 0.29-0.37 (S)<br>Sulphur LS 0.19 (NS)<br>LP 0.147; RP 0.096<br>LK 0.67; RK 1.41<br>LMg 0.23; LB 16 ppm | PCS 30 (NS)<br>FP 20 (NS)<br>LAI 5.7 (NS) | Responses to N commenced in leaflet tissues. |
| 334 Sangara<br>Urea, TSP<br>Soil: Volcanic ash | 10 | N and P, 34.5 (NS) | B/ha 1767 (NS)<br>SBW 19.8 (NS) | Urea LN 2.58 (NS)<br>RN 0.308 (NS)<br>TSP LP 0.152 (NS) | PCS | No response |
| 335 Ambogo<br>Urea, TSP<br>Soil: Volcanic ash | 2 | Urea 3.8-5.2<br>TSP 4.48 (NS) | Urea B/ha 1223-1483<br>Urea SBW 3.1-3.5 (NS) | Urea LN 2.56-2.68 (NS)<br>RN 0.292 (NS)<br>TSP LP 0.160 (NS) | PCS 7.7 (NS)<br>Urea FA 2.2-2.4<br>BI 0.20-0.27 | Significant responses to Urea |

**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, fertilizer 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, 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 2009 and for the combined 2007-2009 period however PCS, FDM TDM and VDM were significantly affected in 2009. 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 35.8 t/ha for palms that received N fertiliser, mean yield for the palms that did not receive N fertiliser was only 15.3 t/ha in 2009. 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.

**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 | 13 | 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) | |
| Progeny | Unknown | Agronomist in charge | Susan Tomda |

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

| Depth<br>cm | pH in water | Exch K | Exch Ca | Exch Mg | CEC | OM<br>% | Total N<br>% | Avail N<br>kg/ha | Olsen P<br>mg/kg | P Ret<br>% | Boron<br>mg/kg | Sulphate S<br>mg/kg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | cmol/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 and 2009, 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 2009 and for the 2007-2009 period (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 2009 and the combined 2007-2009 period, the significant effect on yield was mainly due to a combined increase in the number of bunches (BNO) and single bunch weight (SBW). The yield difference between annual N-rate of 0.84 and 1.68 kg per palm was not significant at $l.s.d._{0.05}$ but the differences between either 0.42 and 0.84, and 0.42 and 1.68 kg per palm were significant at $l.s.d._{0.05}$.
In 2009 the difference in yield between +N and –N was about 17 t/ha. The average yield for +N was 36 t/ha and the average yield for –N was 15 t/ha in 2009. This indicates the importance of N in oil palm FFB production.

**Table 4**. Effects (p values) of treatments on FFB yield and its components in 2009 and 2007–2009. p values <0.05 are shown in bold.

| Source | | 2009 | | | | 2007 – 2009 | | |
|---|---|---|---|---|---|---|---|---|
| | | **Yield** | **BNO** | **SBW** | | **Yield** | **BNO** | **SBW** |
| Type | | 0.104 | 0.297 | 0.085 | | 0.242 | 0.357 | 0.328 |
| Rate | | **<0.001** | **<0.001** | 0.279 | | **<0.001** | **<0.001** | **0.003** |
| Type. Rate | | 0.430 | 0.735 | **0.036** | | 0.251 | 0.489 | 0.365 |
| *CV %* | | *8.6* | *8.5* | *4.6* | | *5.8* | *6.2* | *4.8* |

**Table 5**. Main effects of treatments on FFB yield (t/ha) for 2007 - 2009 and 2009. p values <0.05 are shown in bold.

| | | 2009 | | | | 2007 - 2009 | | |
|---|---|---|---|---|---|---|---|---|
| **Treatments** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** |
| Control | | 15.3 | 1116 | 13.3 | | 16.7 | 1153 | 14.1 |
| | | | | | | | | |
| SOA | | 35.5 | 1646 | 21.5 | | 35.7 | 1690 | 21.1 |
| AMC | | 37.5 | 1758 | 21.4 | | 37.1 | 1755 | 21.2 |
| Urea | | 34.3 | 1672 | 20.5 | | 35.4 | 1707 | 20.8 |
| AMN | | 36.5 | 1743 | 21.0 | | 36.4 | 1768 | 20.6 |
| DAP | | 35.0 | 1694 | 20.7 | | 35.5 | 1744 | 20.4 |
| | | | | | | | | |
| Rate 1 | | **32.3** | **1554** | 20.8 | | **32.1** | **1597** | **20.1** |
| Rate 2 | | **37.0** | **1741** | 21.3 | | **37.7** | **1790** | **21.1** |
| Rate 3 | | **38.0** | **1813** | 21.0 | | **38.4** | **1810** | **21.2** |
| *$l.s.d._{0.05}$* | | *1.96* | *92.4* | *0.62* | | *1.33* | *68.8* | *0.640* |
| | | | | | | | | |
| Grand Mean | | 35.8 | 1703 | 21.0 | | 36.0 | 1733 | 20.8 |
| Se | | 3.069 | 144.8 | 0.968 | | 2.090 | 107.8 | 1.003 |
| Cv % | | *8.6* | *8.5* | *4.6* | | *5.8* | *6.2* | *4.8* |

**Effects of treatments on leaf (F17) nutrient concentrations**

The between N-types difference in leaflet and rachis N was not significant except for the rachis P concentrations. (Tables 6 and 7). Concentration of rachis P in the DAP treated plots was greater than in other N types treated plots. On the other hand, leaflets Ash, N, P, K and rachis N 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 2009. p values less than 0.05 are in bold.

| **Source** | | **Leaflets nutrient concentrations** | | | | | | | **Rachis nutrient concentrations** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **B** | | **Ash** | **N** | **P** | **K** |
| Type | | **<0.001** | 0.411 | 0.100 | 0.608 | 0.815 | 0.214 | | 0.24 | 0.391 | **<0.001** | 0.313 |
| Rate | | **<0.001** | **<0.001** | **0.010** | **0.003** | 0.247 | **0.033** | | 0.151 | **<0.001** | **<0.001** | 0.867 |
| Type. Rate | | 0.200 | 0.018 | 0.275 | 0.162 | 0.285 | 0.463 | | 0.633 | 0.131 | 0.565 | 0.283 |
| CV % | | 3.2 | 3.2 | 2.6 | 5.5 | 8.7 | 10.2 | | 7.4 | 8.2 | 18.1 | 8.3 |

**Table 7**. Trial 324, main effects of treatments on frond 17 leaf let and rachis nutrient concentrations in 2009, in units of % dry matter. p values less than 0.05 are shown in bold. 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* | | 16.2 | 2.01 | 0.135 | 0.65 | 0.26 | 13.8 | | 6.6 | 0.245 | 0.374 | 1.97 |
| | | | | | | | | | | | | |
| SOA | | **15.6** | 2.50 | 0.145 | 0.72 | 0.20 | 10.5 | | 5.6 | 0.321 | **0.151** | 1.77 |
| AMC | | **15.4** | 2.51 | 0.146 | 0.71 | 0.19 | 9.9 | | 5.9 | 0.328 | **0.147** | 1.84 |
| Urea | | **14.9** | 2.47 | 0.147 | 0.71 | 0.19 | 10.5 | | 5.4 | 0.308 | **0.146** | 1.72 |
| AMN | | **14.8** | 2.52 | 0.148 | 0.72 | 0.19 | 10.7 | | 5.6 | 0.314 | **0.147** | 1.77 |
| DAP | | **15.4** | 2.53 | 0.149 | 0.73 | 0.20 | 9.9 | | 5.3 | 0.322 | **0.196** | 1.73 |
| *l.s.d.$_{0.05}$* | | *0.4057* | | | | | | | | | 0.0235 | |
| | | | | | | | | | | | | |
| Rate 1 | | **15.0** | **2.42** | **0.145** | **0.70** | 0.20 | **10.6** | | 5.5 | **0.294** | **0.193** | 1.76 |
| Rate 2 | | **15.1** | **2.52** | **0.148** | **0.72** | 0.19 | **10.5** | | 5.7 | **0.320** | **0.152** | 1.78 |
| Rate 3 | | **15.6** | **2.58** | **0.148** | **0.74** | 0.19 | **9.8** | | 5.4 | **0.342** | **0.127** | 1.76 |
| *l.s.d.$_{0.05}$* | | *0.3143* | *0.0514* | *0.0025* | *0.0240* | | *0.670* | | | *0.0166* | *0.0182* | |
| | | | | | | | | | | | | |
| GM | | 15.2 | 2.51 | 0.147 | 0.72 | 0.19 | 10.3 | | 5.5 | 0.319 | 0.157 | 1.77 |
| SE | | 0.492 | 0.004 | 0.004 | 0.0376 | 0.0168 | 1.05 | | 0.408 | 0.026 | 0.0284 | 0.147 |
| CV % | | 3.2 | 3.2 | 2.6 | 5.5 | 8.7 | 10.2 | | 7.4 | 8.2 | 18.1 | 8.3 |

**Effects of fertiliser treatments on Vegetative parameters**

N-type treatment had a significant effect on PCS (p=0.002), FDM (p<0.001), TDM and VDM (Tables 8 and 9). Petiole cross section of palms in AMC fertilized plots were greater that those in the other N source treated plots and this was also reflected in the dry matter production. However the significant effect of N type on the vegetative dry matter did not translate to significant differences in yield though AMC fertilized plots did produce the highest yield.

N-rate treatment had a significant effect on all the physiological parameters except BI (Table 8 and 9). 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 fertilized plots. These results correspond well with yield and leaf tissue results.

**Table 8**. Effect (p values) of treatments on vegetative growth parameters in 2009. p values less than 0.05 are shown in bold.

| Source | | | | | | Radiation interception | | | | Dry matter production | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FL | HI | PCS | | FP | FA | LAI | | FDM | BDM | TDM | VDM | | BI |
| Fert. type | | | | **0.002** | | 0.090 | 0.384 | 0.059 | | **<0.001** | 0.077 | **<0.001** | **<0.001** | | 0.188 |
| Rate | | | | **<0.001** | | **<0.001** | **0.036** | **<0.001** | | **<0.001** | **<0.001** | **<0.001** | **<0.001** | | 0.457 |
| Type.Rate | | | | 0.553 | | 0.911 | 0.410 | 0.442 | | 0.429 | 0.207 | 0.200 | 0.388 | | 0.389 |
| *CV %* | | | | *6.3* | | *4.4* | *3.2* | *4.7* | | *6.8* | *8.6* | *5.7* | *6.2* | | *4.8* |

*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 2009. Significant effects ($p<0.05$) are shown in bold.

| Treatments | | | | | | Radiation interception | | | | Dry matter production (t/ha/yr) | | | | | BI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FL | HI | PCS | | FP | FA | LAI | | FDM | BDM | TDM | VDM | | |
| Control | | 513.5 | | 27.9 | | 19.4 | 10.0 | 4.23 | | 8.1 | 8.6 | 18.6 | 10.0 | | 0.45 |
| | | | | | | | | | | | | | | | |
| SOA | | | | **44.0** | | 23.5 | 12.9 | 5.65 | | **14.9** | 18.8 | **37.5** | **18.6** | | 0.50 |
| AMC | | | | **47.0** | | 23.6 | 12.9 | 5.54 | | **16.0** | 20.0 | **39.9** | **20.0** | | 0.50 |
| Urea | | | | **42.3** | | 23.2 | 12.7 | 5.34 | | **14.2** | 18.1 | **35.9** | **17.8** | | 0.50 |
| AMN | | | | **43.7** | | 23.9 | 12.9 | 5.60 | | **15.1** | 19.4 | **38.3** | **18.9** | | 0.50 |
| DAP | | | | **45.6** | | 24.4 | 12.7 | 5.60 | | **18.6** | 18.6 | **38.4** | **19.8** | | 0.48 |
| *$lsd_{0.05}$* | | | | *2.306* | | | | | | *0.855* | | ***1.798*** | *0.967* | | |
| | | | | | | | | | | | | | | | |
| Rate 1 | | | | **41.7** | | **23.0** | **12.7** | **5.35** | | **13.8** | **17.2** | **34.5** | **17.3** | | 0.50 |
| Rate 2 | | | | **45.1** | | **23.8** | **13.0** | **5.63** | | **15.4** | **19.6** | **39.0** | **19.3** | | 0.50 |
| Rate 3 | | | | **46.9** | | **24.4** | **13.0** | **5.33** | | **16.4** | **20.1** | **40.5** | **20.5** | | 0.49 |
| *$lsd_{0.05}$* | | | | *1.786* | | *0.660* | *0.2642* | *0.166* | | *0.662* | *1.039* | *1.392* | *0.749* | | |
| | | | | | | | | | | | | | | | |
| GM | | | | 44.5 | | 23.7 | 12.8 | 5.54 | | 15.23 | 19.0 | 38.01 | 19.0 | | 0.50 |
| SE | | | | 2.798 | | 1.035 | 0.414 | 0.259 | | 1.038 | 1.628 | 2.181 | 1.174 | | 0.024 |
| CV % | | | | *6.3* | | *4.4* | *3.2* | *4.7* | | *6.8* | *8.6* | *5.7* | *6.2* | | *4.8* |

*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 2009. The non significant effects on yield were 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 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 can not be sustained or increased.

# Trial 326: Nitrogen x EFB Trial on Volcanic Soils, Sangara Estate (RSPO 4.2, 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 no significant effect on yield and though did increase single bunch weight in 2009 Empty fruit bunch increased yield from 31.7 to 34.5 t/ha. SOA treatment had significant effect on leaflet and rachis N concentrations. EFB significantly increased leaflet N and P, and rachis P and K concentrations but lowered leaflet Mg contents. However, regardless of treatments, all nutrients were above their respective critical concentrations. SOA treatment had a significant effect on LAI, FDM, TDM and VDM but not any other measured or calculated vegetative growth parameter. EFB treatment significantly increased all the vegetative parameters except for 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 PNG OPRA 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 | 10 | 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) | |
| Progeny | Not known | Agronomist in charge | Susan Tomda |

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

| Depth (cm) | pH | Exch K | Exch Ca | Exch Mg | Exch Na | CEC | Res. K | Base Sat. (%) | Org. Matter (%) | Total N (%) | Olsen P (mg/kg) | Sulfate S | Org S |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | (cmol/kg) | | | | | | | | | | (mg/kg) | |
| 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 fertilizer on yield and its components are presented in Tables 4 and 5. SOA had no significant effect on yield and its components in 2009 (except on single bunch weight) and for the 2007 to 2009 period. The insignificant effect on yield and its components is consistent since the trial started in 2002. EFB on the other hand increased FFB yield by 3 tonnes and this was due to increases in the number of bunches and single bunch weights which were inconsistently significant. The mean yield was 33.5 t/ha in 2009.

**Table 4**. Effects (p values) of treatments on FFB yield and its components in 2009 and 2007-2009.

| | 2009 | | | | 2007 – 2009 | | |
|---|---|---|---|---|---|---|---|
| **Source** | **FFB yield** | **BNO** | **SBW** | | **FFB yield** | **BNO** | **SBW** |
| SOA | 0.266 | 0.157 | **<0.001** | | 0.170 | 0.486 | 0.162 |
| EFB | **0.049** | 0.182 | 0.077 | | 0.093 | 0.658 | **0.043** |
| SOA.EFB | 0.820 | 0.594 | 0.185 | | 0.859 | 0.809 | 0.226 |
| *CV %* | *11.8* | *11.1* | *5.1* | | *8.1* | *9.5* | *5.7* |

**Table 5**. Main effects of treatments on FFB yield (t/ha) in 2009 and from 2007 to 2009.

| Treatments | | 2009 | | | | 2007-2009 | | |
|---|---|---|---|---|---|---|---|---|
| | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** |
| SOA 0 | | 32.5 | 1520 | **21.4** | | 33.5 | 1652 | 20.4 |
| SOA 2.5 | | 34.6 | 1515 | **22.9** | | 34.5 | 1645 | 21.1 |
| SOA 5.0 | | 32.5 | 1438 | **22.6** | | 32.5 | 1572 | 20.9 |
| SOA 7.5 | | 34.5 | 1497 | **23.1** | | 34.4 | 1627 | 21.3 |
| | | | | | | | | |
| EFB 0 | | **31.7** | 1437 | 22.1 | | 32.6 | 1613 | **20.4** |
| EFB 130 | | **34.4** | 1530 | 22.6 | | 34.4 | 1650 | **21.0** |
| EFB 390 | | **34.5** | 1511 | 22.9 | | 34.1 | 1609 | **21.4** |
| *$l.s.d_{0.05}$* | | *2.522* | | | | | | *0.763* |
| | | | | | | | | |
| GM | | 33.5 | 1493 | 22.5 | | 33.7 | 1624 | 20.0 |
| SE | | 3.967 | 165.3 | 1.146 | | 2.738 | 154.7 | 1.200 |
| CV % | | 11.8 | 11.1 | 5.1 | | 8.1 | 9.5 | 5.7 |

**Effects of interaction between treatments on FFB yield**

There was no significant interaction of SOA.EFB but the highest yield of 35.9 t/ha was obtained at 2.5 kg SOA per palm per year) and 130 kg EFB per palm of EFB (Table 6).

**Table 6**. Effect of SOA and EFB (two-way interactions) on FFB yield (t/ha/yr) in 2009. The interaction was not significant (p=0.820).

| | **EFB 0** | **EFB 130** | **EFB 390** |
|---|---|---|---|
| **SOA 0** | 28.5 | 33.7 | 35.1 |
| **SOA 2.5** | 33.1 | 35.9 | 34.9 |
| **SOA 5.0** | 31.1 | 33.2 | 33.1 |
| **SOA 7.5** | 33.8 | 34.8 | 35.0 |
| Grand mean: 33.5 | | | *sed 2.509* |

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

SOA treatment had a significant effect on leaflet N and K and rachis N, P and K concentrations in 2009 (Tables 7 and 8). The N concentrations in the rachis and leaflets were increased with N rates, rachis K was also increased however P was lowered. EFB treatment had a significant effect on the concentrations of leaflet and rachis ash, leaflet N, P and Mg, and rachis P and K (Tables 7 and 8). The increase in rachis K concentrations was due to the high content of K in EFB (approx 2.0% DM). Regardless of treatment effects, all the nutrients were above their respective critical concentrations.

**Table 7**: Effects (p values) of treatments on frond 17 (F17) nutrient concentrations 2009 (Trial 326). p values <0.05 are indicated in bold.

| | | Leaflets | | | | | | | Rachis | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Source** | | **Ash** | **N** | **P** | **K** | **Mg** | **B** | | **Ash** | **N** | **P** | **K** |
| SOA | | 0.146 | **<0.001** | 0.099 | 0.041 | 0.447 | 0.770 | | 0.063 | **0.020** | **0.010** | **0.015** |
| EFB | | **0.039** | **<0.001** | **0.007** | 0.137 | **0.010** | 0.421 | | **<0.001** | 0.813 | **<0.001** | **<0.001** |
| SOA.EFB | | 0.177 | **0.012** | 0.091 | 0.086 | 0.144 | 0.445 | | 0.525 | 0.828 | 0.577 | 0.469 |
| *CV%* | | *4.4* | *2.7* | *2.1* | *5.7* | *7.7* | *11.6* | | *8.5* | *9.6* | *16* | *11.1* |

**Table 8**: Main effects of treatments on F17 nutrient concentrations in 2009, in units of % dry matter, except for B (mg/kg) (Trial 326). Effects with p<0.05are shown in bold.

| **Treatments** | | **Leaflet nutrient concentrations (% DM)** | | | | | | | **Rachis nutrient concentrations (% DM)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **B** | | **Ash** | **N** | **P** | **K** |
| SOA 0 | | 15.4 | **2.52** | 0.148 | 0.79 | 0.21 | 15.8 | | 5.1 | **0.289** | **0.103** | **1.49** |
| SOA 2.5 | | 15.3 | **2.64** | 0.151 | 0.77 | 0.21 | 15.1 | | 5.2 | **0.303** | **0.086** | **1.51** |
| SOA 5.0 | | 15.6 | **2.64** | 0.150 | 0.74 | 0.22 | 15.7 | | 5.2 | **0.318** | **0.089** | **1.62** |
| SOA 7.5 | | 15.8 | **2.64** | 0.149 | 0.76 | 0.21 | 15.5 | | 5.5 | **0.300** | **0.087** | **1.67** |
| $l.s.d_{0.05}$ | | | *0.05* | | | | | | | *0.022* | *0.010* | *0.128* |
| EFB 0 | | **15.7** | **2.56** | **0.148** | 0.76 | **0.22** | 15.9 | | **4.7** | 0.305 | **0.081** | **1.28** |
| EFB 130 | | **15.6** | **2.63** | **0.149** | 0.76 | **0.21** | 15.4 | | **5.6** | 0.308 | **0.091** | **1.68** |
| EFB 390 | | **15.2** | **2.64** | **0.151** | 0.78 | **0.21** | 15.2 | | **5.8** | 0.311 | **0.101** | **1.77** |
| $l.s.d_{0.05}$ | | *0.44* | *0.04* | *0.002* | | *0.010* | | | *0.290* | | *0.019* | *0.11* |
| GM | | 15.5 | 2.61 | 0.149 | 0.77 | 0.21 | 15.5 | | 5.3 | 0.308 | 0.0911 | 1.57 |
| SE | | 0.698 | 0.070 | 0.003 | 0.044 | 0.016 | 1.798 | | 0.456 | 0.029 | 0.0146 | 0.174 |
| CV% | | 4.4 | 2.7 | 2.1 | 5.7 | 7.7 | 11.6 | | 8.5 | 9.6 | 16 | 11.1 |

**Effects of fertiliser treatments on Vegetative parameters**

SOA has started to show significant effects on LAI, FDM, TDM and VDM in 2009 however these effects have not yet translated to FFB yields (Tables 9 and 10). On the other hand, EFB continued to have significant effects on all the measured vegetative parameters except BI.

**Table 9**. Effect (p values) of treatments on vegetative growth parameters in 2009. p values less than 0.05 are shown in bold.

| **Source** | | | | | | **Radiation interception** | | | | **Dry matter production** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **FL** | **HI** | **PCS** | | **FP** | **FA** | **LAI** | | **FDM** | **BDM** | **TDM** | **VDM** | | **BI** |
| SOA | | | | 0.085 | | 0.06 | 0.088 | **<0.001** | | **0.002** | 0.151 | **0.005** | **0.001** | | 0.123 |
| EFB | | | | **0.053** | | **0.052** | **0.041** | **0.014** | | **0.005** | **0.021** | **0.001** | **0.003** | | 0.294 |
| SOA.EFB | | | | 0.291 | | 0.634 | 0.646 | 0.630 | | 0.302 | 0.799 | 0.510 | 0.301 | | 0.558 |
| *CV %* | | | | *6.2* | | *8.5* | *4.3* | *5.7* | | *9.8* | *10.7* | *7.6* | *9.0* | | *7.4* |

*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 2009. Significant effects (p<0.05) are shown in bold.

| **Treatments** | | | | | | **Radiation interception** | | | | **Dry matter production (t/ha/yr)** | | | | | **BI** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **FL** | **HI** | **PCS** | | **FP** | **FA** | **LAI** | | **FDM** | **BDM** | **TDM** | **VDM** | | |
| SOA 0 | | | | 44.1 | | 22.7 | 12.6 | **6.26** | | **14.5** | 17.0 | **34.9** | **18.0** | | 0.49 |
| SOA 2.5 | | | | 45.3 | | 23.8 | 13.0 | **6.60** | | **15.6** | 18.1 | **37.4** | **19.3** | | 0.49 |
| SOA 5.0 | | | | 45.9 | | 24.4 | 13.1 | **6.80** | | **16.1** | 17.0 | **36.8** | **19.8** | | 0.46 |
| SOA 7.5 | | | | 46.7 | | 25.0 | 13.1 | **6.80** | | **16.8** | 18.1 | **38.8** | **20.7** | | 0.47 |
| $lsd_{0.05}$ | | | | | | | | 0.28 | | 1.14 | | 2.08 | 1.29 | | |
| EFB 0 | | | | **44.3** | | **23.5** | **12.7** | **6.49** | | **15.0** | **16.6** | **35.1** | **18.5** | | 0.47 |
| EFB 130 | | | | **45.7** | | **23.6** | **12.9** | **6.53** | | **15.5** | **18.0** | **37.3** | **19.3** | | 0.48 |
| EFB 390 | | | | **46.5** | | **24.9** | **13.2** | **6.82** | | **16.7** | **18.1** | **38.6** | **20.5** | | 0.47 |
| $lsd_{0.05}$ | | | | *1.81* | | *1.30* | *0.35* | *0.24* | | *0.99* | *1.20* | ***1.80*** | *1.12* | | |
| | | | | | | | | | | | | | | | |
| GM | | | | 45.5 | | 24.0 | 13.0 | 6.62 | | 15.7 | 17.5 | 37.0 | 19.4 | | 0.47 |
| SE | | | | 2.843 | | 2.042 | 0.552 | 0.377 | | 1.549 | 1.884 | 2.828 | 1.753 | | 0.0351 |
| CV % | | | | 6.2 | | 8.5 | 4.3 | 5.7 | | 9.8 | 10.7 | 7.6 | 9.0 | | 7.4 |

*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**

Though SOA did not affect FFB yield, it started increasing leaf tissue N concentrations and some vegetative parameters in 2009. EFB continued to have significant effects on yield (and its components), leaf tissue nutrient concentrations and vegetative parameters.

# Trial 329: Nitrogen, Potassium, Phosphorus and Magnesium Trial, Mamba (RSPO 4.2, 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.

Only MOP treatment had a significant effect on yield. Increasing MOP from 0 to either 2 or 4 kg per palm increased FFB yield by 0.3 to 3.0 t/ha. 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. The effect of MOP on bunch dry matter (BDM), total dry matter (TDM) and bunch index (BI) corresponded well to its effects on yield and leaf K. Higher rates of MOP treatment significantly increased BDM and TDM in 2009.

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.

**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 | 9 | 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 | 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 mg/kg | P Ret. (%) | Exch. K | Exch. Ca | Exch. Mg | CEC | Org. Matter (%) | Total N (%) | Avail. N (kg/ha) | Sulfate S | B |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | (cmolc/kg) | | | | | | | (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 2009 but had a positive effect for 2007-2009 period. (Tables 4 and 5). The yield in 2009 did increase by 2 tonnes/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 mineralisation and available N, thus responses to N fertiliser are unlikely until soil N reserves are depleted over time. Similar to the effects of SOA treatment, TSP and KIE treatments had no significant effect on FFB yield in 2009 and 2007-2009 and during the course of the trial. On the other hand, increasing MOP from 0 to 4 kg per palm resulted in a substantial yield increase (by 2-3 t/ha) in 2009 and 2007-2009.

**Table 4**: Effects (p values) of treatments on FFB yield and its components in the combined harvest for 2007 – 2009 and for 2009 alone. p values less than 0.05 are in bold.

| | **2009** | | | | **2007- 2009** | | |
|---|---|---|---|---|---|---|---|
| **Source** | **Yield** | **BNO** | **SBW** | | **Yield** | **BNO** | **SBW** |
| SOA | 0.055 | **0.019** | 0.443 | | **0.047** | **0.044** | 0.92 |
| TSP | 0.663 | 0.838 | 0.322 | | 0.536 | 0.255 | 0.76 |
| MOP | **0.041** | 0.562 | **0.012** | | **<0.001** | 0.079 | **<0.001** |
| KIE | 0.107 | 0.183 | 0.928 | | 0.113 | 0.197 | 0.96 |
| SOA.TSP | 0.644 | 0.986 | 0.171 | | 0.981 | 0.469 | 0.147 |
| SOA.MOP | **0.015** | 0.102 | 0.080 | | 0.093 | 0.478 | 0.105 |
| TSP.MOP | 0.910 | 0.278 | 0.124 | | 0.989 | 0.223 | 0.087 |
| SOA.KIE | 0.833 | 0.908 | 0.927 | | 0.751 | 0.771 | 0.275 |
| TSP.KIE | 0.361 | 0.257 | 0.700 | | 0.144 | 0.284 | 0.183 |
| MOP.KIE | 0.813 | 0.816 | 0.663 | | 0.724 | 0.314 | 0.235 |
| *CV %* | *13.6* | *13.2* | *6.3* | | *8.3* | *8.0* | *5.2* |

**Table 5**: Main effects of treatments on FFB yield (t/ha) for the combined harvest for 2007 – 2009 and 2009 alone (Yield, Bunch No and SBW in bold are significant at P<0.05).

| **Treatments** | | **2009** | | | | **2007 – 2009** | | |
|---|---|---|---|---|---|---|---|---|
| **(kg/palm/yr)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** | | **FFB yield (t/ha)** | **BNO** | **SBW (kg)** |
| SOA 2.0 | | 22.6 | **859** | 26.3 | | **23.6** | **969** | 24.5 |
| SOA 4.0 | | 24.4 | **940** | 26.0 | | **24.7** | **1015** | 24.5 |
| *$Lsd_{0.05}$* | | | 66.2 | | | 1.126 | 44.2 | |
| TSP 0.0 | | 23.7 | 913 | 26.0 | | 24.4 | 1002 | 24.5 |
| TSP 2.0 | | 23.8 | 894 | 26.7 | | 23.7 | 966 | 24.7 |
| TSP 4.0 | | 22.9 | 891 | 25.8 | | 24.3 | 1007 | 24.4 |
| | | | | | | | | |
| MOP 0.0 | | **21.8** | 875 | **25.0** | | **22.4** | 968 | **23.3** |
| MOP 2.0 | | **24.3** | 915 | **26.6** | | **24.5** | 982 | **25.1** |
| MOP 4.0 | | **24.4** | 908 | **26.8** | | **25.6** | 1025 | **25.1** |
| *$Lsd_{0.05}$* | | *2.191* | | 1.241 | | *1.379* | | *0.871* |
| KIE 0.0 | | 24.2 | 921 | 26.2 | | 24.5 | 1005 | 24.5 |
| KIE 2.0 | | 24.2 | 920 | 26.2 | | 24.6 | 1007 | 24.6 |
| KIE 4.0 | | 22.1 | 856 | 26.0 | | 23.3 | 964 | 24.4 |
| | | | | | | | | |
| GM | | 26.5 | 899 | 26.2 | | 24.1 | 992 | 24.5 |
| SE | | 3.197 | 118.3 | 1.812 | | 2.013 | 79 | 1.271 |
| CV % | | 13.6 | 13.2 | 6.3 | | 8.3 | 8.0 | 5.2 |

**Effects of treatments on leaf (F17) nutrient concentrations**

SOA treatment started having significant effect on leaflet and rachis nutrient concentrations in 2009, which was not reported in previous years (Tables 6 and 7). TSP treatment had a significantly effect on rachis P concentrations only (Tables 6 and 7). MOP treatment had a significant effect on leaflet K, Mg and B and rachis P and K concentrations (Tables 6 and 7). MOP increased leaflet K, rachis P and K but suppresses leaflet Mg and B. The rachis K content at nil MOP fertilized plots was very low at 0.46 % DM. The positive effect of MOP on leaf tissue K contents is also reflected in responses in yield. Kieserite increased leaflet Mg concentrations but lowered the K contents. However, the significant positive effect on tissue Mg contents is not translated to FFB yield. All the nutrients were above their respective critical concentrations for leaflet except for rachis K.

**Table 6**: Effects (p values) of treatments on frond 17 (F17) nutrient concentrations 2009 (Trial 329). p values <0.05 are indicated in bold.

| **Source** | | **Leaflets** | | | | | | | **Rachis** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **B** | | **Ash** | **N** | **P** | **K** |
| SOA | | | **0.004** | **<0.001** | **0.029** | **0.054** | **0.017** | | | **0.033** | **<0.001** | **0.032** |
| TSP | | | 0.935 | 0.071 | 0.916 | 0.416 | 0.310 | | | 0.313 | **<0.001** | 0.442 |
| MOP | | | 0.673 | 0.099 | **<0.001** | **<0.001** | **0.001** | | | 0.919 | **<0.001** | **<0.001** |
| KIE | | | 0.229 | 0.375 | **0.016** | **<0.001** | 0.961 | | | 0.686 | 0.062 | 0.133 |
| SOA.TSP | | | 0.544 | 0.331 | 0.470 | 0.637 | 0.477 | | | 0.833 | 0.466 | 0.929 |
| SOA.MOP | | | 0.993 | 0.772 | 0.472 | 0.424 | 0.312 | | | 0.235 | 0.628 | 0.282 |
| TSP.MOP | | | 0.546 | 0.503 | 0.804 | 0.990 | **0.050** | | | 0.551 | 0.808 | 0.433 |
| SOA.KIE | | | 0.985 | 0.536 | 0.715 | 0.156 | 0.685 | | | 0.566 | 0.203 | 0.059 |
| TSP.KIE | | | 0.843 | 0.797 | 0.864 | 0.784 | 0.682 | | | 0.762 | 0.164 | 0.286 |
| MOP.KIE | | | 0.407 | 0.222 | 0.463 | 0.555 | 0.786 | | | 0.411 | 0.165 | 0.269 |
| *CV%* | | | *6.3* | *2.8* | *9.8* | | *8.7* | | | *9.2* | *11.1* | *9.4* |

**Table 7**: Main effects of treatments on F17 nutrient concentrations in 2009, in units of % dry matter, except for B (mg/kg) (Trial 329). Effects with p<0.05are shown in bold

| **Source** | | **Leaflet nutrient contents** | | | | | | | **Rachis nutrient contents** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **B** | | **Ash** | **N** | **P** | **K** |
| SOA 2.0 | | 8.6 | **2.58** | **0.162** | **0.72** | **0.27** | **12.0** | | 3.8 | **0.262** | **0.093** | **1.06** |
| SOA 4.0 | | 8.7 | **2.73** | **0.166** | **0.77** | **0.25** | **11.3** | | 3.6 | **0.277** | **0.079** | **1.00** |
| *$Lsd_{0.05}$* | | | *0.093* | *0.025* | *0.041* | *0.016* | *0.567* | | | *0.014* | ***0.0054*** | *0.0541* |
| TSP 0.0 | | 8.6 | 2.65 | 0.162 | 0.74 | 0.27 | 12.0 | | 3.5 | 0.262 | **0.074** | 1.01 |
| TSP 2.0 | | 8.8 | 2.67 | 0.164 | 0.75 | 0.26 | 11.7 | | 3.9 | 0.273 | **0.091** | 1.05 |
| TSP 4.0 | | 8.5 | 2.65 | 0.166 | 0.74 | 0.25 | 11.4 | | 3.7 | 0.272 | **0.095** | 1.02 |
| | | | | | | | | | | | ***0.0066*** | |
| MOP 0.0 | | 9.5 | 2.68 | 0.166 | **0.62** | **0.28** | **12.5** | | 2.7 | 0.269 | **0.074** | **0.46** |
| MOP 2.0 | | 8.6 | 2.65 | 0.164 | **0.78** | **0.25** | **11.6** | | 4.0 | 0.267 | **0.089** | **1.16** |
| MOP 4.0 | | 8.2 | 2.63 | 0.162 | **0.84** | **0.24** | **11.1** | | 4.5 | 0.271 | **0.096** | **1.45** |
| *$Lsd_{0.05}$* | | | | | *0.050* | *0.019* | *0.694* | | | | ***0.0066*** | *0.0662* |
| KIE 0.0 | | 9.1 | 2.61 | 0.163 | **0.78** | **0.16** | 11.7 | | 3.9 | 0.269 | 0.085 | 1.04 |
| KIE 2.0 | | 8.6 | 2.71 | 0.165 | **0.75** | **0.28** | 11.7 | | 3.6 | 0.273 | 0.084 | 1.05 |
| KIE 4.0 | | 8.3 | 2.64 | 0.163 | **0.71** | **0.33** | 11.7 | | 3.7 | 0.266 | 0.091 | 0.99 |
| *$l.s.d_{0.05}$* | | | | | *0.050* | *0.019* | | | | | | |
| | | | | | | | | | | | | |
| GM | | 8.6 | 2.66 | 0.164 | 0.75 | 0.26 | 11.7 | | 3.7 | 0.269 | 0.086 | 1.03 |
| SE | | 0.655 | 0.167 | 0.005 | 0.073 | 0.029 | 1.013 | | 0.300 | 0.0248 | 0.009 | 0.097 |
| CV% | | | 6.3 | 2.8 | 9.8 | | 8.7 | | | 9.2 | 11.1 | 9.4 |

**Effects of fertiliser treatments on Vegetative parameters**

SOA had a positive effect on BDM and TDM only in 2009. TSP did not affect any of the measured parameters while MOP and kieserite affected BDM and TDM (and LAI for MOP) (Tables 8 and 9).

The mean BI was 0.36 suggesting more than 50% of the DM is diverted VDM compared to trials on the Popondetta Plains (BI>0.50) where >50% DM is diverted to bunch production.

**Table 8**. Effect (p values) of treatments on vegetative growth parameters in 2009. p values less than 0.05 are shown in bold.

| Source | | | | | | Radiation interception | | | | Dry matter production | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **FL** | **HI** | **PCS** | | **FP** | **FA** | **LAI** | | **FDM** | **BDM** | **TDM** | **VDM** | | **BI** |
| SOA | | | | 0.305 | | 0.478 | 0.212 | 0.703 | | 0.272 | **0.038** | **0.024** | 0.188 | | 0.241 |
| TSP | | | | 0.216 | | 0.679 | 0.796 | 0.427 | | 0.392 | 0.706 | 0.659 | 0.411 | | 0.541 |
| MOP | | | | 0.139 | | 0.924 | 0.073 | **0.045** | | 0.367 | **0.025** | **0.017** | 0.242 | | 0.233 |
| KIE | | | | 0.124 | | 0.241 | 0.593 | 0.237 | | 0.104 | **0.046** | **0.029** | 0.086 | | 0.133 |
| SOA.TSP | | | | 0.080 | | 0.160 | 0.523 | 0.609 | | 0.254 | 0.677 | 0.208 | 0.221 | | 0.982 |
| SOA.MOP | | | | 0.972 | | 0.717 | 0.219 | 0.654 | | 0.842 | **0.006** | **0.025** | 0.673 | | 0.061 |
| TSP.MOP | | | | 0.622 | | 0.154 | 0.756 | 0.750 | | 0.404 | 0.851 | 0.724 | 0.422 | | 0.626 |
| SOA.KIE | | | | 0.778 | | 0.635 | 0.494 | 0.610 | | 0.965 | 0.632 | 0.771 | 0.962 | | 0.777 |
| TSP.KIE | | | | 0.252 | | 0.321 | 0.849 | 0.909 | | 0.745 | 0.171 | 0.248 | 0.695 | | 0.426 |
| MOP.KIE | | | | 0.365 | | 0.377 | 0.267 | 0.428 | | 0.525 | 0.594 | 0.402 | 0.491 | | 0.698 |
| *CV%* | | | | *4.8* | | *4.9* | *7.0* | *8.9* | | *7.8* | *12.2* | *6.7* | *7.3* | | *8.8* |

*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 2009. Significant effects (p<0.05) are shown in bold.

| Treatments | | | | | | Radiation interception | | | | Dry matter production (t/ha/yr) | | | | | BI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **FL** | **HI** | **PCS** | | **FP** | **FA** | **LAI** | | **FDM** | **BDM** | **TDM** | **VDM** | | |
| SOA 2 | | | | 56.1 | | 22.0 | 14.2 | 6.90 | | 17.6 | **11.7** | **32.5** | 20.8 | | 0.36 |
| SOA 4 | | | | 56.8 | | 22.2 | 13.9 | 6.84 | | 18.0 | **12.5** | **33.9** | 21.4 | | 0.37 |
| *l.s.d$_{0.05}$* | | | | | | | | | | | *0.826* | *1.242* | | | |
| TSP 0 | | | | 55.5 | | 22.0 | 13.9 | 6.73 | | 17.4 | 12.3 | 33.0 | 20.7 | | 0.37 |
| TSP 2 | | | | 57.0 | | 22.2 | 14.1 | 6.89 | | 18.1 | 12.2 | 33.6 | 21.4 | | 0.36 |
| TSP 4 | | | | 56.9 | | 21.9 | 14.1 | 6.99 | | 17.8 | 11.9 | 33.0 | 21.1 | | 0.36 |
| *l.s.d$_{0.05}$* | | | | | | | | | | | | | | | |
| MOP 0 | | | | 55.5 | | 22.2 | 13.6 | **6.62** | | 17.4 | **11.3** | **31.9** | 20.6 | | 0.36 |
| MOP 2 | | | | 56.6 | | 22.0 | 14.4 | **7.16** | | 17.8 | **12.5** | **33.6** | 21.2 | | 0.37 |
| MOP 4 | | | | 57.3 | | 22.1 | 14.1 | **6.83** | | 18.1 | **12.6** | **34.0** | 21.5 | | 0.37 |
| *l.s.d$_{0.05}$* | | | | | | | | *0.419* | | | ***1.011*** | ***1.521*** | | | |
| | | | | | | | | | | | | | | | |
| KIE 0 | | | | 55.8 | | 21.7 | 13.9 | 6.68 | | 17.3 | **12.4** | **33.0** | 20.6 | | 0.37 |
| KIE 2 | | | | 57.6 | | 22.3 | 14.2 | 7.03 | | 18.3 | **12.6** | **34.4** | 21.8 | | 0.36 |
| KIE 4 | | | | 56.0 | | 22.2 | 14.1 | 6.91 | | 17.7 | **11.4** | **32.3** | 20.9 | | 0.35 |
| *l.s.d$_{0.05}$* | | | | | | | | | | | *1.011* | *1.521* | | | |
| GM | | | | 56.5 | | 22.1 | 14.0 | 6.87 | | 17.8 | 12.1 | 33.2 | 21.1 | | 0.36 |
| SE | | | | 2.738 | | 1.088 | 0.983 | 0.610 | | 1.384 | 1.476 | 2.22 | 1.543 | | 0.032 |
| CV % | | | | 4.8 | | 4.9 | 7.0 | 8.9 | | 7.8 | 12.2 | 6.7 | 7.3 | | 8.8 |

*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, leaf tissues and physiological parameters in 2009. 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 330: Grassland Sulphur Trial on Outwash Plains, Heropa Mini Estate (RSPO 4.2, 8.1)

**SUMMARY**
The Nitrogen (N) x Sulphur (S) trial was established on the grasslands of Popondetta for the purpose of developing a fertiliser strategy for oil palm grown on the sandy soils of the grasslands. In the second year treatment, there was no significant effect of fertilisers on yield, tissue nutrients and the physiological growth parameters.

**INTRODUCTION**
With increased oil palm plantings in the Popondetta grassland areas, both by smallholders and the mini-estate schemes, this trial was initiated purposely to provide information for fertiliser recommendations. In the grassland areas, N and S are expected to be the major limiting nutrients. The soils in the grassland areas are sandy with very low organic matter content. These areas also experience periods of water deficit during low rainfall months. Due to the porous nature of the sandy soils, leaching of nutrients can be a problem during periods of heavy rainfall. Soil results indicate low levels of K and P levels in the top 30 cm of the soil layer (Table 2). However, N and organic matter levels are high within the top 30 cm of the soil, possibly as products of mineralization of decaying plant debris within the oil palm establishment. With frequent burning during the dry season, soil C (OM) is not expected to accumulate in the surrounding grassland areas.
The objective of the trial is to provide information for fertiliser recommendations (especially for N and S) to the Estate, mini estates and the smallholder growers in the grassland areas of Popondetta.
Background information of the trial is presented in Table 1.

**Table 1**. Trial 330 background information.

| **Trial number** | **330** | Company | Higaturu Oil Palms |
|---|---|---|---|
| Estate | Embi | Block No. | Heropa (9HE01) |
| Planting Density | 135 palms/ha | Soil Type | Ambogo/Penderretta |
| Pattern | Triangular | Drainage | Moderate |
| Date planted | 2000 | Topography | Flat |
| Age after planting | 9 | Altitude | |
| Recording Started | May 2005 | Previous Land-use | Grassland |
| Planting material | Dami D x P | Area under trial soil type (ha) | 1830 |
| Progeny | Not known | Agronomist in charge | Susan Tomda |

**Table 2**. Initial soil analysis results from soil samples taken in 2005

| **Depth** | **pH in water** | **Exch K** | **Exch Ca** | **Exch Mg** | **CEC** | **OM (%)** | **Total N (%)** | **Olsen P (mg/kg)** |
|---|---|---|---|---|---|---|---|---|
| **cm** | | **cmol/kg** | | | | | | |
| 0-10 | 5.6 | 0.14 | 3.3 | 1.2 | 18.0 | 13.0 | 0.50 | 6.1 |
| 10-20 | 5.9 | 0.06 | 1.4 | 0.6 | 9.6 | 6.6 | 0.24 | 3.4 |
| 20-30 | 6.0 | 0.04 | 0.7 | 0.1 | 3.5 | 1.9 | 0.12 | 7.6 |
| 30-60 | 6.8 | 0.34 | 10.0 | 1.88 | 15.7 | 1.1 | 0.05 | 13.3 |

**METHODS**

**Experimental Design and Treatments**
The trial design was a Randomised Complete Block Design (RCBD). The treatment structure was a factorial arrangement of 4 rates of N (urea) x 3 rates of S (elemental Sulphur) x 4 replicates, resulting in 36 plots. Each replicate had 12 plots and the treatments were randomly allocated within each replicate block. Each plot consisted of 36 palms, the central 16 were recorded and the outer 20 were guard palms. The initial plan was to test out 4 rates of ammonium nitrate (AN) and 3 rates of elemental sulphur (S). However, AN was replaced with urea, which is the source of N that the

plantation (HOP) was using. Table 3 shows different rates of each fertiliser tested. Fertiliser treatments commenced in 2006 and treatments were applied in two applications per year. There was no nil N treatment because it was felt landowners might not want very low crop yields in the mini estates. The trial received an annual blanket application of MOP (2.0 kg/palm/yr), Borate (0.2 kg/palm/yr), FO1 magnesite (0.66 kg/palm/yr) and TSP (0.5 kg/palm/yr).

**Table 3**. Fertiliser treatments and levels in Trial 330.

| **Fertiliser** | **Amount (kg/palm/year)** | | | |
|---|---|---|---|---|
| | **Level 1** | **Level 2** | **Level 3** | **Level 4** |
| Urea | 0.5 | 1.5 | 2.5 | 3.5 |
| Elemental Sulphur | 0.00 | 0.15 | 0.30 | - |

**Data Collection**

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 once annually according to standard procedures and analysed for nutrient concentrations using standard analytical procedures. All data collection from the trial stopped in June 2009.

**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.

**RESULTS and DISCUSSION**

**Effects of treatment on FFB yield and its components**

Fertiliser treatments had no significant effect on FFB yield and yield components in 2009 (Jan-June) and 2007-2009 (Tables 4 and 5). The CV% for yield and BNO are very high and this indicates huge variability between plots in terms of bunch number and subsequently the yield. One possible explanation for this is because of the substantial moisture difference observed within the trial block, mainly due to the difference in the soil's physical properties.

**Table 4**. Effects (p values) of treatments on FFB yield and its components in 2009 and 2007 – 2009

| | **2009** | | | **2007-2009** | | |
|---|---|---|---|---|---|---|
| **Source** | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** |
| Urea | 0.419 | 0.390 | 0.724 | 0.551 | 0.739 | 0.844 |
| El. Sulphur | 0.142 | 0.291 | 0.230 | 0.085 | 0.337 | 0.084 |
| Urea x El. Sulphur | 0.113 | **0.032** | 0.796 | 0.324 | 0.321 | 0.763 |
| *CV %* | *19.2* | *13.8* | *10.4* | *13.0* | *11.6* | *9.0* |

**Table 5**. Main effects of treatments on FFB yield (t/ha) in 2007 – 2009 and 2009 (Jan – July).

| **Fertiliser (kg/palm)** | **2009** | | | **2007-2009** | | |
|---|---|---|---|---|---|---|
| | **FFB yield (t/ha)** | **BNO** | **SBW (kg)** | **FFB yield (t/ha)** | **BNO** | **SBW (kg)** |
| Urea 0.5 | 7.50 | 480 | 15.34 | 16.07 | 1166 | 14.15 |
| Urea 1.5 | 7.99 | 513 | 15.54 | 15.76 | 1159 | 14.07 |
| Urea 2.5 | 8.51 | 514 | 16.30 | 16.46 | 1173 | 14.50 |
| Urea 3.5 | 8.63 | 539 | 15.91 | 15.08 | 1110 | 14.00 |
| | | | | | | |
| El. Sulphur 0.00 | 7.44 | 485 | 15.24 | 14.70 | 1119 | 13.58 |
| El. Sulphur 0.15 | 8.74 | 529 | 16.43 | 16.40 | 1139 | 14.81 |
| El. Sulphur 0.30 | 8.29 | 421 | 15.79 | 16.42 | 1198 | 14.16 |
| | | | | | | |
| Grand Mean | 8.16 | 511 | 15.82 | 15.84 | 1152 | 14.18 |
| SE | 1.57 | 70.7 | 1.639 | 2.057 | 133.2 | 1.28 |
| CV % | *19.2* | *13.8* | *10.4* | *13.0* | *11.6* | *9.0* |

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

Urea started having significant effects on leaflet and rachis N contents in 2009. Elemental sulphur significantly affected leaflet P and reduced rachis N contents (Tables 6 and 7). All the nutrients were in the adequate range except leaflet and rachis K contents (Table 7).

**Table 6**: Effects (p values) of treatments on frond 17 (F17) nutrient concentrations 2009 (Trial 330). p values <0.05 are indicated in bold.

| Source | | Leaflets | | | | | | | Rachis | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **B** | | **Ash** | **N** | **P** | **K** |
| Urea | | | **0.003** | 0.586 | 0.995 | 0.463 | 0.920 | | | **0.006** | 0.474 | 0.516 |
| S | | | 0.114 | 0.153 | **0.002** | 0.437 | 0.845 | | | **0.001** | 0.736 | 0.164 |
| Urea x S | | | 0.749 | 0.427 | 0.278 | 0.296 | 0.762 | | | **0.042** | 0.496 | 0.756 |
| *CV%* | | | *3.1* | *3.1* | *5.4* | *14.3* | *15.9* | | | *14.7* | *29.4* | *14.9* |

**Table 7**: Main effects of treatments on F17 nutrient concentrations in 2009, in units of % dry matter, except for B (mg/kg) (Trial 330). Effects with p<0.05 are shown in bold.

| | | Leaflet nutrient contents | | | | | | | Rachis nutrient contents | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **B** | | **Ash** | **N** | **P** | **K** |
| Urea 0.5 | | 12.54 | **2.35** | 0.145 | 0.668 | 0.241 | 12.37 | | 4.63 | **0.286** | 0.108 | 1.39 |
| Urea 1.5 | | 12.34 | **2.40** | 0.147 | 0.670 | 0.233 | 12.69 | | 4.78 | **0.314** | 0.097 | 1.49 |
| Urea 2.5 | | 12.57 | **2.44** | 0.146 | 0.672 | 0.220 | 13.00 | | 4.48 | **0.306** | 0.087 | 1.42 |
| Urea 3.5 | | 11.60 | **2.51** | 0.148 | 0.670 | 0.243 | 12.52 | | 4.37 | **0.371** | 0.092 | 1.34 |
| *Lsd0.05* | | | *0.08* | | | | | | | *0.046* | | |
| S 0.00 | | 12.08 | 2.39 | **0.147** | 0.635 | 0.238 | | | 4.42 | **0.366** | 0.100 | 1.31 |
| S 0.15 | | 12.30 | 2.47 | **0.148** | 0.685 | 0.240 | | | 4.61 | **0.295** | 0.095 | 1.45 |
| S 0.30 | | 12.41 | 2.42 | **0.145** | 0.690 | 0.224 | | | 4.66 | **0.297** | 0.092 | 1.47 |
| *Lsd0.05* | | | | *0.030* | | | | | | *0.04* | | |
| | | | | | | | | | | | | |
| GM | | 12.26 | 2.43 | 0.147 | 0.670 | 0.234 | | | 4.57 | 0.319 | 0.096 | 1.41 |
| SE | | 0.854 | 0.083 | 0.004 | 0.036 | 0.033 | 2.014 | | 0.399 | 0.0469 | 0.028 | 0.210 |
| CV % | | | *3.1* | *3.1* | *5.4* | *14.3* | *15.9* | | | *14.7* | *29.4* | *14.9* |

**Effects of fertiliser treatments on vegetative parameters**

There was no significant effect of fertiliser treatment on vegetative growth parameters in 2009 except for elemental sulphur on BDM and BI. and elemental sulphur x Urea on bunch index (Tables 8 and 9). The mean BI was 0.43 implying high VDM production in relation to BDM production.

**Table 8**. Effect (p values) of treatments on vegetative growth parameters in 2009. p values less than 0.05 are shown in bold.

| Source | | | | | | Radiation interception | | | | Dry matter production | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FL | HI | PCS | | FP | FA | LAI | | FDM | BDM | TDM | VDM | | BI |
| Urea | | | | 0.423 | | 0.729 | 0.988 | 0.813 | | 0.632 | 0.444 | 0.506 | 0.609 | | 0.322 |
| S | | | | 0.914 | | 0.670 | 0.646 | 0.468 | | 0.681 | **0.035** | 0.106 | 0.562 | | **0.037** |
| Urea x S | | | | 0.398 | | 0.892 | 0.920 | 0.849 | | 0.424 | 0.152 | 0.348 | 0.461 | | **0.034** |
| *CV %* | | | | *11.7* | | *6.1* | *11.4* | *10.8* | | *12.9* | *17.7* | *12.9* | *12.4* | | *8.1* |

**Table 9**. Main effects of treatments on vegetative growth parameters in 2009. Significant effects ($p<0.05$) are shown in bold.

| Treatments | | | | | | Radiation interception | | | | Dry matter production (t/ha/yr) | | | | | BI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FL | HI | PCS | | FP | FA | LAI | | FDM | BDM | TDM | VDM | | |
| Urea 0.5 | | | | 31.1 | | 19.3 | 10.4 | 5.53 | | 8.9 | 8.4 | 19.2 | 10.8 | | 0.43 |
| Urea 1.5 | | | | 28.8 | | 19.7 | 10.4 | 5.63 | | 8.4 | 8.8 | 19.2 | 10.3 | | 0.46 |
| Urea 2.5 | | | | 31.4 | | 19.7 | 10.4 | 5.81 | | 9.1 | 9.3 | 20.5 | 11.1 | | 0.45 |
| Urea 3.5 | | | | 30.4 | | 20.0 | 10.3 | 5.68 | | 8.9 | 9.5 | 20.5 | 11.0 | | 0.46 |
| | | | | | | | | | | | | | | | |
| S 0.00 | | | | 30.3 | | 19.6 | 10.1 | 5.50 | | 8.7 | **8.0** | 18.6 | 10.6 | | **0.43** |
| S 0.15 | | | | 30.8 | | 19.9 | 10.6 | 5.82 | | 9.0 | **9.7** | 20.9 | 11.1 | | **0.46** |
| S 0.30 | | | | 30.2 | | 19.6 | 10.4 | 5.67 | | 8.7 | **9.4** | 20.0 | 10.7 | | **0.46** |
| *l.s.d$_{0.05}$* | | | | | | | | | | | 1.4 | | | | 0.030 |
| | | | | | | | | | | | | | | | |
| GM | | | | 30.4 | | 19.7 | 10.4 | 5.66 | | 8.8 | 9.0 | 19.8 | 10.8 | | 0.45 |
| SE | | | | 3.56 | | 1.19 | 1.18 | 0.612 | | 1.13 | 1.60 | 2.56 | 1.34 | | 0.036 |
| CV % | | | | 11.7 | | 6.1 | 11.4 | 10.8 | | 12.9 | 17.7 | 12.9 | 12.4 | | 8.1 |

*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

Fertiliser treatments had no significant effect on yield and its components, however, Urea has commenced having effects the N contents in the leaf.

# Trial 334: Nitrogen x Phosphorus Trial (Mature Phase) on Volcanic Ash Soils, Sangara Estate (RSPO 4.2, 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) while 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 | Sangara |
| Planting Density | 135 palms/ha | Soil Type | Volcanic ash |
| Pattern | Triangular | Drainage | Good |
| Date planted | 1999 | Topography | Flat |
| Age after planting | 10 | Altitude | 104.79 m asl |
| Recording Started | 2006 | Previous Land-use | Oil palm replant |
| Planting material | Dami D x P | Area under trial soil type (ha) | |
| Progeny | Not known | Agronomist in charge | Susan Tomda |

## METHODS

Urea treatment is to be applied three times per year while TSP will be applied twice a year. 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 3**. 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 significant yield and yield components yield responses in 2009 (Tables 4 and 5).

**Table 4**. Effects (p values) of treatments on FFB yield and its components in 2009.

| Source | 2009 | | |
|---|---|---|---|
| | FFB yield | BNO | SBW |
| Urea | 0.588 | 0.432 | 0.097 |
| TSP | 0.173 | 0.135 | 0.284 |
| Urea.x TSP | 0.945 | 0.864 | 0.374 |
| *CV %* | *10.0* | *10.2* | *4.8* |

**Table 5**. Main effects of treatments on FFB yield (t/ha) in 2009.

| Treatments | 2009 | | |
|---|---|---|---|
| | FFB yield (t/ha) | BNO/ha | SBW (kg) |
| Urea-1 | 34.6 | 1788 | 19.3 |
| Urea-2 | 35.6 | 1797 | 19.9 |
| Urea-3 | 34.3 | 1718 | 20.1 |
| | | | |
| TSP-1 | 34.8 | 1727 | 20.2 |
| TSP-2 | 33.5 | 1752 | 19.2 |
| TSP-3 | 33.2 | 1663 | 20.0 |
| TSP-4 | 36.8 | 1880 | 19.6 |
| TSP-5 | 35.8 | 1814 | 19.7 |
| | | | |
| Grand Mean | 34.8 | 1767 | 19.8 |
| SE | 3.47 | 180.3 | 0.953 |
| CV % | 10.0 | 10.2 | 4.8 |

### Effects of interaction between treatments on FFB yield
There was no significant interaction effect of SOA.TSP but the highest yield of 37.1 t/ha was obtained at urea-1 and TSP-1 levels. It is still very early to report actual responses (Table 6).

**Table 6**. Effect of SOA and EFB (two-way interactions) on FFB yield (t/ha/yr) in 2009. The interaction was not significant (p=0.945).

| | TSP-1 | TSP-2 | TSP-3 | TSP-4 | TSP-5 |
|---|---|---|---|---|---|
| **Urea-1** | 36.0 | 32.8 | 32.1 | 36.2 | 35.7 |
| **Urea-2** | 34.2 | 35.9 | 33.9 | 37.1 | 36.8 |
| **Urea-3** | 34.3 | 32.0 | 33.5 | 37.2 | 34.8 |
| Grand mean | 34.8 | | | | |

### Effects of Urea and TSP treatments on leaf (F17) nutrient concentrations
Leaf tissue samples were taken from the trial before fertilizer treatments were given and therefore cannot be commented for responses. Mean nutrient contents of all the plots were above their respective critical levels.

**Table 7**: Effects (p values) of treatments on frond 17 (F17) nutrient concentrations 2009 (Trial 334). p values <0.05 are indicated in bold.

| Source | | Leaflet | | | | | | | Rachis | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ash | N | P | K | Mg | B | | Ash | N | P | K |
| Urea | | 0.472 | 0.109 | 0.059 | 0.578 | 0.206 | **0.005** | | 0.753 | 0.339 | **0.035** | 0.499 |
| TSP | | 0.413 | 0.642 | 0.179 | 0.114 | **0.002** | 0.106 | | 0.716 | 0.862 | 0.060 | 0.528 |
| Urea.TSP | | 0.537 | 0.349 | **0.010** | 0.193 | 0.298 | 0.472 | | 0.348 | 0.885 | **0.010** | 0.407 |
| *CV%* | | *3.8* | *2.2* | *1.6* | *5.1* | *7.9* | *9.0* | | *6.6* | *8.9* | *10.9* | *8.4* |

**Table 8**: Main effects of treatments on F17 nutrient concentrations in 2009, in units of % dry matter, except for B (mg/kg) (Trial 334). Effects with p<0.05are shown in bold.

| **Treatments** | | **Leaflet nutrient contents (% DM)** | | | | | | | **Rachis nutrient contents (% DM)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **B (ppm)** | | **Ash** | **N** | **P** | **K** |
| Urea-1 | | 14.1 | 2.56 | 0.151 | 0.74 | 0.19 | **14.5** | | 5.9 | 0.305 | **0.13** | 1.61 |
| Urea-2 | | 14.0 | 2.57 | 0.153 | 0.75 | 0.18 | **13.2** | | 5.9 | 0.304 | **0.12** | 1.66 |
| Urea-3 | | 13.9 | 2.61 | 0.153 | 0.75 | 0.18 | **13.1** | | 6.0 | 0.317 | **0.12** | 1.67 |
| *l.s.d$_{0.05}$* | | | | | | | 0.916 | | | | 0.012 | |
| TSP-1 | | 14.1 | 2.57 | 0.151 | 0.75 | **0.17** | 14.3 | | 5.9 | 0.301 | 0.12 | 1.62 |
| TSP-2 | | 14.3 | 2.57 | 0.152 | 0.76 | **0.20** | 13.9 | | 6.0 | 0.314 | 0.12 | 1.69 |
| TSP-3 | | 13.9 | 2.59 | 0.152 | 0.74 | **0.19** | 13.7 | | 6.1 | 0.308 | 0.12 | 1.68 |
| TSP-4 | | 13.9 | 2.56 | 0.151 | 0.71 | **0.19** | 13.3 | | 5.8 | 0.312 | 0.12 | 1.59 |
| TSP-5 | | 13.9 | 2.59 | 0.154 | 0.75 | **0.18** | 12.8 | | 5.9 | 0.306 | 0.13 | 1.66 |
| *l.s.d$_{0.05}$* | | | | | | 0.0139 | | | | | | |
| | | | | | | | | | | | | |
| GM | | 14.0 | 2.58 | 0.152 | 0.75 | 0.184 | 13.6 | | 5.9 | 0.308 | 0.123 | 1.65 |
| SE | | 0.533 | 0.057 | 0.002 | 0.038 | 0.014 | 1.225 | | 0.391 | 0.027 | 0.013 | 0.138 |
| CV % | | 3.8 | 2.2 | 1.6 | 5.1 | 7.9 | 9.0 | | 6.6 | 8.9 | 10.9 | 8.4 |

**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 (RSPO 4.2, 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) while 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 resect 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 | 2 | 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 Progenies | 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 will be done in 2008. Yield recording will commence as soon as fruits are ready to be harvested. Recordings and measurements are taken on the central 16 palms in each plot. The number of bunches and bunch weights will be 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 will be carried out for each of the variables of interest 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 fertilizer on yield ant 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 yield components. Urea increased FFB yield and this was due to a significant increase in the number of bunches and single bunch weight. There was no response to TSP and there were some interactions between Urea and TSP but cannot be explained and not stronger than responses to Urea.

**Table 4**. Effects (p values) of treatments on FFB yield and its components in 2009.

| Source | 2009 | | |
|---|---|---|---|
| | **FFB yield** | **BNO** | **SBW** |
| Urea | **<0.001** | **0.026** | **<0.001** |
| TSP | 0.602 | 0.302 | 0.596 |
| Urea.x TSP | **0.011** | 0.134 | **0.012** |
| *CV %* | *22.4* | *21.7* | *7.8* |

**Table 5**. Main effects of treatments on FFB yield (t/ha) in 2009.

| Treatments | 2009 | | |
|---|---|---|---|
| | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** |
| Urea-1 | **3.82** | **1223** | **3.09** |
| Urea-2 | **4.41** | **1347** | **3.24** |
| Urea-3 | **5.21** | **1483** | **3.50** |
| *l.s.d$_{0.05}$* | *0.639* | *186.6* | *0.16* |
| TSP-1 | 4.55 | 1341 | 3.31 |
| TSP-2 | 4.66 | 1437 | 3.19 |
| TSP-3 | 4.06 | 1200 | 3.33 |
| TSP-4 | 4.52 | 1353 | 3.33 |
| TSP-5 | 4.60 | 1424 | 3.23 |
| Grand Mean | 4.48 | 1351 | 3.28 |
| SE | 1.001 | 292.5 | 0.256 |
| CV % | 22.4 | 21.7 | 7.8 |

**Effects of interaction between treatments on FFB yield**

**Table 6**. Effect of SOA and EFB (two-way interactions) on FFB yield (t/ha/yr) in 2009.

| | **TSP-1** | **TSP-2** | **TSP-3** | **TSP-4** | **TSP-5** |
|---|---|---|---|---|---|
| **Urea-1** | 2.73 | 4.59 | 3.60 | 4.12 | 4.06 |
| **Urea-2** | 6.03 | 4.09 | 3.43 | 3.76 | 4.73 |
| **Urea-3** | 4.89 | 5.29 | 5.14 | 5.68 | 5.03 |
| Grand mean | 4.48 | | Sed= | | |

Monthly yields have increased to 1.6 t/ha at 29 months while the number of bunches also increased to around 300 at about the same time (Figures 1 and 2). Mean single bunch weight also increased from <0.5 kg to 5.5 kg during the 29 months (Figure 3)

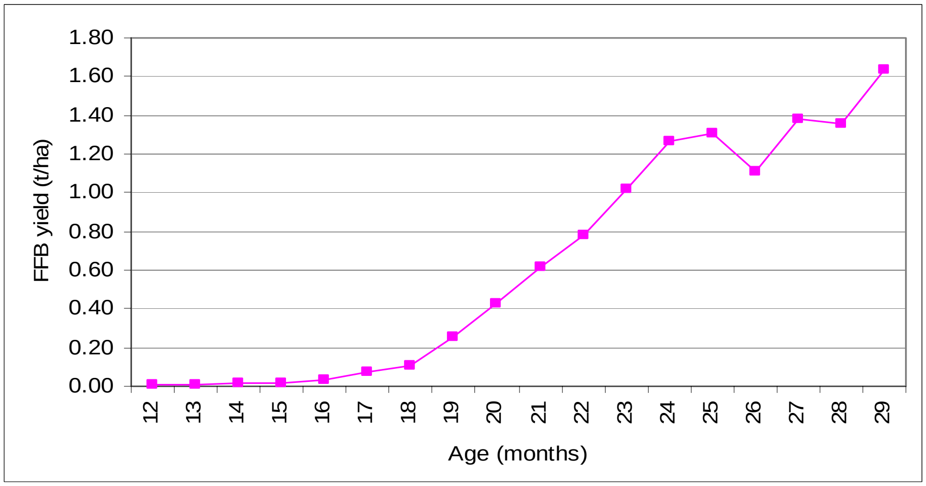



**Figure 1**. Mean FFB yield in t/ha from month 12 to month 29

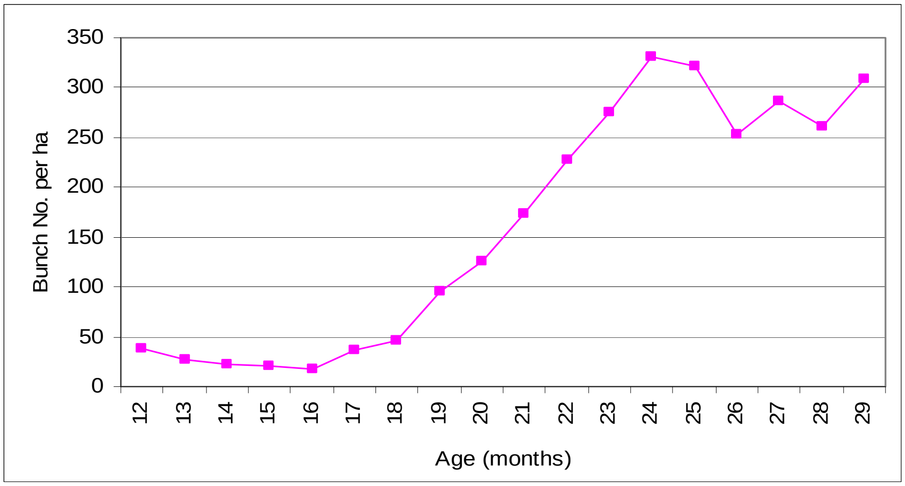



**Figure 2**. Mean number of bunches per ha from month 12 to month 29

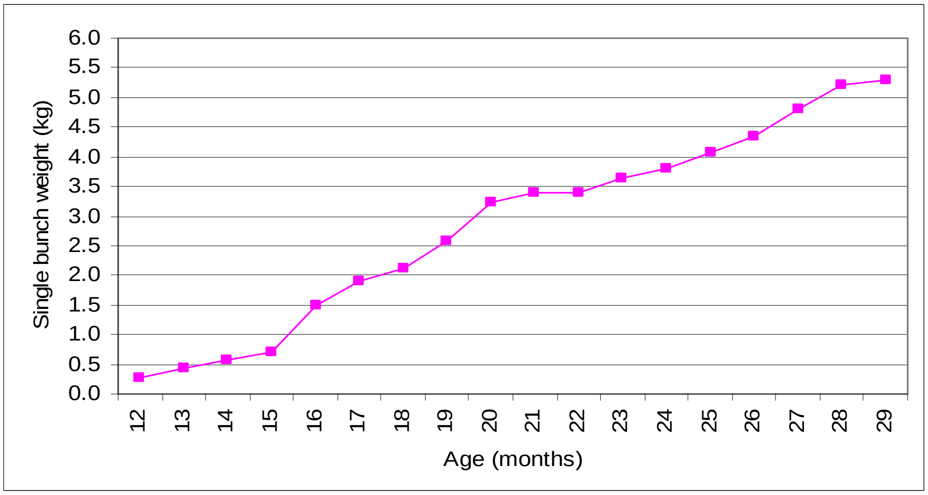



**Figure 3**. Mean single bunch weight from month 12 to month 29

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

Urea significantly increased leaflet N and rachis P and also affected rachis ash and K. TSP increased leaflet ash and rachis P.

**Table 7**: Effects (p values) of treatments on frond 9 nutrient concentrations 2009 (Trial 335). p values <0.05 are indicated in bold.

| **Source** | | **Leaflets** | | | | | | | **Rachis** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **B** | | **Ash** | **N** | **P** | **K** |
| Urea | | 0.106 | **0.011** | 0.353 | 0.286 | 0.474 | 0.912 | | **0.001** | 0.958 | **<0.001** | **<0.001** |
| TSP | | **0.038** | 0.238 | 0.805 | 0.814 | 0.437 | 0.096 | | 0.610 | 0.359 | **<0.001** | 0.876 |
| Urea.TSP | | 0.331 | 0.090 | 0.280 | 0.155 | 0.108 | 0.624 | | 0.187 | 0.280 | 0.281 | 0.111 |
| *CV%* | | *5.1* | *4.7* | *3.7* | *6.1* | *6.4* | *23.5* | | *7.9* | *5.6* | *14.2* | *14.3* |

**Table 8**: Main effects of treatments on F9 nutrient concentrations in 2009, in units of % dry matter, except for B (mg/kg) (Trial 335). Effects with p<0.05are shown in bold.

| **Treatments** | | **Leaflet nutrient contents** | | | | | | | **Rachis nutrient contents** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **B** | | **Ash** | **N** | **P** | **K** |
| Urea-1 | | 11.07 | **2.56** | 0.159 | 0.870 | 0.349 | 30.46 | | **3.877** | 0.293 | **0.198** | **0.856** |
| Urea-2 | | 10.88 | **2.65** | 0.162 | 0.884 | 0.350 | 30.64 | | **4.064** | 0.292 | **0.187** | **0.970** |
| Urea-3 | | 11.29 | **2.68** | 0.599 | 0.857 | 0.342 | 31.39 | | **3.673** | 0.292 | **0.153** | **0.814** |
| *l.s.d$_{0.05}$* | | | 0.08 | | | | | | 0.196 | | 0.016 | 0.080 |
| TSP-1 | | **10.62** | 2.66 | 0.159 | 0.882 | 0.353 | 35.10 | | 3.750 | 0.294 | **0.149** | 0.858 |
| TSP-2 | | **11.04** | 2.57 | 0.158 | 0.867 | 0.353 | 30.73 | | 3.904 | 0.289 | **0.174** | 0.886 |
| TSP-3 | | **11.18** | 2.59 | 0.161 | 0.877 | 0.344 | 30.12 | | 3.873 | 0.285 | **0.180** | 0.910 |
| TSP-4 | | **11.15** | 2.66 | 0.161 | 0.857 | 0.348 | 31.57 | | 3.883 | 0.295 | **0.194** | 0.867 |
| TSP-5 | | **11.40** | 2.64 | 0.161 | 0.870 | 0.338 | 26.63 | | 3.945 | 0.298 | **0.199** | 0.879 |
| *l.s.d$_{0.05}$* | | 0.49 | | | | | | | | | 0.021 | |
| | | | | | | | | | | | | |
| GM | | 11.08 | 2.63 | 0.160 | 0.870 | 0.347 | 30.83 | | 3.871 | 0.292 | 0.179 | 0.880 |
| SE | | 0.596 | 0.124 | 0.006 | 0.053 | 0.022 | 7.244 | | 0.307 | 0.016 | 0.025 | 0.125 |
| CV % | | 5.1 | 4.7 | 3.7 | 6.1 | 6.4 | 23.5 | | 7.9 | 5.6 | 14.2 | 14.3 |

Urea significantly increased frond length and increment, frond area, dry matter production and BI. TSP affected frond length increment and leaf area index.

**Table 9**: Trial 335, effects (p values) of treatments on frond 9 (F9) nutrient concentrations 2009. p values <0.05 are indicated in bold.

| **Source** | | | | | | **Radiation interception** | | | | **Dry matter production** | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **FL** | **FLI** | **PCS** | | **FP** | **FA** | **LAI** | | **FDM** | **BDM** | **TDM** | **VDM** | | **BI** |
| Urea | | **<0.001** | **<0.001** | 0.187 | | 0.328 | **0.010** | 0.183 | | **0.045** | **<0.001** | **<0.001** | **0.008** | | **<0.001** |
| TSP | | 0.063 | **0.002** | 0.321 | | 0.400 | 0.085 | **0.009** | | 0.179 | 0.739 | 0.975 | 0.253 | | 0.340 |
| Urea x TSP | | 0.053 | 0.721 | 0.461 | | 0.909 | 0.785 | 0.492 | | 0.507 | **0.031** | **0.018** | 0.328 | | 0.101 |
| *CV %* | | 4.6 | 15.2 | *7.4* | | *3.4* | *6.8* | *8.0* | | *6.1* | *22.0* | *7.7* | *6.0* | | *17.0* |

**Table 10**. Trial 335, main effects of treatments on vegetative growth parameters in 2009. Significant effects ($p<0.05$) are shown in bold.

| **Treatments** | | | | **Radiation interception** | | | **Dry matter production (t/ha/yr)** | | | | **BI** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **FL** | **FLI** | **PCS** | **FP** | **FA** | **LAI** | **FDM** | **BDM** | **TDM** | **VDM** | |
| Urea-1 | **205.4** | **81.6** | 7.5 | 39.2 | **2.2** | 1.40 | **5.1** | **1.6** | **7.5** | **5.9** | **0.20** |
| Urea-2 | **213.1** | **101.8** | 7.8 | 39.8 | **2.3** | 1.43 | **5.4** | **2.0** | **8.2** | **6.2** | **0.24** |
| Urea-3 | **216.8** | **102.7** | 7.8 | 39.7 | **2.4** | 1.47 | **5.4** | **2.4** | **8.7** | **6.3** | **0.27** |
| *lsd* $_{0.05}$ | 4.621 | 9.27 | | | 0.0990 | | 0.206 | 0.281 | 0.397 | 0.232 | 0.0262 |
| TSP-1 | 214.5 | **94.1** | 7.9 | 39.8 | 2.4 | **1.52** | 5.4 | 2.0 | 8.2 | 6.2 | 0.23 |
| TSP-2 | 212.7 | **102.0** | 7.4 | 39.9 | 2.2 | **1.36** | 5.2 | 2.1 | 8.1 | 6.0 | 0.25 |
| TSP-3 | 212.5 | **104.7** | 7.8 | 39.8 | 2.3 | **1.49** | 5.4 | 1.9 | 8.1 | 6.2 | 0.23 |
| TSP-4 | 206.1 | **79.9** | 7.6 | 40.0 | 2.2 | **1.40** | 5.1 | 2.1 | 8.1 | 6.0 | 0.25 |
| TSP-5 | 212.8 | **96.2** | 7.8 | 39.4 | 2.2 | **1.41** | 5.3 | 1.9 | 8.1 | 6.1 | 0.24 |
| *lsd* $_{0.05}$ | | 11.97 | | | | 0.0952 | | | | | |
| | | | | | | | | | | | |
| Grand mean | 211.7 | 95.4 | 7.7 | 39.6 | 2.3 | 1.44 | 5.3 | 2.0 | 8.1 | 6.1 | 0.24 |
| SE | 9.814 | 14.53 | 0.574 | 1.343 | 0.1552 | 0.116 | 0.3223 | 0.441 | 0.622 | 0.364 | 0.0417 |
| CV % | 4.6 | 15.2 | *7.4* | *3.4* | *6.8* | *8.0* | *6.1* | *22.0* | *7.7* | *6.0* | *17.0* |

*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.

# Trial 331: Spacing and Thinning Trial, Ambogo Estate (RSPO 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 and issue when the trial 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 spacings 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 back ground information of the trial is presented in Table 1.

**Table 1**. Trial 331 back ground information

| **Trial number** | **331** | Company | Higaturu Oil Palms |
|---|---|---|---|
| Estate | Ambogo | Block No. | 4971A2 |
| Planting Density | See Table 2 | Soil Type | Alluvial flood plain |
| Pattern | Triangular | Drainage | Good |
| Date planted | 2001 | Topography | Flat |
| Age after planting | 5 | Altitude | m asl |
| Recording Started | Jan 2002 | Previous Land-use | Oil Palm plantation |
| Planting material | Dami D x P | Area under trial soil type (ha) | Not known |
| Progeny | Mixed Dami DxP | Agronomist in charge | Dr. Murom Banabas |

## 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 row 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 these 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 5$^{th}$ 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 it components in 2009 (Table 3). 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.

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

| Source | Yield | BNO | SBW | Yield | BNO | SBW |
|---|---|---|---|---|---|---|
| Density treatment | **<0.001** | **<0.001** | **0.009** | **0.035** | **0.051** | **0.058** |
| *CV %* | *2.4* | *3.0* | *1.7* | *5.1* | *5.9* | *2.0* |

**Table 4.** Main effects of treatments on FFB yield (t/ha) in 2007 (treatments which are significantly different at P<0.05 are presented in bold).

| | | 2009 | | | | 2007-2009 | | |
|---|---|---|---|---|---|---|---|---|
| **Density Treatment** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** |
| 128 | | **36.2** | **2080** | 17.4 | | **37.6** | **2386** | **15.9** |
| 135 | | **35.1** | **2096** | 16.8 | | **36.1** | **2414** | **15.1** |
| 143 | | **35.3** | **2065** | 17.2 | | **36.4** | **2378** | **15.5** |
| 128 (192) | | **32.6** | **1852** | 17.6 | | **33.5** | **2112** | **16.0** |
| 135 (203) | | **31.4** | **1847** | 17.0 | | **32.1** | **2085** | **15.5** |
| 143 (215) | | **32.5** | **1928** | 16.9 | | **32.4** | **2114** | **15.5** |
| $lsd_{0.05}$ | | 2.721 | 182.9 | | | 1.484 | 131.4 | 0.539 |
| sig | | **0.015** | **0.030** | | | **<0.001** | **<0.001** | **0.040** |
| Grand Mean | | **33.9** | **1978** | **17.1** | | **34.7** | **2248** | **15.6** |
| SE | | **1.496** | **100.5** | **0.403** | | **0.816** | **72.2** | **0.296** |
| CV % | | **4.4** | **5.1** | **2.4** | | **2.4** | **3.2** | **1.9** |

(..) Previous density

| Treatments | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
| | | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
| 128 | | 15.3 | 21.4 | 29.4 | 29.6 | 39.4 | 37.1 | 36.2 |
| 135 | | 14.4 | 21.4 | 29.2 | 29 | 37.6 | 35.6 | 35.1 |
| 143 | | 16.0 | 20.2 | 28.4 | 29.9 | 38.4 | 35.6 | 35.3 |
| 128 (192) | | 23.2 | 28.5 | 32.4 | 40.2 | 34.4 | 33.5 | 32.6 |
| 135 (203) | | 19.5 | 28.2 | 26.5 | 37.8 | 32.6 | 32.3 | 31.4 |
| 143 (215) | | 22.7 | 29.2 | 28.2 | 41.4 | 32.4 | 32.3 | 32.6 |
| | | | | | | | | |
| *Significance* | | | | | | | | |
| $lsd_{0.05}$ | | | | | | | | |
| Grand Mean | | 18.5 | 25.1 | 29.0 | 34.7 | 35.8 | 34.4 | 33.9 |

**Leaf tissue nutrient concentrations**
There was no difference in leaf tissue nutrient contents and all nutrient concentrations were above their respective critical values for oil palm (Table 5 and 6).

**Table 5**: P values of frond 17 nutrient concentrations 2008 (Trial 331). p values <0.05 are indicated in bold.

| Source | Leaflet | | | | | | Rachis | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | B | Ash | N | P | K |
| Density | 0.273 | 0.921 | 0.216 | 0.595 | 0.299 | 0.615 | 0.106 | 0.478 | 0.070 | 0.277 |
| *CV%* | *2.8* | *1.7* | *1.4* | *3.8* | *4.7* | *20.7* | *4.3* | *8.7* | *7.7* | *5.6* |

**Table 6**: Main effects of treatments on F17 nutrient concentrations in 2008, in units of % dry matter, except for B (mg/kg) (Trial 331). Effects with p<0.05 are shown in bold.

| **Density** | | **Leaflet nutrient contents** | | | | | | | **Rachis nutrient content** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **B** | | **Ash** | **N** | **P** | **K** |
| 128 | | 11.8 | 2.70 | 0.154 | 0.66 | 0.25 | 19.1 | | 5.6 | 0.290 | 0.147 | 1.92 |
| 135 | | 11.8 | 2.65 | 0.158 | 0.72 | 0.25 | 18.6 | | 6.1 | 0.317 | 0.167 | 2.04 |
| 143 | | 11.8 | 2.62 | 0.158 | 0.69 | 0.24 | 20.9 | | 6.1 | 0.317 | 0.154 | 2.01 |
| 128 (192) | | 11.6 | 2.56 | 0.155 | 0.72 | 0.24 | 19.4 | | 6.1 | 0.310 | 0.163 | 2.03 |
| 135 (203) | | 11.4 | 2.66 | 0.158 | 0.70 | 0.26 | 23.3 | | 6.3 | 0.307 | 0.167 | 2.03 |
| 143 (215) | | 11.9 | 2.68 | 0.158 | 0.67 | 0.25 | 22.5 | | 5.8 | 0.327 | 0.149 | 1.93 |
| | | | | | | | | | | | | |
| GM | | 11.7 | 2.65 | 0.157 | 0.69 | 0.25 | 20.6 | | 6.0 | 0.311 | 0.158 | 1.99 |
| Se | | 0.358 | 0.0676 | 0.0030 | 0.0338 | 0.0125 | 2.329 | | 0.573 | 0.0271 | 0.0176 | 0.206 |
| Cv% | | 3.0 | 2.6 | 1.9 | 4.9 | 5.0 | 11.3 | | 9.5 | 8.7 | 11.2 | 10.3 |

(..) previous density

**CONCLUSIONS**
The density treatment had a significant effect on yield in 2007 with the higher yields achieved by un-thinned planting densities of 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 an adequate level.

# CTP POLIAMBA ESTATE

**SUMMARY**
A single fertilizer response trial was undertaken with Poliamba Estates in 2009: Factorial trial response to B and K: two types of Boron fertilizer (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 fertilizer, but K levels have not changed (and this nutrient is present at an adequate level).

**CTP Poliamba Estates: Synopsis of 2007 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 | 19 | B x MOP 33.1 (NS) | BHA 1285 (NS) SBW 25.9 (NS) | MOP LK 0.74 (NS) RK 1.77 B LB 13 to 16 mg/kg LN 2.48, RN 0.30: LP 0.157, RP 0.153 LMg 0.25 | 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 fertilizer strategies can be calculated if costs of production are provided to OPRA
- Plantation management (harvest time, pruning, clean weeded circles, fertilizer 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, 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 CTP Poliamba. This trial is designed to provide information that will help make recommendations for N, K and B fertilizer 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 a NxKxB trial. Background information to the trial is supplied in Table 1.

**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. he 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 fertilizers 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.

**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 | 19 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 |

**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)

| Trial | Plot | Rep | AC | MOP | NaB | Trial | Plot | Rep | AC | MOP | NaB |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 254 | 1 | 2 | 4 | 2.5 | 0 | 254 | 25 | 2 | 4 | 2.5 | 0.08 |
| 254 | 2 | 2 | 8 | 2.5 | 0 | 254 | 26 | 3 | 8 | 2.5 | 0.08 |
| 254 | 3 | 4 | 4 | 2.5 | 0 | 254 | 27 | 3 | 8 | 7.5 | 0.08 |
| 254 | 4 | 3 | 4 | 2.5 | 0.08 | 254 | 28 | 3 | 4 | 7.5 | 0 |
| 254 | 5 | 4 | 8 | 2.5 | 0.08 | 254 | 29 | 3 | 8 | 7.5 | 0.16 |
| 254 | 6 | 2 | 4 | 2.5 | 0.16 | 254 | 30 | 1 | 4 | 7.5 | 0 |
| 254 | 7 | 3 | 4 | 7.5 | 0.16 | 254 | 31 | 1 | 4 | 7.5 | 0.08 |
| 254 | 8 | 2 | 8 | 7.5 | 0.16 | 254 | 32 | 3 | 8 | 7.5 | 0 |
| 254 | 9 | 4 | 8 | 2.5 | 0.16 | 254 | 33 | 2 | 4 | 7.5 | 0.08 |
| 254 | 10 | 1 | 4 | 2.5 | 0 | 254 | 34 | 4 | 8 | 7.5 | 0 |
| 254 | 11 | 4 | 8 | 7.5 | 0.16 | 254 | 35 | 2 | 8 | 7.5 | 0.08 |
| 254 | 12 | 3 | 4 | 2.5 | 0.16 | 254 | 36 | 4 | 8 | 2.5 | 0 |
| 254 | 13 | 4 | 4 | 7.5 | 0 | 254 | 37 | 1 | 8 | 2.5 | 0.08 |
| 254 | 14 | 1 | 4 | 2.5 | 0.08 | 254 | 38 | 3 | 8 | 2.5 | 0.16 |
| 254 | 15 | 1 | 8 | 7.5 | 0.16 | 254 | 39 | 4 | 4 | 2.5 | 0.16 |
| 254 | 16 | 1 | 8 | 2.5 | 0 | 254 | 40 | 4 | 4 | 2.5 | 0.08 |
| 254 | 17 | 1 | 4 | 7.5 | 0.16 | 254 | 41 | 4 | 4 | 7.5 | 0.16 |
| 254 | 18 | 2 | 4 | 7.5 | 0 | 254 | 42 | 1 | 8 | 7.5 | 0.08 |
| 254 | 19 | 1 | 4 | 2.5 | 0.16 | 254 | 43 | 4 | 4 | 7.5 | 0.08 |
| 254 | 20 | 2 | 4 | 7.5 | 0.16 | 254 | 44 | 1 | 8 | 2.5 | 0.16 |
| 254 | 21 | 2 | 8 | 2.5 | 0.08 | 254 | 45 | 2 | 8 | 7.5 | 0 |
| 254 | 22 | 4 | 8 | 7.5 | 0.08 | 254 | 46 | 3 | 4 | 7.5 | 0.08 |
| 254 | 23 | 3 | 4 | 2.5 | 0 | 254 | 47 | 2 | 8 | 2.5 | 0.16 |
| 254 | 24 | 3 | 8 | 2.5 | 0 | 254 | 48 | 1 | 8 | 7.5 | 0 |

**Treatment fertilizers**

The treatment fertilizers 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 fertilizer:** 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 significantly increased FFB yield (P=0.011) by 2 t/ha in 2009 (see Table 4) while MOP had a negative effect on yield in 2007-2009 (p=0.006). There was no effect of boron, and the mean yield was 33.1 t/ha in 2009. Though statistically not significant, at 0 boron levels, high yields were obtained at high AC and MOP levels, however, yields were suppressed in the presence of boron. Monitoring will continue on this trial to see if this pattern will continue (Table 5).

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 2009 and 2007 to 2009 (3 years averaged data). P values less than 0.05 are presented in bold.

| Source | | 2009 | | | | 2007 to 2009 | | |
|---|---|---|---|---|---|---|---|---|
| | | **Yield** | **BN** | **SBW** | | **Yield** | **BN** | **SBW** |
| AC | | **0.011** | 0.095 | 0.390 | | 0.080 | 0.492 | 0.625 |
| MOP | | 0.264 | 0.291 | 0.953 | | **0.006** | 0.132 | 0.609 |
| BORATE | | 0.246 | 0.116 | 0.516 | | 0.372 | 0.063 | 0.367 |
| AC.MOP | | 0.300 | 0.526 | 0.709 | | 0.479 | 0.854 | 0.821 |
| AC.Borate | | 0.923 | 0.954 | 0.811 | | 0.893 | 0.506 | 0.484 |
| MOP.Borate | | 0.128 | 0.081 | **0.038** | | 0.457 | 0.088 | 0.171 |
| CV % | | | | | | | | |

**Table 4**. Trial 254, effects of treatments on FFB yield and its components for 2009 and 2007 to 2009 (3 years averaged data). P values less than 0.05 are presented in bold.

| | | 2009 | | | | 2007-2009 | | |
|---|---|---|---|---|---|---|---|---|
| **Treatments (kg/palm)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** |
| AC 4.0 | | **32.0** | 1254 | 25.6 | | 31.0 | 1320 | 23.7 |
| 8.0 | | **34.2** | 1316 | 26.1 | | 31.9 | 1342 | 24.0 |
| *l.s.d.$_{0.05}$* | | 1.670 | | | | | | |
| MOP 2.5 | | 33.6 | 1304 | 25.9 | | **32.2** | 1356 | 24.0 |
| 7.5 | | 32.6 | 1266 | 25.8 | | **30.7** | 1306 | 23.7 |
| *l.s.d.$_{0.05}$* | | | | | | 1.015 | | |
| Borate 0 | | 34.1 | 1328 | 25.7 | | 31.8 | 1349 | 23.6 |
| 0.08 | | 32.7 | 1293 | 25.5 | | 31.6 | 1368 | 23.4 |
| 0.16 | | 32.5 | 1234 | 26.3 | | 30.9 | 1277 | 24.4 |
| | | | | | | | | |
| **GM** | | 33.1 | 1285 | 25.9 | | 31.4 | 1331 | 23.8 |
| **Se** | | 2.850 | 124.6 | 2.110 | | 1.732 | 111.2 | 1.948 |
| **CV %** | | 8.6 | 9.7 | 8.2 | | 5.5 | 8.4 | 8.2 |

**Table 5.** Trial 254, impact of FFB yield in 2009 from N (AC), K (MOP) and B (borate)

| AC (kg/p) | MOP (kg/p) | Borate (kg/p) | | |
|---|---|---|---|---|
| | | **0** | **0.08** | **0.16** |
| 4 | 2.5 | 31.9 | 31.9 | 32.3 |
| 4 | 7.5 | 33.6 | 31.6 | 30.7 |
| 8 | 2.5 | 34.8 | 36.0 | 34.4 |
| 8 | 7.5 | 36.0 | 31.4 | 32.4 |
| **Significant difference:** | | | | |
| | **AC** | | **NS** | |
| | **MOP** | | **NS** | |
| | **B** | | **NS** | |

*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 there after (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, primarily due to fewer bunches being harvested, however the crop recovered to 33 t/ha in 2009.

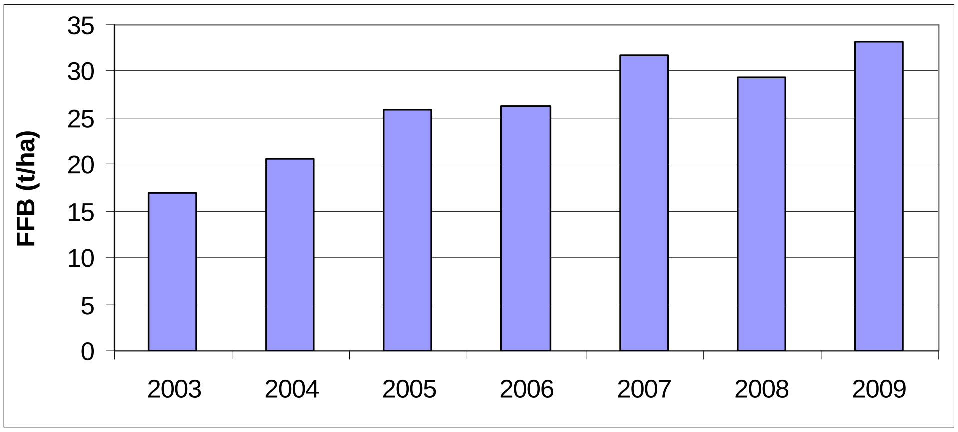



**Figure 1**. Trial yield since establishment in 2002.

**Tissue nutrient concentration**

Effects of fertiliser treatments on leaf tissue nutrient concentrations are presented in Tables 6 and 7. AC significantly increase leaflet N and P and rachis N concentrations in 2009. MOP lowered leaflet N but increased rachis ash and K concentrations. Borate significantly increased B concentrations in the leaflets.

**Table 6.** Trial 254, p values of treatment effects on F17 nutrient concentrations in 2009. Effects with p<0.05 are shown in bold.

| **Source** | | **Leaflet nutrient concentrations** | | | | | | | | **Rachis nutrient concentrations** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** | **B** | | **Ash** | **N** | **P** | **K** |
| AC | | 0.600 | **<0.001** | **0.019** | 0.174 | 0.105 | 0.859 | 1.000 | | 0.731 | **0.009** | 0.408 | 0.418 |
| MOP | | 0.866 | **0.029** | 0.616 | 0.672 | 0.813 | 0.859 | 0.124 | | **<0.001** | 0.602 | 0.089 | **<0.001** |
| Borate | | 0.667 | 0.782 | 0.152 | 0.992 | 0.530 | 0.629 | **<0.001** | | 0.054 | 0.845 | 0.886 | 0.139 |
| AC.MOP | | 0.825 | 0.325 | 0.850 | 0.344 | 0.411 | 0.290 | 0.442 | | 0.630 | 0.602 | 0.924 | 0.807 |
| AC.Borate | | **0.044** | 0.909 | 0.718 | 0.582 | **0.018** | 0.629 | 0.969 | | 0.134 | 0.706 | 0.868 | 0.289 |
| MOP.Borate | | 0.696 | 0.704 | 0.764 | 0.885 | 0.145 | 0.768 | 0.332 | | 0.654 | 0.431 | 0.853 | 0.245 |
| CV % | | | | | | | | | | | | | |

**Table 7.** Trial 254, main effects of treatments on frond 17 nutrient concentrations in 2009, in units of dry matter % except for B (mg/kg). P values less than 0.05 are indicated in bold.

| **Treatments (kg/palm)** | | **Leaflet nutrient contents (% DM)** | | | | | | | | **Rachis nutrient contents (% DM)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **Ca** | **B (ppm)** | | **Ash** | **N** | **P** | **K** |
| AC 4.0 | | 6.7 | **2.43** | **0.155** | 0.73 | 0.25 | 1.01 | 15.6 | | 4.9 | **0.292** | 0.158 | 1.79 |
| 8.0 | | 6.6 | **2.53** | **0.158** | 0.75 | 0.24 | 1.00 | 15.6 | | 4.9 | **0.310** | 0.147 | 1.75 |
| *l.s.d.*$_{0.05}$ | | | 0.0491 | 0.0027 | | | | | | | 0.0129 | | |
| MOP 2.5 | | 6.7 | **2.51** | 0.157 | 0.74 | 0.25 | 1.01 | 16.0 | | **4.7** | 0.303 | 0.141 | **1.65** |
| 7.5 | | 6.7 | **2.45** | 0.156 | 0.74 | 0.25 | 1.01 | 15.3 | | **5.2** | 0.300 | 0.164 | **1.88** |
| *l.s.d.*$_{0.05}$ | | | 0.0491 | | | | | | | 0.2072 | | | 0.103 |
| Borate 0 | | 6.6 | 2.49 | 0.156 | 0.74 | 0.24 | 1.01 | **13.9** | | 4.8 | 0.302 | 0.150 | 1.76 |
| 0.08 | | 6.7 | 2.48 | 0.156 | 0.74 | 0.25 | 1.00 | **16.6** | | 5.1 | 0.303 | 0.151 | 1.83 |
| 0.16 | | 6.7 | 2.47 | 0.159 | 0.74 | 0.25 | 1.02 | **16.4** | | 4.8 | 0.299 | 0.157 | 1.71 |
| *l.s.d.*$_{0.05}$ | | | | | | | | 1.092 | | | | | |
| **GM** | | 6.7 | 2.48 | 0.157 | 0.74 | 0.25 | 1.01 | 15.6 | | 4.9 | 0.301 | 0.153 | 1.77 |
| **Se** | | 0.6607 | 0.0838 | 0.0046 | 0.5413 | 0.0243 | 0.0806 | 1.521 | | 0.3536 | 0.0219 | 0.0452 | 0.1762 |
| **CV %** | | 9.9 | 3.4 | 2.9 | 7.3 | 9.8 | 8.0 | 9.7 | | 7.2 | 7.3 | 29.6 | 10.0 |

The levels of leaflet N (mean 2.5%) and rachis N (mean 0.26); leaflet P (mean 0.154%) and rachis P (mean 0.11%); and leaflet Mg (mean 0.25%) and rachis K (1.77 %) were all adequate.

**Effects of fertilizer treatments on vegetative growth parameters**

The effects of fertiliser treatments on physiological growth parameters are presented in Tables 8 and 9. Generally in 2009, the fertilizer treatments did not have any significant effect on the growth parameters except for AC on leaf area index and bunch dry matter.

**Table 8**. Trial 254, p values of effects of fertilizer treatments on vegetative growth parameters in 2009. P values less than 0.05 are shown in bold.

| Source | | | | | Radiation interception | | | | Dry matter production | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FL | PCS | | FP | FA | LAI | | FDM | BDM | TDM | VDM | | BI |
| AC | | 0.589 | 0.788 | | 0.455 | 0.113 | **0.022** | | 0.927 | **0.018** | 0.270 | 0.968 | | 0.338 |
| MOP | | 0.779 | 0.253 | | 0.972 | 0.446 | 0.687 | | 0.229 | 0.235 | 0.097 | 0.205 | | 0.688 |
| Borate | | 0.719 | 0.450 | | 0.078 | 0.367 | 0.318 | | 0.208 | 0.360 | 0.386 | 0.221 | | 0.134 |
| AC.MOP | | 0.489 | 0.407 | | 0.106 | 0.632 | 0.385 | | 0.219 | 0.299 | 0.536 | 0.239 | | 0.115 |
| AC.Borate | | 0.884 | 0.394 | | 0.949 | 0.564 | 0.340 | | 0.348 | 0.852 | 0.321 | 0.337 | | 0.625 |
| MOP.Borate | | 0.601 | 0.581 | | 0.381 | 0.516 | 0.233 | | 0.418 | 0.224 | 0.137 | 0.370 | | 0.921 |
| CV % | | | | | | | | | | | | | | |

**Table 9.** Trial 254, main effects of fertilizer treatments on the vegetative growth parameters in 2009. P values less than 0.05 are shown in bold

| Source | | | | | Radiation interception | | | | Dry matter production (t/ha/yr) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FL | PCS | | FP | FA | LAI | | FDM | BDM | TDM | VDM | | BI |
| | | | | | | | | | | | | | | |
| AC 4.0 | | 603.7 | 46.0 | | 23.0 | 13.1 | **5.39** | | 14.4 | **17.0** | 34.9 | 17.9 | | 0.49 |
| 8.0 | | 608.1 | 45.2 | | 23.3 | 13.5 | **5.72** | | 14.3 | **18.2** | 36.2 | 17.9 | | 0.50 |
| *l.s.d.*$_{0.05}$ | | | | | | | 0.279 | | | 0.986 | | | | |
| MOP 2.5 | | 604.7 | 47.5 | | 23.1 | 13.4 | 5.58 | | 14.9 | 17.9 | 36.4 | 18.6 | | 0.49 |
| 7.5 | | 607.1 | 43.8 | | 23.1 | 13.2 | 5.53 | | 13.8 | 17.3 | 34.6 | 17.3 | | 0.50 |
| | | | | | | | | | | | | | | |
| Borate 0 | | 605.2 | 43.8 | | 23.0 | 13.2 | 5.55 | | 13.7 | 18.1 | 35.4 | 17.3 | | 0.51 |
| 0.08 | | 602.2 | 48.5 | | 23.7 | 13.6 | 5.69 | | 15.5 | 17.4 | 36.6 | 19.2 | | 0.48 |
| 0.16 | | 610.3 | 44.6 | | 22.7 | 13.1 | 5.43 | | 13.8 | 17.4 | 34.7 | 17.3 | | 0.50 |
| | | | | | | | | | | | | | | |
| **GM** | | 605.9 | 45.6 | | 23.1 | 13.3 | 5.56 | | 14.4 | 17.6 | 35.5 | 17.9 | | 0.49 |
| **Se** | | 28.5 | 11.0 | | 1.207 | 1.028 | 0.477 | | 3.141 | 1.682 | 3.829 | 3.480 | | 0.0400 |
| **CV %** | | 4.7 | 24.2 | | 5.2 | 7.7 | 8.6 | | 21.9 | 9.5 | 10.8 | 19.4 | | 8.0 |

*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 and leaf tissue nutrient concentrations. Muriate of Potash (MOP) also affected yield but negatively in 2007-2009. Borate fertilizer had no impact on yield but significantly increased B concentrations in the leaflets.

# RAMU AGRI-INDUSTRIES

## Trial 601: N x P x K x S fertilizer trial on Immature palms, Gusap (RSPO 4.2, 8.1)

**SUMMARY**
The trial was planted in 2003, and 2009 was the second year of full data collection. The trial received reduced rates of treatment fertilizers from 2003 to 2007. In 2008 and 2009, the trial received full doses of treatment fertilizers. No significant effects or trends of fertilizer treatments could be determined on yield or tissue nutrient contents. Tissue nutrient content appears to be adequate.

**INTRODUCTION**
Oil palm planting started at RAMU in 2003, production has started and the mill opened in 2008. Three factorial fertilizer trials were established for 2003 and 2004 plantings, to assist with determining optimum fertilizer rates for oil palm in this generally drier environment with heavier clay soils. Harvest commenced in June 2007 and the results of two trials (601 and 602), both planted in 2003, are discussed. See Table 1 for background information on the first trial.

**Table 1.** Trial 601 background information (trial 601 was RAI trial RM1-03)

| **Trial number** | **601** | Company | Ramu Oil Palm |
|---|---|---|---|
| Estate | Gusap | Block No. | GN203 |
| Planting Density | 120 palms/ha | Soil Type | Ramu clay |
| Pattern | Triangular | Drainage | Intermediate |
| Date planted | 2003 | Topography | Flat |
| Age after planting | 6 | Altitude | 450 m asl |
| Recording Started | 2007 | Previous Land-use | Grassland |
| Planting material | Dami D x P | Area under trial soil type (ha) | Not known |
| Progeny | Known | Supervisor in charge | Kelly Naulis |

**METHODS**
This trial was planted in November 2003 in block GN203 (Gusap) (previously recorded as Ramu trial RM1-03). A NxKxPxS factorial design with 2 replicates was used (for details of treatments see Table 2) (the trial treatments had 3 rates of N; 3 rates of K, 2 rates of S and 2 rates of P). Sixteen identified progenies were planted in each plot. All the treatments were randomised, including the progenies within plots and the fertilizer treatment plots within each replicate. During the immature phase following planting all treatment plots were fertilised with reduced treatment rates (see PNGOPRA Annual Report 2007). 2009 was the second year with a full application of treatment fertilisers (see Table 2).

**Table 2**. Details treatment fertiliser application in trial 601 (kg per palm) in 2008.

| Fertiliser | Nutrient | Level 1 | Level 2 | Level 3 | Schedule for application |
|---|---|---|---|---|---|
| Urea | N | 0 | 1.5 | 3.0 | (3) March, June, November |
| MOP | K | 0 | 2.4 | 4.8 | (2) April, November |
| TSP | P | 0 | 1 | | (1) April |
| Tiger90 | S | 0 | 0.5 | | (2) April, November |

**RESULTS and DISCUSSION**
Harvest commenced in June 2007. The 2009 and 2008-2009 yield data were analysed using ANOVA.

*Yield*
Effects of fertilisers on yield and its components for 2009 and 2008-2009 are presented in Tables 3 and 4. In 2009, Urea significantly increased the number of bunches (p=0.024) and single bunch weight

(p=0.004) and this caused 3 t/ha increase in yield. In 2008-2009, Urea increased FFB yield (p=0.007) by 2-3 tonnes and this was due to a significant increase in SBW (p=0.008) and an increase BNO (though not significant). TSP only affected BNO in 2009 (p=0.042) and 2008-2009 (p=0.038) and this caused an increase in yield however it was not statistically significant. MOP only affected SBW in 2009 (p=0.001) and 2008-2009 (p=0.008). Tiger S had a positive significant effect on FFB yield (p=0.043) which was due to a significant increase in SBW (p=0.042) and BNO (though not significant) in 2008-2009. The average yield for the trial site for 2009 was 20.5 t/ha, made up of 1601 bunches/ha with a SBW of 12.7 kg.

**Table 3.** Trial 601, p values of fertiliser effects on FFB yield, bunch number and single bunch weight for 2009 and 2008-2009. p values <0.050 are in bold.

| | | **2009** | | | | **2008-2009** | | |
|---|---|---|---|---|---|---|---|---|
| **Source** | | **FFB yield** | **BNO/ha** | **SBW** | | **FFB yield** | **BNO/ha** | **SBW** |
| Urea | | **0.012** | **0.024** | **0.004** | | **0.007** | 0.160 | **0.008** |
| TSP | | 0.079 | **0.042** | 0.816 | | **0.048** | **0.038** | 0.477 |
| MOP | | 0.097 | 0.597 | **0.001** | | 0.170 | 0.853 | **0.008** |
| Tiger S | | 0.079 | 0.158 | 0.140 | | **0.043** | 0.395 | **0.042** |
| Urea.TSP | | **0.038** | **0.032** | 0.689 | | 0.176 | 0.628 | 0.368 |
| Urea.MOP | | 0.870 | 0.301 | 0.235 | | 0.938 | 0.382 | 0.509 |
| Urea.Tiger S | | 0.897 | 0.099 | **0.023** | | 0.650 | 0.740 | **0.042** |
| TSP.MOP | | 0.339 | 0.165 | 0.841 | | 0.827 | 0.521 | 0.747 |
| TSP.Tiger S | | 0.923 | 0.498 | 0.939 | | 0.880 | 0.842 | 0.901 |
| MOP.Tiger S | | 0.082 | 0.120 | 0.405 | | 0.145 | 0.190 | 0.591 |
| CV % | | 17 | 13.8 | 7.8 | | 15.2 | 11.6 | 8.6 |

**Table 4**. Trial 601, main effects of fertilisers on FFB yield, number of bunches and single bunch weight in 2009 and 2008-2009. p values <0.050 are in bold.

| | | **2009** | | | | **2008-2009** | | |
|---|---|---|---|---|---|---|---|---|
| **Treatments (kg/palm)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** |
| Urea 0 | | **18.7** | **1497** | **12.2** | | **16.8** | 1738 | **10.0** |
| 1.5 | | **21.7** | **1639** | **13.2** | | **18.9** | 1785 | **10.8** |
| 3.0 | | **21.1** | **1667** | **12.7** | | **19.3** | 1855 | **10.6** |
| *$l.s.d_{0.05}$* | | *2.026* | *128.6* | *0.575* | | *1.615* | | *0.524* |
| TSP 0 | | 19.8 | **1547** | 12.7 | | 17.7 | **1740** | 10.4 |
| 1 | | 21.2 | **1656** | 12.7 | | 19.0 | **1845** | 10.5 |
| *$l.s.d_{0.05}$* | | | *105.0* | | | | *121.0* | |
| MOP 0 | | 19.2 | 1585 | **12.1** | | 14.5 | 1783 | **10.0** |
| 2.4 | | 21.2 | 1639 | **12.9** | | 18.8 | 1812 | **10.6** |
| 4.8 | | 21.1 | 1580 | **13.2** | | 18.8 | 1783 | **10.8** |
| *$l.s.d_{0.05}$* | | | | *0.575* | | | | *0.524* |
| Tiger S 0 | | 19.8 | 1564 | 12.5 | | **17.7** | 1772 | **10.2** |
| 0.5 | | 21.2 | 1639 | 12.9 | | **19.0** | 1814 | **10.7** |
| *$l.s.d_{0.05}$* | | | | | | *1.319* | | *0.427* |
| GM | | 20.5 | 1601 | 12.7 | | 18.4 | 1793 | 10.5 |
| SE | | 3.496 | 221.7 | 0.991 | | 2.785 | 208.6 | 0.902 |
| CV % | | 17 | 13.8 | 7.8 | | 15.2 | 11.6 | 8.6 |

*Fertiliser effect on tissue nutrient content*

Leaflet and rachis samples were collected in April/May 2009 from each monitored palm and combined for each plot. The samples were analysed by AAR in Malaysia. The effects of fertilisers on tissue nutrient contents are presented in Tables 5 and 6. Urea had significant effects on leaflets N, P, Mg and S, and on rachis ash, N, P and K contents. TSP only affected leaflet B contents. MOP significantly affected leaflet ash, K and Mg, and rachis P. MOP had a negative effect on leaflet K contents. Tiger S affected leaflet ash and P, and rachis N contents.

**Table 5**. Trial 601, p values of treatments on F17 nutrient concentrations in 2009. Effects with p<0.05 are shown in bold.

| Source | Leaflet | | | | | | | Rachis | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Ash** | **N** | **P** | **K** | **Mg** | **S** | **B** | **Ash** | **N** | **P** | **K** |
| Urea | 0.333 | **<0.001** | **0.002** | 0.547 | **0.043** | **<0.001** | 0.651 | **0.019** | **<0.001** | **0.004** | **0.016** |
| TSP | 0.093 | 0.910 | 0.655 | 0.248 | 0.805 | 0.754 | **0.043** | 0.236 | 0.175 | 0.303 | 0.417 |
| MOP | **<0.001** | 0.161 | 0.606 | **<0.001** | **0.027** | 0.285 | 0.943 | 0.750 | **0.025** | **<0.001** | 0.575 |
| Tiger S | **0.018** | 0.897 | **0.002** | 0.524 | 0.826 | 0.398 | 0.795 | 0.075 | **<0.001** | 0.193 | 0.203 |
| Urea.TSP | 0.612 | 0.518 | 0.881 | 0.902 | 0.112 | 0.764 | 0.600 | 0.422 | 0.107 | 0.454 | 0.523 |
| Urea.MOP | 0.703 | **0.002** | **0.033** | 0.915 | 0.635 | **0.019** | **0.021** | **0.002** | 0.081 | 0.533 | **0.038** |
| Urea.Tiger S | 0.074 | 0.681 | **0.003** | 0.966 | 0.963 | 0.070 | 0.052 | 0.084 | **0.030** | 0.142 | 0.072 |
| TSP.MOP | 0.109 | 0.804 | 0.464 | 0.600 | 0.471 | 0.876 | 0.188 | 0.855 | 0.177 | 0.244 | 0.639 |
| TSP.Tiger S | 0.947 | 0.082 | **0.031** | 0.744 | 0.710 | 0.368 | 0.374 | 0.551 | **0.027** | 0.356 | 0.811 |
| MOP.Tiger S | 0.315 | 0.486 | 0.270 | 0.657 | **0.005** | 0.429 | 0.052 | 0.637 | 0.300 | 0.606 | 0.839 |
| CV % | | | | | | | | | | | |

**Table 6**. Trial 601, main effects of treatments on F17 nutrient concentrations in 2009, in units of % dry matter, except for B (mg/kg) (Trial 326). Effects with p<0.05 are shown in bold.

| **Treatments** | | **Leaflet nutrient contents (% DM)** | | | | | | | | **Rachis nutrient contents (% DM)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(kg/palm)** | | **Ash** | **N** | **P** | **K** | **Mg** | **S** | **B (ppm)** | | **Ash** | **N** | **P** | **K** |
| Urea 0 | | 15.7 | **2.57** | **0.152** | 0.68 | **0.31** | **0.18** | 14.7 | | **5.2** | **0.31** | **0.147** | **1.65** |
| 1.5 | | 15.7 | **2.62** | **0.153** | 0.68 | **0.30** | **0.19** | 14.9 | | **5.4** | **0.35** | **0.131** | **1.72** |
| 3.0 | | 15.4 | **2.67** | **0.155** | 0.69 | **0.29** | **0.19** | 14.5 | | **5.5** | **0.36** | **0.125** | **1.77** |
| $l.s.d_{0.05}$ | | | 0.0337 | 0.0018 | | 0.0145 | 0.0046 | | | 0.336 | 0.0155 | 0.0133 | 0.0856 |
| TSP 0 | | 15.4 | 2.62 | 0.153 | 0.69 | 0.30 | 0.18 | **15.1** | | 5.3 | 0.34 | 0.137 | 1.70 |
| 1 | | 15.7 | 2.62 | 0.153 | 0.68 | 0.30 | 0.19 | **14.4** | | 5.4 | 0.33 | 0.131 | 1.73 |
| $l.s.d_{0.05}$ | | | | | | | | 0.706 | | | | | |
| MOP 0 | | **16.3** | 2.61 | 0.154 | **0.73** | **0.30** | 0.19 | 14.8 | | 5.4 | **0.33** | **0.116** | 1.70 |
| 2.4 | | **15.2** | 2.64 | 0.153 | **0.66** | **0.30** | 0.19 | 14.7 | | 5.4 | **0.34** | **0.143** | 1.74 |
| 4.8 | | **15.2** | 2.61 | 0.153 | **0.66** | **0.29** | 0.18 | 14.8 | | 5.3 | **0.35** | **0.143** | 1.70 |
| $l.s.d_{0.05}$ | | 0.4334 | | | 0.0302 | 0.0145 | | | | | 0.0155 | 0133 | |
| Tiger S 0 | | **15.4** | 2.62 | **0.155** | 0.69 | 0.30 | 0.18 | 14.7 | | 5.3 | **0.35** | 0.138 | 1.69 |
| 0.5 | | **15.8** | 2.62 | **0.152** | 0.68 | 0.30 | 0.19 | 14.8 | | 5.5 | **0.32** | 0.130 | 1.74 |
| $l.s.d_{0.05}$ | | 0.3538 | | 0.0014 | | | | | | | 0.0126 | | |
| | | | | | | | | | | | | | |
| GM | | 15.6 | 2.62 | 0.153 | 0.68 | 0.30 | 0.18 | 14.7 | | 5.4 | 0.34 | 0.134 | 1.71 |
| Se | | 0.747 | 0.05814 | 0.0031 | 0.052 | 0.0251 | 0.008 | 1.491 | | 0.410 | 0.0267 | 0.0228 | 0.147 |
| **CV %** | | 4.8 | 2.2 | 2.0 | 7.6 | 8.4 | 4.3 | 10.1 | | 7.6 | 7.9 | 17.1 | 8.6 |

As expected, rachis P content decreased significantly with increasing application of N fertiliser; however it is not clear why increasing rates of MOP decreased leaflet K. The mean values for nutrient levels in the leaflet and rachis (Table 7) indicate that the overall nutrient status for the palms is satisfactory.

**Table 7**. Mean values for nutrients in the leaflet and rachis (trial 601, 2009)

| | Leaflet | Rachis |
|---|---|---|
| N %dm | 2.62 | 0.34 |
| P %dm | 0.153 | 0.134 |
| K %dm | 0.68 | 1.71 |
| Mg %dm | 0.30 | |
| S %dm | 0.18 | |
| B ppm | 14.7 | |

*Fertiliser effects on physiological growth parameters*

The effects of fertilisers on physiological growth parameters measured in 2009 are presented in Tables 8.and 9. 2009 was the first year in which physiological growth parameters were measured. Urea significantly increased frond length, height increment, petiole cross section and dry matter production. TSP increased frond length and vegetative dry matter production only. Tiger S significantly increased frond length, petiole cross section, leaf area index and dry matter production (except bunch dry matter). MOP did not affect any physiological growth parameters. None of the 4 fertilisers had any effect on bunch index however the index was high with a mean of 0.52.

**Table 8**. Trial 601, p values of effects of fertilisers on physiological growth parameters in 2009. p values <0.05 are shown in bold.

| Source | | | | Radiation interception | | | Dry matter production | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FL | HI | PCS | FP | FA | LAI | FDM | BDM | TDM | VDM | BI |
| Urea | **0.014** | **0.042** | **0.006** | 0.068 | 0.548 | 0.355 | **0.002** | **0.009** | **0.003** | **0.002** | 0.059 |
| TSP | **0.033** | 0.867 | 0.070 | 0.399 | 0.705 | 0.491 | 0.053 | 0.083 | 0.055 | **0.043** | 0.243 |
| MOP | 0.450 | 0.894 | 0.358 | 0.845 | 0.419 | 0.481 | 0.339 | 0.110 | 0.133 | 0.263 | 0.186 |
| Tiger S | **0.006** | 0.119 | **0.006** | **0.037** | 0.054 | 0.032 | **0.001** | 0.155 | **0.040** | **0.002** | 0.821 |
| Urea.TSP | 0.094 | 0.148 | 0.130 | 0.344 | 0.176 | 0.642 | 0.259 | 0.069 | 0.070 | 0.158 | 0.145 |
| Urea.MOP | 0.696 | 0.497 | 0.996 | **0.022** | 0.646 | 0.808 | 0.866 | 0.924 | 0.943 | 0.910 | 0.674 |
| Urea.Tiger S | 0.575 | 0.658 | 0.574 | 0.103 | 0.255 | 0.369 | 0.234 | 0.864 | 0.999 | 0.435 | 0.221 |
| TSP.MOP | 0.116 | 0.250 | 0.215 | 0.505 | 0.082 | 0.074 | 0.146 | 0.261 | 0.186 | 0.134 | 0.447 |
| TSP.Tiger S | 0.762 | 0.438 | 0.340 | 0.121 | 0.661 | 0.306 | 0.687 | 0.984 | 0.900 | 0.735 | 0.725 |
| MOP.Tiger S | 0.254 | 0.396 | 0.808 | **0.031** | 0.913 | 0.907 | 0.457 | 0.116 | 0.156 | 0.356 | 0.086 |
| | | | | | | | | | | | |
| CV % | | | | | | | | | | | |

*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**. Trial 601, main effects of fertilisers on physiological growth parameters in 2009. p values <0.05 are shown in bold.

| Source | | | | Radiation interception | | | Dry matter production (t/ha/yr) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | FL | HI | PCS | FP | FA | LAI | FDM | BDM | TDM | VDM | BI |
| | | | | | | | | | | | |
| Urea 0 | **402.6** | **23.5** | **16.9** | 31.5 | 6.1 | 3.24 | **7.3** | **9.7** | **18.8** | **9.2** | 0.51 |
| 1.5 | **416.8** | **27.3** | **18.4** | 31.9 | 6.2 | 3.33 | **8.0** | **11.3** | **21.4** | **10.1** | 0.52 |
| 3.0 | **415.5** | **28.0** | **17.7** | 32.1 | 6.2 | 3.34 | **7.7** | **11.1** | **21.0** | **9.8** | 0.53 |
| $l.s.d_{0.05}$ | 10.3 | 3.69 | 0.898 | | | | 0.376 | 1.109 | 1.529 | 0.504 | |
| TSP 0 | **407.0** | 26.1 | 17.3 | 31.7 | 6.2 | 3.32 | 7.5 | 10.3 | 19.8 | **9.5** | 0.52 |
| 1 | **416.2** | 26.4 | 18 | 31.9 | 6.1 | 3.28 | 7.8 | 11.1 | 21.0 | **9.9** | 0.52 |
| $l.s.d_{0.05}$ | 8.4 | | | | | | | | | 0.412 | |
| MOP 0 | 408.2 | 25.8 | 17.4 | 31.8 | 6.1 | 3.27 | 7.5 | 10.0 | 19.5 | 9.5 | 0.51 |
| 2.4 | 414.7 | 26.3 | 17.6 | 31.8 | 6.1 | 3.28 | 7.6 | 11.1 | 20.8 | 9.7 | 0.53 |
| 4.8 | 411.9 | 26.7 | 18.0 | 31.9 | 6.2 | 3.35 | 7.8 | 11.0 | 20.9 | 9.9 | 0.52 |
| | | | | | | | | | | | |
| Tiger S 0 | **405.5** | 25.1 | **17.1** | 31.6 | 6.1 | **3.24** | **7.4** | 10.4 | **19.7** | **9.4** | 0.52 |
| 0.5 | **417.7** | 27.4 | **18.2** | 32.0 | 6.2 | **3.37** | **7.9** | 11.0 | **21.1** | **10.0** | 0.52 |
| $l.s.d_{0.05}$ | 8.4 | | 0.734 | | | 0.117 | 0.307 | | 1.249 | 0.412 | |
| | | | | | | | | | | | |
| GM | 411.6 | 26.3 | 17.7 | 31.8 | 6.2 | 3.30 | 7.7 | 10.7 | 20.4 | 9.7 | 0.52 |
| Se | 17.8 | 6.369 | 1.550 | 0.925 | 0.390 | 0.247 | 0.649 | 1.913 | 2.639 | 0.870 | 0.0326 |
| **CV %** | 4.3 | 24.3 | 8.8 | 2.9 | 6.3 | 7.5 | 8.5 | 17.9 | 12.9 | 9.0 | 6.3 |

*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)*

**DISCUSSION**

N fertiliser (urea) has started having significant effects on yield components, leaf tissue nutrient concentrations and physiological growth parameters. There were also responses in leaf tissue nutrient contents and physiological growth parameters to TSP, MOP and Tiger S but these effects have not yet translated to yield in 2009.

# Trial 602: N x P x K x S fertilizer trial on Immature palms, Gusap (RSPO 4.2, 8.1)

**SUMMARY**

The trial was planted in 2003, and 2008 was the first year of full data collection. The trial received reduced rates of treatment fertilizers from 2003 to 2007. In 2008 and 2009, the trial received the full dose of treatment fertilizers. No significant effects or trends of fertilizer treatments could be determined on yield however effects are seen on leaf tissue nutrient in 2009. Tissue nutrient content appears to be adequate however the level of zinc in the leaflets could be low and should be further investigated.

**INTRODUCTION**

Oil palm planting started at RAMU in 2003, production has started and the mill opened in 2008. Three factorial fertilizer trials were established for 2003 and 2004 plantings, to assist with determining optimum fertilizer rates for oil palm in this generally drier environment with heavier clay soils. Harvest commenced in June 2007 and the results of two trials (601 and 602), both planted in 2003, are discussed. See Table 1 for background information on the second trial.

**Table 1**. Trial 602 background information (trial 602 was RAI trial RM2-03)

| **Trial number** | **602** | Company | Ramu Oil Palm |
|---|---|---|---|
| Estate | Gusap | Block No. | GN106 |
| Planting Density | 120 palms/ha | Soil Type | Ramu clay |
| Pattern | Triangular | Drainage | Intermediate |
| Date planted | 2003 | Topography | Flat |
| Age after planting | 6 | Altitude | 475 m asl |
| Recording Started | 2007 | Previous Land-use | Grassland |
| Planting material | Dami D x P | Area under trial soil type (ha) | Not known |
| Progeny | Known | Supervisor in charge | Kelly Naulis |

**METHODS**

This trial was planted in November 2003 in block GN106 (Gusap) (previously recorded as Ramu trial RM2-03). A NxKxPxS factorial design with 2 replicates was used (for details of treatments see Table 2) (the trial treatments had 3 rates of N; 3 rates of K, 2 rates of S and 2 rates of P). Sixteen identified progenies were planted in each plot. All the treatments were randomised, including the progenies within plots and the fertilizer treatment plots within each replicate. During the immature phase following planting all treatment plots were fertilised with reduced treatment rates (see PNGOPRA Annual Report 2007). 2008 was the first year with a full application of treatment fertilisers (see Table 2).

**Table 2**. Details treatment fertiliser application in trial 601 (kg per palm) in 2009.

| Fertiliser | Nutrient | Level 1 | Level 2 | Level 3 | Schedule for application |
|---|---|---|---|---|---|
| Urea | N | 0 | 1.5 | 3.0 | (3) March, June, November |
| MOP | K | 0 | 2.4 | 4.8 | (2) April, November |
| TSP | P | 0 | 1 | | (1) April |
| Tiger90 | S | 0 | 0.5 | | (2) April, November |

**RESULTS and DISCUSSION**

Harvest commenced in June 2007. The 2009 and 2008-2009 yield data were analysed using ANOVA.

*Yield - Analysis of Variance*

There were no significant responses to the main effects of fertiliser treatments in 2009 as was reported in 2008 (Tables 3 and 4). The trial is still in the early stage and therefore there are no significant differences between treatments, however there were a number of significant interactions between the different fertilizers. The average yield for the trial site for 2009 was 19.1 t/ha, made up of 1401 bunches/ha with a SBW of 13.5 kg.

**Table 3**. Trial 602, effects (p values) of treatments on FFB yield and its components in 2009 and 2008–2009. p values <0.05 are shown in bold.

| **Source** | | **2009** | | | | **2008-2009** | | |
|---|---|---|---|---|---|---|---|---|
| | | **FFB yield** | **BNO/ha** | **SBW** | | **FFB yield** | **BNO/ha** | **SBW** |
| Urea | | 0.638 | 0.637 | 0.842 | | 0.572 | 0.636 | 0.493 |
| TSP | | 0.544 | 0.706 | 0.449 | | 0.433 | 0.666 | 0.158 |
| MOP | | 0.729 | 0.702 | 0.997 | | 0.757 | 0.788 | 0.864 |
| Tiger S | | 0.260 | *0.231* | *0.513* | | *0.142* | *0.109* | *0.332* |
| Urea.TSP | | 0.995 | 0.930 | 0.634 | | 0.986 | 0.948 | 0.960 |
| Urea.MOP | | 0.068 | *0.080* | 0.185 | | 0.049 | 0.078 | 0.070 |
| Urea.Tiger S | | 0.694 | 0.124 | *0.468* | | *0.781* | *0.534* | 0.482 |
| TSP.MOP | | **0.010** | 0.586 | **0.003** | | **0.017** | 0.146 | **0.002** |
| TSP.Tiger S | | **0.035** | **0.050** | 0.075 | | **0.022** | **0.026** | **0.032** |
| MOP.Tiger S | | 0.179 | 0.462 | **0.015** | | 0.165 | 0.330 | **0.023** |
| | | | | | | | | |
| CV % | | 22.6 | 19.7 | 8.7 | | 23.3 | 19.2 | 9.0 |

**Table 4**. Trial 602, main effects of fertiliser treatments on FFB yield and its components in 2009 and 2007-2009. p values <0.05 are shown in bold.

| **Treatments** | | **2009** | | | | **2008-2009** | | |
|---|---|---|---|---|---|---|---|---|
| **(kg/palm)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** | | **FFB yield (t/ha)** | **BNO/ha** | **SBW (kg)** |
| Urea 0 | | 19.2 | 1405 | 13.5 | | 14.1 | 1230 | 11.0 |
| 1.5 | | 18.5 | 1361 | 13.4 | | 13.2 | 1180 | 10.6 |
| 3.0 | | 19.7 | 1437 | 13.6 | | 14.0 | 1240 | 10.7 |
| | | | | | | | | |
| TSP 0 | | 18.8 | 1389 | 13.4 | | 13.5 | 1205 | 10.6 |
| 1 | | 19.4 | 1413 | 13.6 | | 14.1 | 1229 | 10.9 |
| | | | | | | | | |
| MOP 0 | | 19.3 | 1408 | 13.5 | | 13.9 | 1219 | 10.8 |
| 2.4 | | 18.6 | 1365 | 13.5 | | 13.4 | 1192 | 10.7 |
| 4.8 | | 19.5 | 1431 | 13.5 | | 14.1 | 1239 | 10.8 |
| | | | | | | | | |
| Tiger S 0 | | 19.7 | 1440 | 13.6 | | 14.4 | 1262 | 10.9 |
| 0.5 | | 18.5 | 1362 | 13.4 | | 13.2 | 1172 | 10.7 |
| | | | | | | | | |
| **GM** | | 19.1 | 1401 | 13.5 | | 13.8 | 1217 | 10.8 |
| **Se** | | 4.322 | 275.4 | 1.175 | | 3.219 | 233.9 | 0.968 |
| **CV %** | | 22.6 | 19.7 | 8.7 | | 23.3 | 19.2 | 9.0 |

The average yield improved a lot this year to 19.1 tonnes closer to average yield in Trial 601 (20 tonnes/ha.). The co-efficient of variation of both trials is very high.

*Fertiliser effect on tissue nutrient content*

Leaflet and rachis samples were collected in April/May 2009 from each monitored palm and combined for each plot. The samples were analysed by AAR in Malaysia. The effects of fertilisers on leaf tissue nutrient contents are presented in Tables 5 and 6. Urea increased leaflet P, S and B, and rachis Ash, N and P but lowered rachis K. TSP had no effect on the nutrient contents except on leaflet sulphur. MOP increased rachis K while Tiger S decreased leaflet P contents. Though Urea had significant effects on the leaf nutrient contents, this is yet to translate to yield. The mean values for nutrient levels in the leaflet and rachis show that the overall nutrient status for the palms is satisfactory (Table 7).

**Table 5**. Trial 602, p values of treatments on F17 nutrient concentrations in 2009. Effects with p<0.05 are shown in bold.

| Source | | Leaflet | | | | | | | | Rachis | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Ash** | **N** | **P** | **K** | **Mg** | **S** | **B** | | **Ash** | **N** | **P** | **K** |
| Urea | | 0.214 | 0.092 | **0.007** | 0.598 | 0.340 | **<0.001** | **0.031** | | **0.011** | **<0.001** | **<0.001** | **0.031** |
| TSP | | 0.184 | 0.760 | 0.725 | 0.350 | 0.064 | **0.038** | 0.427 | | 0.141 | 0.069 | 0.946 | 0.054 |
| MOP | | 0.665 | 0.317 | 0.538 | 0.535 | 0.104 | 0.058 | 0.358 | | 0.202 | 0.685 | 0.231 | **0.049** |
| Tiger S | | 0.528 | 0.284 | **0.023** | 0.350 | 0.355 | 0.868 | 0.874 | | 0.311 | 0.113 | 0.082 | 0.552 |
| Urea.TSP | | 0.278 | 0.738 | 0.578 | 0.942 | 0.962 | 0.601 | 0.911 | | 0.947 | 0.183 | 0.736 | 0.533 |
| Urea.MOP | | 0.195 | 0.688 | 0.354 | 0.221 | 0.014 | 0.100 | 0.368 | | 0.983 | **0.014** | 0.470 | 0.865 |
| Urea.Tiger S | | 0325 | 0.461 | 0.870 | 0.115 | 0.189 | 0.703 | 0.591 | | 0.606 | 0.521 | 0.870 | 0.499 |
| TSP.MOP | | 0.462 | 0.591 | 0.878 | 0.282 | 0.673 | 0.476 | 0.799 | | 0.667 | 0.427 | 0.733 | 0.232 |
| TSP.Tiger S | | 0.829 | 0.195 | 0.516 | 0.837 | 0.140 | 0.254 | 0.336 | | 0.051 | 0.712 | 0.357 | 0.073 |
| MOP.Tiger S | | 0.209 | 0.467 | 0.616 | 0.362 | 0.367 | 0.897 | 0.836 | | 0.340 | 0.880 | 0.549 | 0.491 |
| | | | | | | | | | | | | | |
| CV % | | | | | | | | | | | | | |

**Table 6**. Trial 602, main effects of treatments on F17 nutrient concentrations in 2009. Effects with p<0.05 are shown in bold.

| **Treatments** | | **Leaflet nutrient contents (% DM)** | | | | | | | | **Rachis nutrient contents (% DM)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **(kg/palm)** | | **Ash** | **N** | **P** | **K** | **Mg** | **S** | **B (ppm)** | | **Ash** | **N** | **P** | **K** |
| Urea 0 | | 16.5 | 2.58 | **0.155** | 0.56 | 0.28 | **0.189** | **15.0** | | **5.6** | **0.344** | **0.209** | **1.62** |
| 1.5 | | 16.2 | 2.60 | **0.157** | 0.55 | 0.28 | **0.195** | **15.5** | | **5.3** | **0.371** | **0.162** | **1.52** |
| 3.0 | | 16.2 | 2.66 | **0.160** | 0.57 | 0.28 | **0.202** | **16.1** | | **5.4** | **0.407** | **0.152** | **1.60** |
| *l.s.d*$_{0.05}$ | | | | *0.0026* | | | *0.0041* | *0.825* | | *0.216* | *0.0165* | *0.0144* | *0.0765* |
| TSP 0 | | 16.2 | 2.62 | 0.157 | 0.56 | 0.28 | **0.193** | 15.4 | | 5.4 | 0.380 | 0.174 | 1.55 |
| 1 | | 16.4 | 2.61 | 0.157 | 0.55 | 0.27 | **0.197** | 15.7 | | 5.5 | 0.368 | 0.175 | 1.61 |
| | | | | | | | *0.0034* | | | | | | |
| MOP 0 | | 16.4 | 2.62 | 0.160 | 0.57 | 0.27 | 0.200 | 15.9 | | 5.3 | 0.373 | 0.168 | **1.54** |
| 2.4 | | 16.2 | 2.58 | 0.156 | 0.55 | 0.28 | 0.193 | 15.3 | | 5.4 | 0.378 | 0.175 | **1.58** |
| 4.8 | | 16.3 | 2.64 | 0.157 | 0.56 | 0.27 | 0.194 | 15.5 | | 5.5 | 0.371 | 0.180 | **1.63** |
| *l.s.d*$_{0.05}$ | | | | | | | | | | | | | *0.0765* |
| Tiger S 0 | | 16.3 | 2.63 | **0.159** | 0.56 | 0.27 | 0.195 | 15.6 | | 5.5 | 0.379 | 0.180 | 1.59 |
| 0.5 | | 16.2 | 2.60 | **0.156** | 0.56 | 0.28 | 0.195 | 15.5 | | 5.4 | 0.369 | 0.169 | 1.57 |
| *l.s.d*$_{0.05}$ | | | | *0.0021* | | | | | | | | | |
| | | | | | | | | | | | | | |
| GM | | 16.3 | 2.61 | 0.157 | 0.56 | 0.28 | 0.195 | 15.6 | | 5.4 | 0.374 | 0.175 | 1.58 |
| Se | | 0.7118 | 0.1337 | 0.0044 | 0.0447 | 0.0250 | 0.0072 | 1.424 | | 0.373 | 0.0285 | 0.0248 | 0.1319 |
| **CV %** | | 4.4 | 5.1 | 2.8 | 8.0 | 9.0 | 3.7 | 9.2 | | 6.9 | 7.6 | 14.2 | 8.3 |

**Table 7**. Mean values for nutrients in the leaflet and rachis (Trial 602, 2009)

| | **Leaflet** | **Rachis** |
|---|---|---|
| N %dm | 2.61 | 0.374 |
| P %dm | 0.157 | 0.175 |
| K %dm | 0.56 | 1.58 |
| Mg %dm | 0.28 | |
| S %dm | 0.195 | |
| B ppm | 15.6 | |

*Physiological growth parameters.*

The effects of fertilisers on physiological growth parameters in 2009 are presented in Tables 8 and 9. The fertiliser treatments did not have any main effects on the physiological growth parameters in 2009, however there were significant interactions between TSP and MOP/Tiger S on various physiological parameters. The actual data is not presented however the interactions will be monitored over time to see if the interactions are real and if there are reasons for the interactions.

**Table 8**. Trial 602, p values of treatment effects on physiological growth parameters in 2009. Effects with p<0.05 are shown in bold.

| Source | | | | | | Radiation interception | | | | Dry matter production | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FL | HI | PCS | | FP | FA | LAI | | FDM | BDM | TDM | VDM | | BI |
| | | | | | | | | | | | | | | | |
| Urea | | 0.634 | 0.822 | 0.877 | | 0.056 | 0.453 | 0.781 | | 0.481 | 0.669 | 0.634 | 0.594 | | 0.889 |
| TSP | | 0.716 | 0.454 | 0.646 | | 0.782 | 0.407 | 0.490 | | 0.621 | 0.589 | 0.557 | 0.523 | | 0.617 |
| MOP | | 0.506 | 0.394 | 0.757 | | 0.453 | 0.559 | 0.567 | | 0.648 | 0.739 | 0.670 | 0.555 | | 0.723 |
| Tiger S | | 0.302 | 0.378 | 0.569 | | 0.723 | 0.427 | 0.592 | | 0.776 | 0.267 | 0.378 | 0.720 | | 0.114 |
| Urea.TSP | | 0.967 | 0.538 | 0.898 | | 0.757 | 0.956 | 0.994 | | 0.887 | 0.999 | 0.996 | 0.938 | | 0.614 |
| Urea.MOP | | 0.052 | 0.302 | **0.041** | | 0.285 | 0.530 | 0.060 | | **0.047** | 0.063 | 0.064 | 0.064 | | **0.032** |
| Urea.Tiger S | | 0.915 | 0.027 | 0.605 | | 0.295 | 0.830 | 0.977 | | 0.827 | 0.784 | 0.838 | 0.812 | | 0.322 |
| TSP.MOP | | **0.006** | 0.549 | **0.003** | | 0.395 | 0.148 | 0.079 | | **0.005** | **0.014** | **0.008** | **0.005** | | **0.046** |
| TSP.Tiger S | | **0.014** | 0.049 | **0.009** | | **0.028** | 0.257 | 0.246 | | **0.005** | **0.040** | **0.022** | **0.010** | | 0.152 |
| MOP.Tiger S | | 0.697 | 0.955 | 0.707 | | 0.261 | 0.935 | 0.994 | | 0.523 | 0.224 | 0.292 | 0.525 | | 0.133 |
| | | | | | | | | | | | | | | | |
| CV % | | 5.2 | 16.6 | 10.8 | | 3.8 | 12.1 | 16.0 | | 11.5 | 23.4 | 17.8 | 12.6 | | 7.9 |

**Table 9.** Trial 602, main effects of fertiliser treatments on physiological growth parameters in 2009. Effects with p<0.05 are shown in bold.

| Source | | | | | | Radiation interception | | | | Dry matter production (t/ha/yr) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | FL | HI | PCS | | FP | FA | LAI | | FDM | BDM | TDM | VDM | | BI |
| | | | | | | | | | | | | | | | |
| Urea 0 | | 386.1 | 30.2 | 16.4 | | 31.8 | 5.4 | 2.84 | | 7.2 | 9.9 | 19.0 | 9.1 | | 0.51 |
| 1.5 | | 380.7 | 29.3 | 16.4 | | 31.4 | 5.2 | 2.75 | | 7.1 | 9.5 | 18.4 | 8.9 | | 0.51 |
| 3.0 | | 384.1 | 29.8 | 16.6 | | 32.2 | 5.2 | 2.78 | | 7.4 | 10.1 | 19.3 | 9.2 | | 0.51 |
| | | | | | | | | | | | | | | | |
| TSP 0 | | 382.8 | 29.3 | 16.3 | | 31.8 | 5.2 | 2.75 | | 7.2 | 9.7 | 18.7 | 9.0 | | 0.51 |
| 1 | | 384.5 | 30.2 | 16.5 | | 31.8 | 5.4 | 2.83 | | 7.2 | 10.0 | 19.2 | 9.2 | | 0.51 |
| | | | | | | | | | | | | | | | |
| MOP 0 | | 385.5 | 30.4 | 16.6 | | 31.8 | 5.4 | 2.87 | | 7.3 | 9.9 | 19.1 | 9.2 | | 0.51 |
| 2.4 | | 379.7 | 28.6 | 16.2 | | 31.6 | 5.2 | 2.76 | | 7.1 | 9.5 | 18.4 | 8.9 | | 0.51 |
| 4.8 | | 385.7 | 30.3 | 16.5 | | 32.0 | 5.2 | 2.74 | | 7.3 | 10.1 | 19.3 | 9.2 | | 0.52 |
| | | | | | | | | | | | | | | | |
| Tiger S 0 | | 386.1 | 30.3 | 16.6 | | 31.8 | 5.4 | 2.82 | | 7.2 | 10.1 | 19.3 | 9.1 | | 0.52 |
| 0.5 | | 381.2 | 29.2 | 16.3 | | 31.9 | 5.2 | 2.76 | | 7.2 | 9.5 | 18.6 | 9.0 | | 0.50 |
| | | | | | | | | | | | | | | | |
| GM | | 383.6 | 29.8 | 16.4 | | 31.8 | 5.3 | 2.79 | | 7.2 | 9.8 | 18.9 | 9.1 | | 0.51 |
| Se | | 19.93 | 4.928 | 1.783 | | 1.207 | 0.643 | 0.446 | | 0.8311 | 2.300 | 3.361 | 1.145 | | 0.0403 |
| **CV %** | | 5.2 | 16.6 | 10.8 | | 3.8 | 12.1 | 16.0 | | 11.5 | 23.4 | 17.8 | 12.6 | | 7.9 |

*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)*

## DISCUSSION

In the first year after full fertiliser application there are no significant differences in yield from the different fertiliser treatments in this trial. Significant responses with Urea in leaf nutrient contents have not yet not translated to yield and growth parameters.

# Trial 603: N x P x K x S fertilizer trial on Immature palms, Gusap (RSPO 4.2, 8.1)

**SUMMARY**
The trial was planted in 2003, and 2009 was the first year of full data collection. The trial received reduced rates of treatment fertilizers from 2003 to 2008. In 2009 the trial received the full dose of treatment fertilizers. No significant effects or trends of fertilizer treatments could be determined on yield or tissue nutrient contents. Tissue nutrient content appears to be adequate however the level of zinc in the leaflets could be low and should be further investigated.

**INTRODUCTION**
Oil palm planting started at RAMU in 2003, production has started and the mill opened in 2008. Three factorial fertilizer trials were established for 2003 and 2004 plantings, to assist with determining optimum fertilizer rates for oil palm in this generally drier environment with heavier clay soils. Harvest commenced in June 2007 and the results of two trials (601 and 602), both planted in 2003, are discussed. See Table 1 for background information on the second trial.

**Table 1**. Trial 602 background information (trial 602 was RAI trial RM2-03)

| **Trial number** | **603** | Company | Ramu Oil Palm |
|---|---|---|---|
| Estate | Gusap | Block No. | GN106 |
| Planting Density | 120 palms/ha | Soil Type | Ramu clay |
| Pattern | Triangular | Drainage | Intermediate |
| Date planted | 2003 | Topography | Flat |
| Age after planting | 6 | Altitude | 475 m asl |
| Recording Started | 2008 | Previous Land-use | Grassland |
| Planting material | Dami D x P | Area under trial soil type (ha) | Not known |
| Progeny | Known | Supervisor in charge | Kelly Naulis |

**METHODS**
This trial was planted in November 2003 in block GN106 (Gusap) (previously recorded as Ramu trial RM2-03). A NxKxPxS factorial design with 2 replicates was used (for details of treatments see Table 2) (the trial treatments had 3 rates of N; 3 rates of K, 2 rates of S and 2 rates of P). Sixteen identified progenies were planted in each plot. All the treatments were randomised, including the progenies within plots and the fertilizer treatment plots within each replicate. During the immature phase following planting all treatment plots were fertilised with reduced treatment rates (see PNGOPRA Annual Report 2007). 2008 was the first year with a full application of treatment fertilisers (see Table 2).

**Table 2**. Details treatment fertiliser application in trial 603 (kg per palm) in 2009.

| Fertiliser | Nutrient | Level 1 | Level 2 | Level 3 | Schedule for application |
|---|---|---|---|---|---|
| Urea | N | 0 | 1.5 | 3.0 | (3) March, June, November |
| MOP | K | 0 | 2.4 | 4.8 | (2) April, November |
| TSP | P | 0 | 1 | | (1) April |
| Tiger90 | S | 0 | 0.5 | | (2) April, November |

**RESULTS AND DISCUSSION.**

*Yield and yield components.*
Effects of fertilisers on yield and its components are presented in Tables 3 and 4. There was no effect of fertiliser treatments in 2009 however MOP had a significant effect on single bunch weight and while Tiger S also had an effect of single bunch weight and yield in 2008-2009. The mean FFB yield in 2009 was 16.6 t/ha.

**Table 3**. Trial 603. Effects (p values) of treatments on FFB yield and its components in 2009 and 2008-2009. p values <0.05 are shown in bold.

| Source | | 2009 | | | | 2008-2009 | | |
|---|---|---|---|---|---|---|---|---|
| | | FFB yield | BNO/ha | SBW | | FFB yield | BNO/ha | SBW |
| Urea | | 0.109 | 0.111 | 0.728 | | 0.626 | 0.819 | 0.487 |
| TSP | | 0.160 | 0.409 | 0.346 | | 0.134 | 0.304 | 0.071 |
| MOP | | 0.408 | 0.808 | 0.068 | | 0.073 | 0.278 | **0.007** |
| Tiger S | | 0.092 | 0.516 | 0.063 | | **0.049** | 0.329 | **0.014** |
| Urea.TSP | | 0.825 | 0.701 | 0.850 | | 0.860 | 0.876 | 0.915 |
| Urea.MOP | | 0.441 | 0.526 | 0.282 | | 0.120 | **0.049** | 0.306 |
| Urea.Tiger S | | 0.697 | 0.873 | 0.129 | | 0.438 | 0.551 | 0.277 |
| TSP.MOP | | 0.571 | 0.300 | 0.918 | | 0.899 | 0.847 | 0.965 |
| TSP.Tiger S | | 0.071 | 0.082 | 0.287 | | 0.097 | 0.102 | 0.176 |
| MOP.Tiger S | | 0.608 | 0.888 | 0.206 | | 0.375 | 0.172 | 0.169 |
| | | | | | | | | |
| CV % | | 23.7 | 18.4 | 13.3 | | 19.6 | 11.3 | 11.6 |

**Table 4**. Trial 603, main effects of fertiliser treatments on FFB yield and its components in 2009 and 2008-2009. p values <0.05 are shown in bold.

| Treatments (kg/palm) | | 2009 FFB yield (t/ha) | 2009 BNO/ha | 2009 SBW (kg) | | 2008-2009 FFB yield (t/ha) | 2008-2009 BNO/ha | 2008-2009 SBW (kg) |
|---|---|---|---|---|---|---|---|---|
| Urea 0 | | 15.2 | 1633 | 5.5 | | 12.1 | 1635 | 7.3 |
| 1.5 | | 17.0 | 1753 | 5.6 | | 12.6 | 1602 | 7.6 |
| 3.0 | | 17.5 | 1829 | 5.6 | | 12.7 | 1616 | 7.6 |
| TSP 0 | | 15.9 | 1707 | 5.5 | | 12.0 | 1595 | 7.3 |
| 1 | | 17.2 | 1770 | 5.6 | | 12.9 | 1640 | 7.7 |
| MOP 0 | | 15.7 | 1762 | 5.3 | | 11.5 | 1576 | **7.0** |
| 2.4 | | 17.2 | 1748 | 5.6 | | 13.0 | 1661 | **7.7** |
| 4.8 | | 16.8 | 1704 | 5.8 | | 13.0 | 1615 | **7.8** |
| *l.s.d$_{0.05}$* | | | | | | | | 0.507 |
| Tiger S 0 | | 15.8 | 1714 | 5.4 | | 11.9 | 1596 | **7.3** |
| 0.5 | | 17.4 | 1763 | 5.7 | | 13.1 | 1639 | **7.8** |
| *l.s.d$_{0.05}$* | | | | | | | | 0.414 |
| GM | | 16.6 | 1738 | 5.6 | | 12.5 | 1618 | 7.5 |
| SE | | 3.930 | 319.6 | 0.7410 | | 2.442 | 182.5 | 0.874 |
| CV % | | 23.7 | 18.4 | 13.3 | | 19.6 | 11.3 | 11.6 |

*Leaf tissue nutrient contents*

Effects of fertiliser treatments on leaf tissue nutrient concentrations are presented in Tables 5 and 6. Urea significantly increased leaflet N, P and S while MOP significantly affected leaflet Ash, K and B. Tiger S affected leaflet Ash, N, P and S, and rachis N, P and K. TSP did not affect any of the nutrient concentrations. The significant responses in nutrient contents have not yet translated to yield.

**Table 5.** Trial 603, p values of fertiliser effects on F17 nutrient concentrations in 2009, in units of % dry matter, except for B (mg/kg). Effects with p<0.05 are shown in bold.

| Source | | Leaflet | | | | | | | | Rachis | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Ash | N | P | K | Mg | S | B | | Ash | N | P | K |
| Urea | | 0.223 | **0.013** | **0.021** | 0.488 | 0.196 | **0.044** | 0.391 | | 0.373 | 0.099 | 0.935 | 0.434 |
| TSP | | 0.085 | 0.306 | 0.220 | 0.553 | 0.740 | 0.230 | 0.374 | | 0.586 | 0.340 | 0.316 | 0.602 |
| MOP | | **<0.001** | 0.114 | 0.170 | **<0.001** | 0.196 | 0.479 | **0.021** | | 0.571 | 0.513 | 0.215 | 0.660 |
| Tiger S | | **0.002** | **0.030** | **<0.001** | 0.553 | 0.226 | **0.048** | 0.172 | | 0.165 | **0.010** | **0.001** | **0.045** |
| Urea.TSP | | 0.804 | 0.651 | 0.195 | 0.418 | 0.637 | 0.529 | 0.875 | | 0.664 | 0.985 | 0.739 | 0.761 |
| Urea.MOP | | 0.997 | 0.100 | 0.552 | 0.769 | 0.132 | 0.332 | 0.893 | | 0.298 | 0.810 | **0.022** | 0.416 |
| Urea.Tiger S | | 0.433 | 0.528 | 0.256 | 0.822 | 0.335 | 0.400 | 0.437 | | 0.864 | 0.373 | 0.486 | 0.818 |
| TSP.MOP | | 0.892 | 0.807 | 0.642 | 0.418 | 0.207 | 0.912 | 0.317 | | 0.887 | 0.318 | 0.789 | 0.736 |
| TSP.Tiger S | | 0.366 | 0.250 | 0.805 | 0.627 | 0.658 | 0.163 | 0.073 | | 0.277 | **0.032** | 0.234 | 0.163 |
| MOP.Tiger S | | 0.972 | 0.745 | 0.841 | 0.161 | 0.400 | 0.400 | 0.194 | | 0.757 | 0.806 | 0.442 | 0.793 |
| CV % | | | | | | | | | | | | | |

**Table 6**. Trial 603, main effects of treatments on F17 nutrient concentrations in 2009, in units of % dry matter, except for B (mg/kg). Effects with $p<0.05$ are shown in bold.

| **Treatments** | **Leaflet nutrient contents (% DM)** | | | | | | | **Rachis nutrient contents (% DM)** | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **(kg/palm)** | **Ash** | **N** | **P** | **K** | **Mg** | **S** | **B** (ppm) | **Ash** | **N** | **P** | **K** |
| Urea 0 | 14.6 | **2.48** | **0.157** | 0.71 | 0.30 | **0.185** | 12.9 | 4.1 | 0.343 | 0.174 | 1.23 |
| 1.5 | 14.3 | **2.54** | **0.160** | 0.70 | 0.32 | **0.192** | 12.5 | 4.3 | 0.358 | 0.177 | 1.26 |
| 3.0 | 14.5 | **2.55** | **0.160** | 0.70 | 0.31 | **0.194** | 12.9 | 4.3 | 0.364 | 0.179 | 1.29 |
| *l.s.d$_{0.05}$* | | 0.0535 | 0.0024 | | | 0.0067 | | | | | |
| TSP 0 | 14.3 | 2.51 | 0.160 | 0.71 | 0.31 | 0.189 | 12.6 | 4.2 | 0.359 | 0.183 | 1.25 |
| 1 | 14.6 | 2.53 | 0.158 | 0.70 | 0.31 | 0.192 | 12.9 | 4.3 | 0.351 | 0.170 | 1.27 |
| MOP 0 | **15.2** | 2.49 | 0.158 | **0.74** | 0.32 | 0.188 | **13.3** | 4.2 | 0.349 | 0.163 | 1.24 |
| 2.4 | **14.1** | 2.54 | 0.159 | **0.71** | 0.31 | 0.192 | **12.8** | 4.2 | 0.360 | 0.176 | 1.25 |
| 4.8 | **14.0** | 2.54 | 0.160 | **0.69** | 0.30 | 0.191 | **12.2** | 4.3 | 0.357 | 0.191 | 1.28 |
| *l.s.d$_{0.05}$* | 0.3535 | | | 0.0251 | | | 0.731 | | | | |
| Tiger S 0 | **14.2** | **2.50** | **0.161** | 0.70 | 0.31 | **0.187** | 12.6 | 4.2 | **0.366** | **0.198** | **1.22** |
| 0.5 | **14.7** | **2.55** | **0.160** | 0.71 | 0.31 | **0.193** | 13.0 | 4.3 | **0.344** | **0.155** | **1.30** |
| *l.s.d$_{0.05}$* | 0.2887 | 0.0437 | 0.0020 | | | 0.0055 | | | 0.0162 | 0.0256 | 0.0764 |
| GM | 14.5 | 2.52 | 0.159 | 0.70 | 0.31 | 0.190 | 12.8 | 4.3 | 0.355 | 0.177 | 1.26 |
| SE | 0.6100 | 0.0923 | 0.0042 | 0.0434 | 0.0211 | 0.0116 | 1.261 | 0.538 | 0.0342 | 0.0540 | 0.1615 |
| **CV %** | 4.2 | 3.7 | 2.7 | 6.2 | 6.8 | 6.1 | 9.9 | 12.6 | 9.6 | 30.6 | 12.8 |

*Physiological growth parameters*

2009 was the first year of vegetative measurements and the results are presented in Tables 7 and 8. The fertilisers generally had no significant effect on the growth parameters except for Urea on bunch index and Tiger S on frond length, frond production and dry matter production. Because 2009 was the second year of full treatments, no real responses are expected until 2010 and beyond.

**Table 7**. Trial 603, p values of treatment effects on physiological growth parameters in 2009. Effects with $p<0.05$ are shown in bold.

| Source | | | Radiation interception | | | Dry matter production | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FL | PCS | FP | FA | LAI | FDM | BDM | TDM | VDM | BI |
| Urea | 0.367 | 0.108 | 0.132 | 0.184 | 0.384 | 0.330 | 0.105 | 0.382 | 0.527 | **0.032** |
| TSP | 0.164 | 0.494 | 0.165 | 0.161 | 0.260 | 0.351 | 0.179 | 0.155 | 0.267 | 0.173 |
| MOP | 0.111 | 0.751 | 0.599 | 0.719 | 0.616 | 0.609 | 0.484 | 0.535 | 0.610 | 0.397 |
| Tiger S | **0.001** | 0.150 | **<0.001** | 0.306 | 0.211 | **0.015** | 0.074 | **0.020** | **0.011** | 0.567 |
| Urea.TSP | 0.564 | **0.024** | 0.152 | 0.843 | 0.768 | 0.144 | 0.761 | 0.406 | 0.153 | 0.977 |
| Urea.MOP | 0.285 | 0.107 | 0.075 | 0.563 | 0.344 | 0.121 | 0.410 | 0.505 | 0.188 | 0.146 |
| Urea.Tiger S | 0.338 | 0.751 | 0.736 | 0.130 | 0.367 | 0.716 | 0.662 | 0.665 | 0.704 | 0.761 |
| TSP.MOP | 0.941 | **0.034** | 0.437 | 0.965 | 0.982 | 0.054 | 0.658 | 0.381 | 0.073 | 0.405 |
| TSP.Tiger S | 0.271 | 0.076 | 0.871 | 0.507 | 0.283 | 0.119 | 0.080 | **0.048** | 0.079 | 0.279 |
| MOP.Tiger S | 0.084 | 0.995 | 0.135 | 0.872 | 0.767 | 0.807 | 0.578 | 0.642 | 0.790 | 0.567 |
| CV % | | | | | | | | | | |

**Table 8**. Trial 603, p values of treatment effects on physiological growth parameters in 2009. Effects with $p<0.05$ are shown in bold.

| Source | | | Radiation interception | | | Dry matter production (t/ha/yr) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | FL | PCS | FP | FA | LAI | FDM | BDM | TDM | VDM | BI |
| Urea 0 | 385.1 | 18.7 | 31.5 | 5.7 | 2.89 | 8.0 | 7.8 | 17.5 | 9.7 | **0.44** |
| 1.5 | 388.3 | 18.3 | 32.1 | 5.6 | 2.91 | 8.0 | 8.7 | 18.6 | 9.8 | **0.46** |
| 3.0 | 381.9 | 17.3 | 32.1 | 5.4 | 2.79 | 7.6 | 9.0 | 18.4 | 9.4 | **0.48** |
| *l.s.d$_{0.05}$* | | | | | | | | | | 0.0311 |
| TSP 0 | 382.5 | 17.9 | 31.7 | 5.5 | 2.82 | 7.7 | 8.2 | 17.7 | 9.5 | 0.45 |
| 1 | 387.6 | 18.3 | 32.1 | 5.6 | 2.90 | 8.0 | 8.8 | 18.7 | 9.8 | 0.47 |
| | | | | | | | | | | |
| MOP 0 | 379.7 | 17.9 | 31.8 | 5.5 | 2.81 | 7.8 | 8.1 | 17.6 | 9.5 | 0.45 |
| 2.4 | 386.8 | 17.9 | 31.7 | 5.6 | 2.89 | 7.8 | 8.8 | 18.4 | 9.6 | 0.47 |
| 4.8 | 388.7 | 18.4 | 32.1 | 5.5 | 2.88 | 8.0 | 8.6 | 18.5 | 9.9 | 0.46 |
| | | | | | | | | | | |
| Tiger S 0 | **378.8** | 17.7 | **31.3** | 5.5 | 2.81 | **7.6** | 8.0 | **17.3** | **9.3** | 0.46 |
| 0.5 | **391.3** | 18.5 | **32.5** | 5.6 | 2.91 | **8.1** | 8.9 | **19.0** | **10.0** | 0.46 |
| *l.s.d$_{0.05}$* | 7.27 | | 0.550 | | | 0.468 | | 1.362 | 0.568 | |
| GM | 358.1 | 18.1 | 31.9 | 5.5 | 2.86 | 7.9 | 8.5 | 18.2 | 9.7 | 0.46 |
| Se | 15.36 | 2.323 | 1.162 | 0.522 | 0.326 | 0.988 | 2.061 | 2.878 | 1.200 | 0.0537 |
| **CV %** | 4.0 | 12.8 | 3.6 | 9.4 | 11.4 | 12.6 | 24.3 | 15.8 | 12.4 | 11.6 |

*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**

Generally there was no effect of fertilisers on yield and yield components except for MOP and TSP on SBW. However, significant effects are seen in tissue nutrient contents.

# ORO OIL PALM PROJECT: SMALLHOLDER RESEARCH

## Trial 336: Popondetta Smallholder leaf sampling (RSPO 4.2, 8.1)

**OVERVIEW**
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 2009.

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

**SMALL HOLDER LEAF SAMPLING**
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 57 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 (Table 1). 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 P, K and B contents 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 fertilizer application, differences in palm age, negligence of block upkeep and very old palms due for replanting. In essence, the palms are nutritionally very low in nutrients and need inorganic fertilizer inputs especially nitrogen and potassium fertilizers.

**Table 1**. Mean nutrient contents of 57 smallholder blocks in 2009

| **Division** | **Leaflet (% DM, except B ppm)** | | | | | **Rachis (% DM)** | | |
|---|---|---|---|---|---|---|---|---|
| | **N** | **P** | **K** | **Mg** | **B** | **N** | **P** | **K** |
| Aeka (6) | 1.92 | 0.132 | 0.68 | 0.29 | 11.5 | 0.238 | 0.107 | 0.94 |
| Saiho (11) | 2.30 | 0.140 | 0.66 | 0.25 | 14.1 | 0.265 | 0.056 | 0.68 |
| Igora (11) | 2.24 | 0.138 | 0.71 | 0.22 | 12.8 | 0.267 | 0.076 | 0.98 |
| Illimo (11) | 2.15 | 0.143 | 0.59 | 0.26 | 12.8 | 0.254 | 0.143 | 0.75 |
| Sorovi (18) | 2.16 | 0.139 | 0.70 | 0.25 | 13.3 | 0.256 | 0.128 | 1.14 |
| *Range* | 1.59-2.66 | 0.107-0.160 | 0.32-0.87 | 0.15-0.42 | 8.9-18.7 | 0.200-0.330 | 0.039-0.397 | 0.160-1.82 |
| *Grand mean* | **2.17** | **0.139** | **0.67** | **0.25** | **13.1** | **0.258** | **0.105** | **0.96** |
| *Critical value* | *2.45* | *0.145* | *0.65* | *0.20* | *15* | *0.32* | *0.08* | *1.30* |

(..) = number of blocks

**SMALLHOLDER BLOCK ASSESSMENTS**
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. The summarised scores are presented in Table 2

**Table 2**. Smallholder block assessments scores in 2009

| Criteria used for scoring block assessment | Divisions Aeka (6) | Igora (10) | Ilimo (9) | Saiho (7) | Sorovi (18) | Average score |
|---|---|---|---|---|---|---|
| Palm Nutrient Deficiency | 2.0 | 2.0 | 1.6 | 2.0 | 2.1 | **1.9** |
| Ground cover-deficiency | 3.0 | 3.0 | 2.2 | 3.0 | 3.0 | **2.8** |
| LPC | 2.5 | 2.5 | 2.5 | 2.6 | 2.4 | **2.5** |
| Harvest paths | 1.8 | 2.0 | 2.1 | 2.2 | 1.6 | **1.9** |
| Block Std | 3.0 | 3.0 | 1.8 | 3.0 | 3.0 | **2.8** |
| Ganoderma | 3.0 | 3.0 | 2.9 | 3.0 | 3.0 | **3.0** |
| Rat Damage | 3.0 | 3.0 | 2.6 | 2.9 | 3.0 | **2.9** |
| Insect Damage | 3.0 | 2.9 | 2.3 | 2.5 | 3.0 | **2.7** |
| Harvest | 3.0 | 3.0 | 1.5 | 3.0 | 3.0 | **2.7** |
| Pruning <7years | | 2.9 | 2.0 | 2.9 | 2.7 | **2.6** |
| Pruning >7years | 2.0 | 2.0 | 1.6 | 2.0 | 2.2 | **2.0** |
| Frond stack | 2.2 | 2.1 | 2.3 | 2.4 | 1.9 | **2.2** |
| Trunk weeds/ferns | 3.0 | 3.0 | 1.5 | 3.0 | 2.8 | **2.7** |
| Trunk weeds/woods/vines | 2.0 | 2.1 | 1.3 | 2.2 | 2.3 | **2.0** |
| Weed circle | 2.2 | 2.1 | 1.7 | 2.1 | 1.6 | **1.9** |
| Weed-ground cover | 1.8 | 1.7 | 1.8 | 2.0 | 1.9 | **1.9** |

(..) = number of blocks

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 1.9. The low score in nutrient deficiency scoring correlates well with the low nutrient concentrations in the leaflets discussed earlier. Average pruning standards were 2.6 for palms < 7 years and 2.0 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 a score of 3 in all the divisions except for Ilimo Division, (score 1.5). The low harvesting score at Ilimo could be due to stop harvests caused by roads, culverts and bridge problems. Note here that not all blocks do regular harvests, however blocks selected for sampling were blocks that harvest though not necessarily regular.

Insects pests and diseases scored very high (2.7-3.0) implying no major problems with pests and diseases in the blocks. The scoring assessments indicate that there is average and above average scores in agronomic upkeep standards and pests and disease free blocks, nutrient deficiency is common 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 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 fertilizer trials and shown around the trials plots and third was radio broadcasts. No agronomy field inspections were done in 2009.

## FIELD DAYS AND RADIO BROADCASTS

The field days and radio broad casts are organized by OPIC and PNG OPRA attended to these presentations. There was only 1 major field day and 1 radio broadcast organized in 2009 in Popondetta.

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 SOA
- can the fertilizer application be divided into smaller portions
- what is the orange spots/colour on the palm leaves
- production, when and why is the company not giving fertilizers

The main topics presented to growers during field days and radio broadcasts were;

- What is PNG OPRA and its functions
- The Importance of fertilizer, the main type of fertilizer (SOA), main role of SOA in the oil palm production, the rates to apply in immature and mature palms.
- 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.
- Impacts of HIV-AIDS on oil palm production

**CONCLUSION**

Nutrient deficiency is the major factor in most of the assessed blocks.

# Trial 337: Smallholder oil palm and food-crop intercropping demo block, Sangara (RSPO 4.2, 4.8, 6.1, 8.1)

**SUMMARY**

The palms in altered spacings were planted in 2009 and planting of food and tree crops also commenced in 2009. Work is in progress and monitoring of food crops will commence in 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. 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 plantations for the 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 also 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 these trials 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.

**METHOD**

**Table 1**. Block Details

| **Trial number** | **337** | Soil Type | Alluvial flood plain |
|---|---|---|---|
| Block owner | Mr. Standford Safitoa | Drainage | Good |
| Block No. | 050136 | Topography | Flat |
| Location | Sangara-Monge | Altitude | m asl |
| Division | Sorovi | Previous Land-use | Oil Palm |
| Planting Density | (a) 128 | | |
| | (b) | Agronomist in charge: Susan Tomda | |
| Pattern | Triangular | | |
| Date planted | (a) 2008 | | |
| | (b) 2009-2010 | | |
| Planting material | Dami D x P | | |
| | | | |
| Progeny | Mixed Dami DxP | | |
| Recording Started | Not yet | | |

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 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. 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 oil palms in both the normal and altered planting arrangements will receive fertilisers at the smallholder recommended rates.

# 2. ENTOMOLOGY RESEARCH

### HEAD OF SECTION: CHARLES DEWHURST

**SUMMARY**
Although there were fewer pest reports received during 2009, it became increasingly obvious that areas infested were increasing and that as infestation reports increased that the treatment teams were struggling to keep up with the continual new reports. Suffice to say that not every area receiving a PestRec is recommended for treatment, as many are recommended for monitoring during harvest rounds only (see below). PestRecs may subsequently be recommended for further action, including treatment if the pest situation develops.

The planned roll-out of plantation-wide pest monitoring was not undertaken, as it proved impossible with their work schedules for plantations to regularly undertake the survey and specimen collection that was required. OPIC Divisional Managers continued to provide (irregular) 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. Egg samples are routinely dissected and embryo stage development monitored. These results are being collated, as are the results of field collections in a range of localities within WNB. Changes in the structure of the treatment teams is urgently required, as the 2010 season may well continue to develop into a serious situation if treatment is not effectively planned and executed.

**OIL PALM PEST REPORTS RECEIVED (RSPO 4.5, 8.1)**
Seventy-one (71) reports were received from all areas of PNG this year (Fig.1) as compared to the total of 106 for all areas of PNG in 2008 (Fig.2). This was a 33% drop in reports received during the year as compared with reports from 2008, however, as stated in the 2008 report, it is not the total number of reports but the size of the areas involved that will have the economic impact. Areas that were infested are being collated in collaboration with SHA and OPRS, and will be presented in a subsequent report.

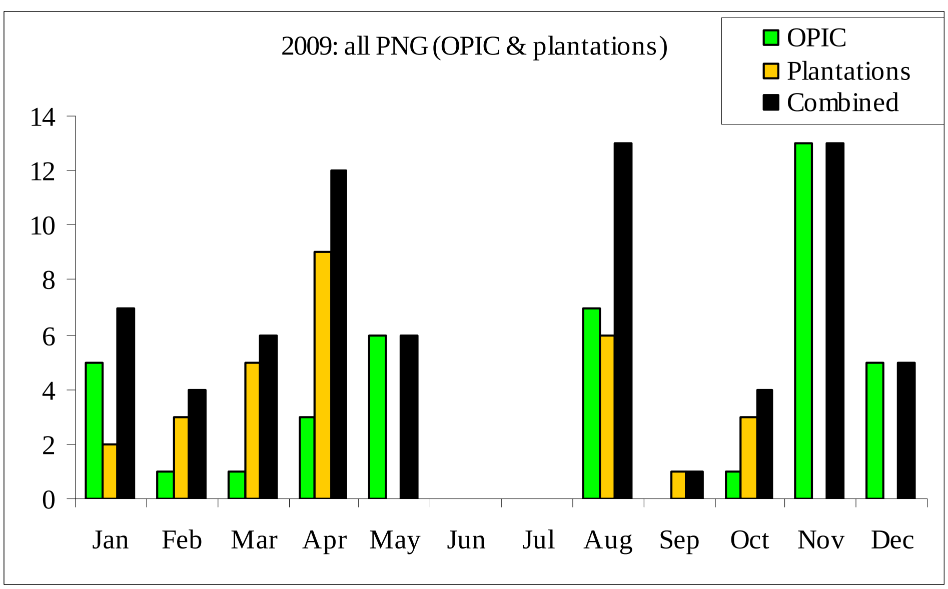



**Figure 1**: Pest infestation reports: PNG (all plantations and smallholders).

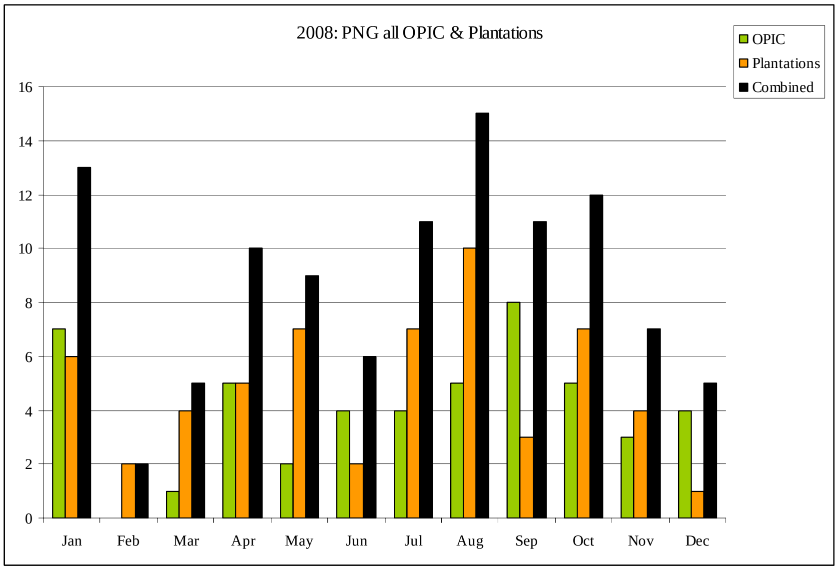



**Figure 2**: 2008 Pest infestation reports: PNG (all plantations and smallholders), for comparison.

### On mainland PNG

There were 4 reports of pest infestations in 2009 as compared to six (6) reports in 2008, with equal numbers reported from smallholder blocks (through OPIC) & plantations (Fig.3).
There were no treatment recommendations made for any of the infestations of either sexava (*Segestidea novaeguineae*) or stick insect (*Eurycantha insularis*) from the mainland during the year.

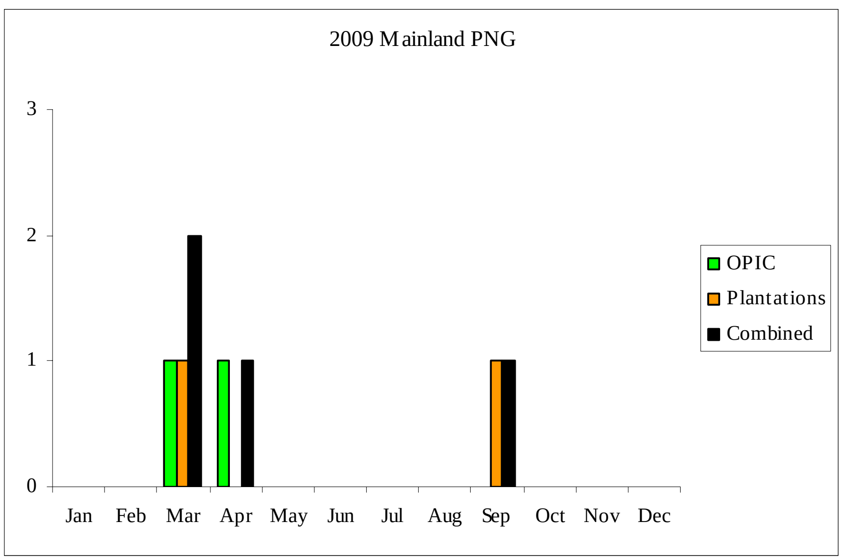



**Figure 3**: Pest infestation reports: Mainland PNG:

### New Ireland

There was one pest report received from New Ireland in August 2009, however, no specimens were collected, and this infestation was not visited by OPRA entomology, although P.Simin (PNGOPRA, Agronomy) reported the infestation, which is therefore considered a correct report.  It was recommended for (careful) monitoring at that time.

**West New Britain**
Of the 71 pest infestation reports through OPIC and plantations received from within PNG during the year, 66 (93%) were received from West New Britain (Fig.4). This was a reduction in infestations reported when compared with the previous year (n=95) (Fig.5).
During June, July and September there were no reported infestations. There were four periods of increased reports in January, April, August and November. In 2008, there were fewer reports, although the pattern of reports and seasonality were similar, although there were infestations being reported in every month in 2008.

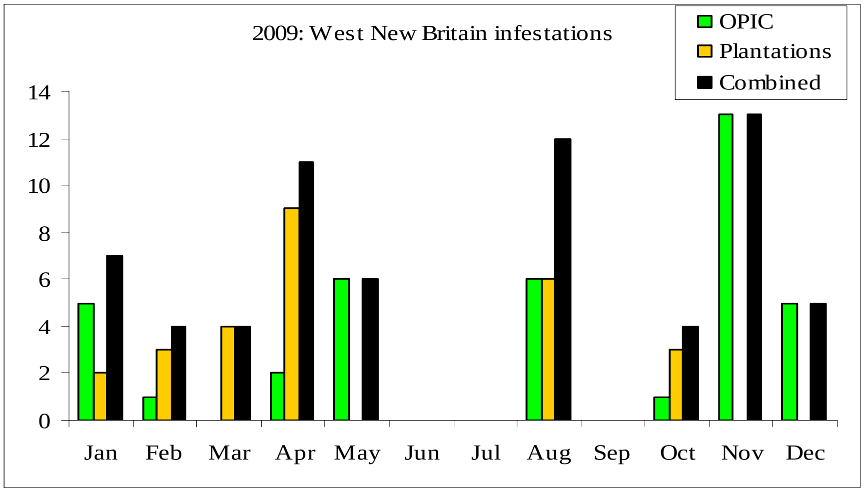



**Figure 4**: Infestation reports: West New Britain 2009. (at the same scale as for 2008-see below).

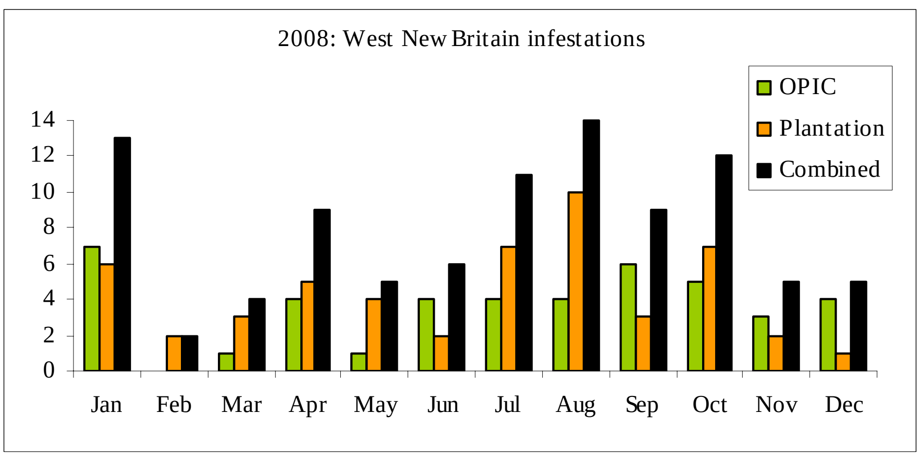



**Figure 5**: Infestation reports: West New Britain 2008 for comparison.

**PEST TAXA RECORDED IN 2009 (RSPO 4.5, 8.1)**
Table 1 is a summary of the infestation reports received from all of PNG from which infestation report data and pest incidences are taken from the entire PID (Pest Infestation Database), while Figures.6-7 show that pest reports were still dominated by "sexava" (*S.decoratus* and *S.defoliaria*), while *S.novaeguineae* was only reported from a single infestation on mainland PNG. *S.defoliaria* replaced *S.decoratus* as the dominant species recorded, while *E.calcarata*, although commonly recorded in all reports was rarely the dominant species. The stick insect, *E.horrida*, is a very similar looking insect to *E.calcarata*, was reported to occur in West New Britain in 1972 (R Straatman *in litt*. P.Brock) has not been recorded by us from any of the thousands of stick insects collected by PNG-OPRA entomology, except from the mainland, where it

was only occasionally recorded. Bagworms (Lepidoptera: Psychidae) were reported only from plantations this year (Fig.6 & Fig.9).

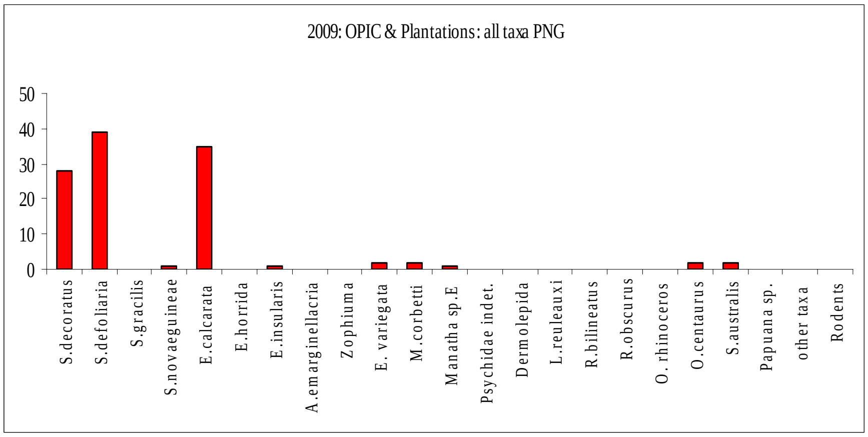



**Figure 6:** 2009 Pest taxa reported: PNG all plantations and smallholders (through OPIC).

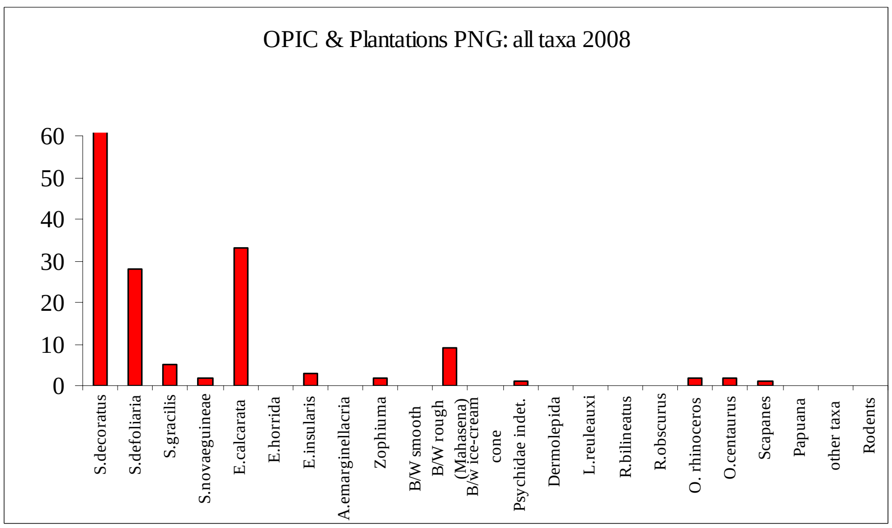



**Figure 7**: 2008 Pest taxa reported: PNG all plantations and smallholders (through OPIC).

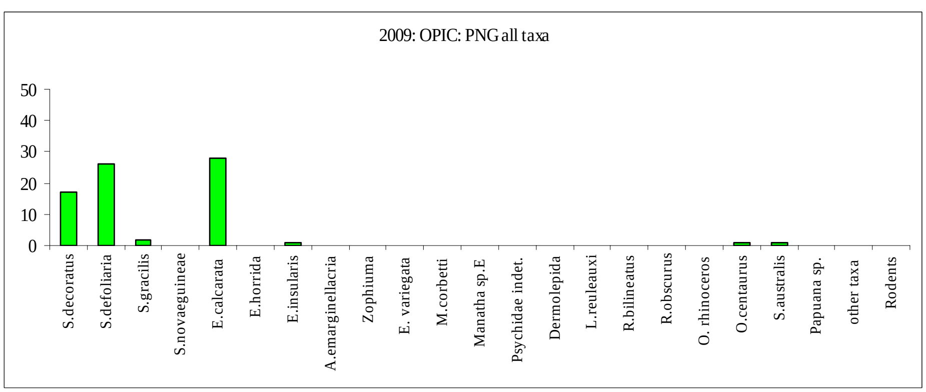



**Figure 8**: 2009 Pest taxa reported from smallholders through OPIC.

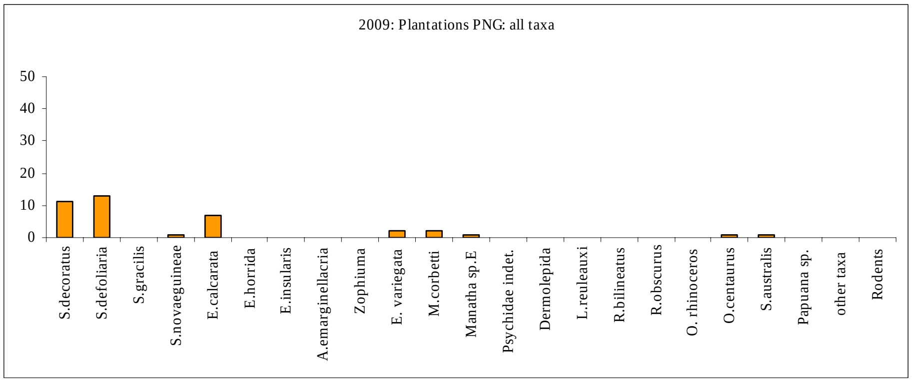



**Figure 9**: 2009 Pest taxa reported from Plantations.

**Table 1**: Summary list of infestations in PNG during 2009

| Report number | Location details | Group/ Division name | Date report issued by PNGOPRA | Main pest (s) |
|---|---|---|---|---|
| 0109 | Bebere Plantation | Mosa | 15-January-2009 | *S.decoratus* |
| 0209 | Sarakolok LSS | Nahavio | 21-January-2009 | *S.decoratus* |
| 0209 | Sarakolok LSS | Nahavio | 21-January-2009 | *S.decoratus* |
| 0309 | Sarakolok LSS | Nahavio | 16-January-2009 | *S.decoratus* |
| 0409 | Mosa VOP | Kavui | 27-January-2009 | *S.decoratus, S.defoliaria* |
| 0509 | Kavui LSS | Kavui | 27-January-2009 | *S.decoratus, S.defoliaria* |
| 0609 | Bebere Plantation | Mosa | 27-January-2009 | *S.decoratus* |
| 0709 | Bebere Plantation | Mosa | 11-February-2009 | *E.variegata, M.corbetti* |
| 0809 | Soi LSS | Bialla | 17-February-2009 | *S.defoliaria, E.calcarata* |
| 0909 | Navo | SIPEF | 17-February-2009 | *S.defoliaria, E.calcarata* |
| 1009 | Bebere Plantation | Mosa | 02-March-2009 | *S.decoratus, S.defoliaria, E.calcarata* |
| 1109 | Volupai | Mosa | 18-March-2009 | *S.decoratus* |
| 1209 | Volupai | Mosa | 18-March-2009 | *S.decoratus* |
| 1309 | Lotomgam Plantation | Mosa | 18-March-2009 | *S.decoratus, S.defoliaria* |
| 1309 | Natupi | Mosa | 18-March-2009 | *S.decoratus* |
| 1409 | Bilomi | Kapiura | 09-April-2009 | *S.defoliaria* |
| 1509 | Igora VOP | Igora | 28-March-2009 | *E.insularis* |
| 1609 | Embi | Higaturu | 29-March-2009 | *S.novaeguineae* |
| 1709 | Kavui LSS | Kavui | 10-April-2009 | *S.decoratus* |
| 1809 | Kautu Plantation | Kapiura | 09-April-2009 | *S.defoliaria* |
| 1909 | Siki LSS | Siki | 14-May-2009 | *S.decoratus* |
| 2009 | Alaba | SIPEF | 30-April-2009 | *S.defoliaria* |
| 2009 | Gilo | SIPEF | 30-April-2009 | *S.defoliaria* |
| 2009 | Northern | SIPEF | 30-April-2009 | *S.defoliaria* |
| 2009 | Magalona | SIPEF | 30-April-2009 | *S.defoliaria* |
| 2009 | Novunebea | SIPEF | 30-April-2009 | *S.defoliaria* |
| 2009 | Mumata | SIPEF | 30-April-2009 | *S.defoliaria* |
| 2009 | Mata-natu | SIPEF | 30-April-2009 | *S.defoliaria* |
| 2209 | Isiveni | Oro | 01-May-2009 | *O.centaurus* |
| 2109 | Kapore | Nahavio | 14-May-2009 | *S.decoratus, S.defoliaria, E.calcarata* |
| 2309 | Tamba LSS | Nahavio | 23-May-2009 | *S.decoratus, S.defoliaria, E.calcarata* |
| 2409 | Tamba LSS | Nahavio | 05-June-2009 | *S.decoratus, S.defoliaria, E.calcarata* |
| 2509 | Kavui LSS | Nahavio | 05-June-2009 | *S.decoratus, S.defoliaria, E.calcarata* |
| 2609 | Mandopa VOP | Nahavio | 05-June-2009 | *S.decoratus, S.defoliaria, E.calcarata* |
| 2709 | Buvussi LSS | Buvussi | 05-June-2009 | *S.decoratus, S.defoliaria, E.calcarata* |
| 2809 | Koimumu VOP | Siki | 13-August-2009 | *S.defoliaria* |
| 2909 | Lavege VOP | Salelubu | 13-August-2009 | *S.decoratus, E.calcarata* |
| 3009 | Bebere Plantation | Mosa | 13-August-2009 | *S.decoratus* |

| | | | | |
|---|---|---|---|---|
| 3109 | Daliavu Plantation | Numundo | 13-August-2009 | *S.decoratus, E.calcarata* |
| 3209 | Haella Plantation | Numundo | 13-August-2009 | *S.decoratus, E.calcarata* |
| 3309 | Tili ME | Numundo | 13-August-2009 | *S.defoliaria, E.calcarata* |
| 3409 | Banaule VOP | Kavui | 18-August-2009 | *S.decoratus, E.calcarata* |
| 3509 | Buluma VOP | Kavui | 18-August-2009 | *S.decoratus, E.calcarata* |
| 3609 | Malilimi Plantation | Kapiura | 20-August-2009 | *S.defoliaria, E.calcarata* |
| 3709 | Kautu Plantation | Kapiura | 28-August-2009 | *S.defoliaria, E.calcarata* |
| 3809 | Mandopa VOP | Kavui | 01-September-2009 | *S.decoratus, S.defoliaria, E.calcarata* |
| 3909 | Kavui LSS | Kavui | 01-September-2009 | *S.decoratus, S.defoliaria, E.calcarata* |
| 4009 | Ambogo Estate | Oro | 02-October-2009 | *E.variegata, M.corbetti, Manatha sp.E* |
| 4209 | Bebere Plantation | Mosa | 13-October-2009 | *S.decoratus, S.defoliaria* |
| 4309 | Lavu Estate, Sale | Bialla | 18-November-2009 | *S.defoliaria, E.calcarata* |
| 4309 | Lavu Estate, Sale | Bialla | 18-November-2009 | *S.defoliaria, E.calcarata* |
| 4409 | Ibana Estate | SIPEF | 09-November-2009 | *S.australis* |
| 4509 | Navo Plantation | SIPEF | 24-October-2009 | *S.defoliaria* |
| 4609 | Bereme VOP | Salelubu | 18-November-2009 | *S.defoliaria, E.calcarata* |
| 4709 | Sabaltapun VOP | Salelubu | 18-November-2009 | *S.defoliaria, E.calcarata* |
| 4809 | Malele VOP | Salelubu | 18-November-2009 | *S.defoliaria, E.calcarata* |
| 4909 | Rerenge VOP (no map) | Salelubu | 18-November-2009 | *S.decoratus, E.calcarata, S.australis* |
| 5009 | Lavege VOP | Salelubu | 07-December-2009 | *S.decoratus, S.defoliaria, E.calcarata* |
| 5109 | Noau VOP | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |
| 5209 | Mumata Estate | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |
| 5309 | Novunabea Estate | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |
| 5409 | Alaba Estate | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |
| 5509 | Magalona Estate | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |
| 5609 | Gamupa VOP | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |
| 5709 | Kilangale VOP | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |
| 5809 | Sale VOP | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |
| 5909 | Noau VOP | Bialla | 30-December-2009 | *S.gracilis, E.calcarata* |
| 6009 | Kabaiya LSS | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |
| 6109 | Soi LSS | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |
| 6209 | Tiauru LSS | Bialla | 30-December-2009 | *S.defoliaria, E.calcarata* |

**RAINFALL RECORDS (RSPO 4.5, 8.1)**

Rainfall and rain days continue to be recorded at many sites, in WNB, NI and on the mainland, by the oil palm companies. Although correlation between rainfall/rain days and subsequent infestations requires further detailed analysis, the association between rainfall and infestations are far from clear at this time.

Figure 10 illustrates the monthly rainfall recorded at OPRS, Dami from 2007-2009. During 2007, after more than 400mm per month was recorded for the first three months, rainfall dropped until a second increase was recorded in November. After a clear peak early in 2008, there was a drop in rainfall later in the year, indicating a lengthy dry period. 2008 also showed a rise in infestation reports during the year (see 2008 Annual Report for comparison). In 2009, there were continual periods of rain early in the year with regular rainfall (albeit at a low level) for the remainder of 2009. There were no recorded "dry" periods with less than 120mm excess Critical Evapotranspiration (E.T.) per month (R Jordan-Som, pers.comm.), although July 2007, September 2008 and October 2009 approached levels (Fig.10). Any relationship between rain days and subsequent infestations was not apparent (Fig.11).

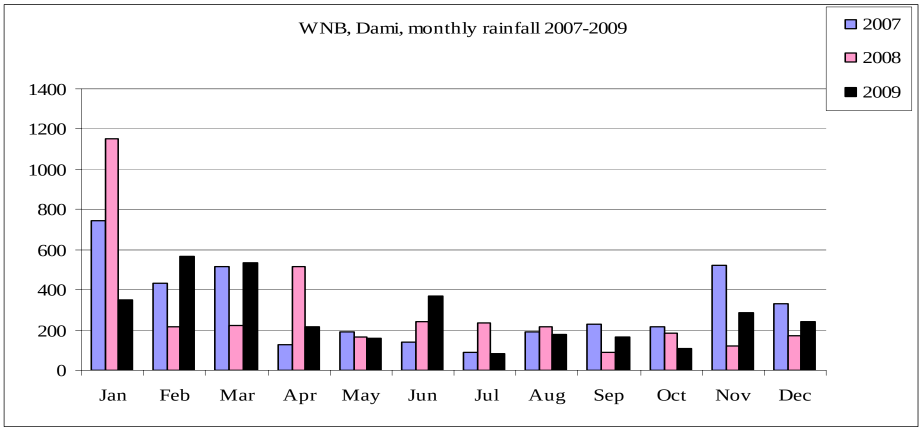



Figure 10: Rainfall at Dami Oil Palm Research Station from 2007-2009. (Adapted from original data: OPRS).

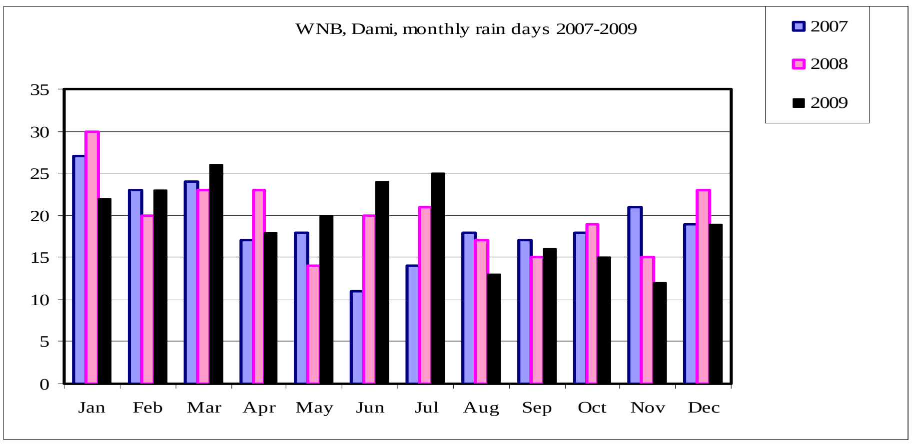



**Figure 11**: Rain days recorded from Dami (2007-2009). (Adapted from original data: OPRS).

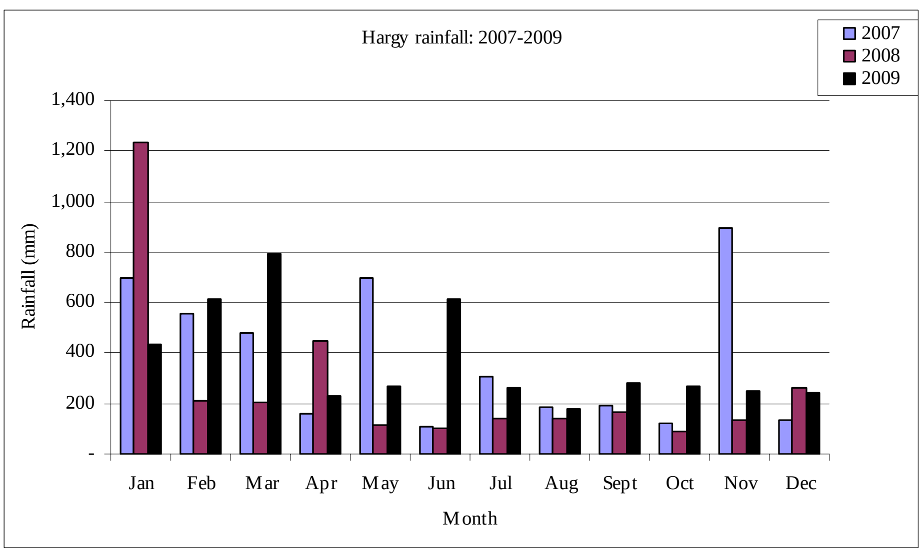



**Figure 12**: Hargy Oil Palms rainfall 2007-2009. (Adapted from original data: Hargy Oil Palms).

At Hargy, 2007 was characterised by three periods of good rainfall, (January, May and November), while 2008, apart from good rain in January and April, the year recorded low rainfall. During 2009, rainfall decreased substantially after June. Rainfall at Navo tailed off a similar pattern to that recorded at Hargy (Fig.13).

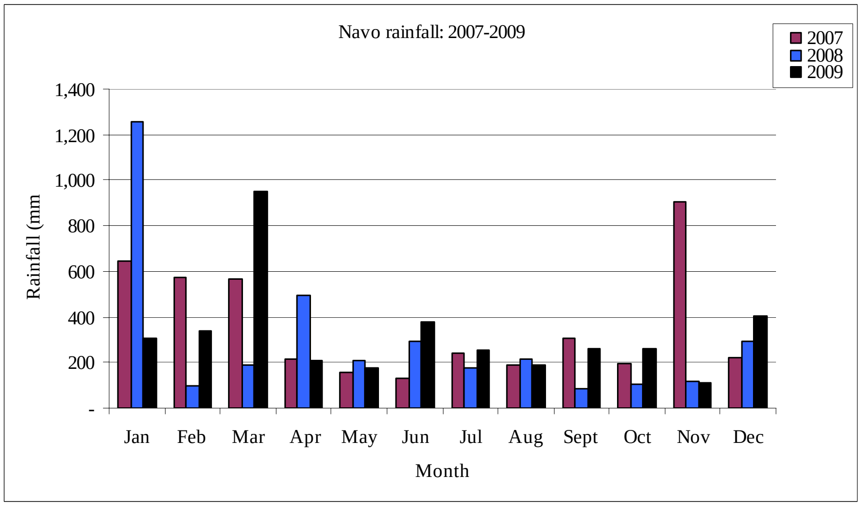



**Figure 13**: Navo Estate, (Hargy Oil Palms), rainfall 2007-2009. (Adapted from original data: Hargy Oil palms).

In Northern (Oro) Province, Ambogo Estate, poor rainfall was only received during in February, April, June & July 2007, there were no low rainfall periods during 2008 (Fig. 14), (<100mm rainfall, C. Lee, pers.comm.) but 100mm or less was recorded in February, April, and September 2009, however none of these dry periods was subsequently followed by any large increase in pest infestations, although bagworm infestations were reported in September and October at Light levels of infestation. *S.novaeguineae*, and all pest sexava in PNG favour wetter periods, so the drier months would not be expected to encourage population increases, even with continual egg laying and with eggs entering diapause, however the good rains of January and November did also not result in any subsequent noticeable population increases.

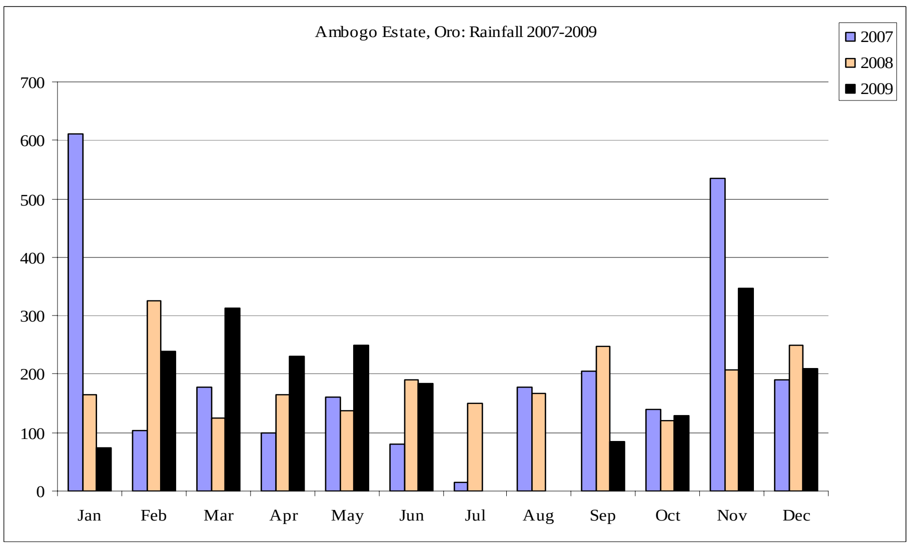



**Figure 14**: Rainfall recorded from Ambogo Estate, Northern (Oro) Province 2007-2009. (Adapted from original data: M Barnabas).

**Rainfall recorded in New Ireland.**

All these three sites show very similar patterns of rainfall distribution, although there was less recorded from Maramakas, although a July peak in 2009 was obvious at all sites (Figs.15-17). Higher rainfall was recorded during the 1st quarter of the year, with another slight rise in November 2007, however there was a pronounced peak in rainfall during July 2009 at all three sites which would have provided good conditions for embryo development and hatching may be a possible precursor to a rise in infestations that could arise during next year (2010).

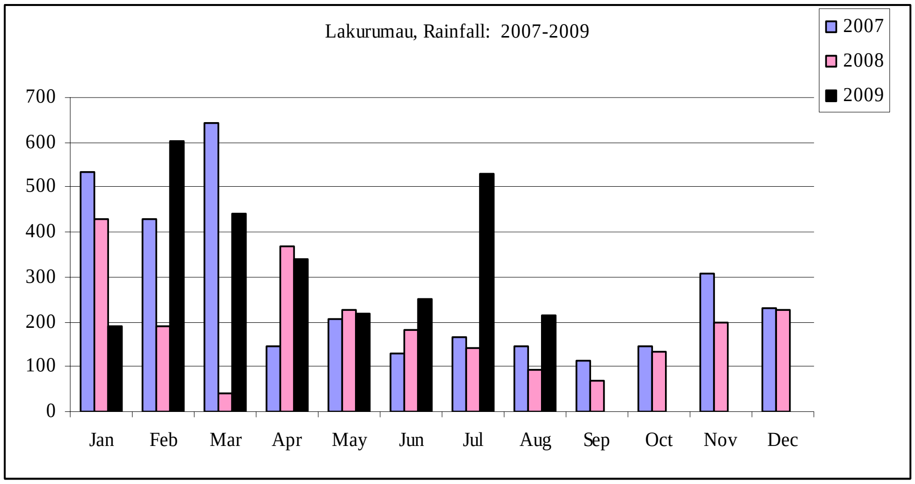



**Figure 15**: Rainfall at Lakurumau during 2007-2009. (Adapted from original data: CTP-TSD).

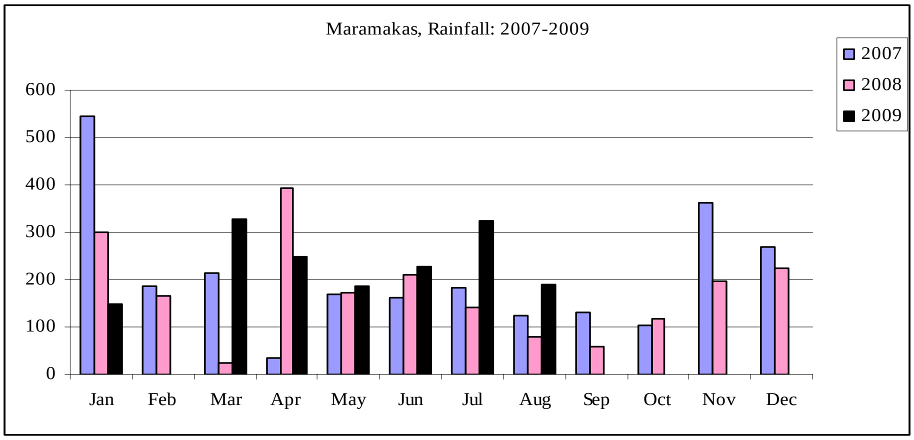



**Figure 16**: Rainfall at Maramakas (New Ireland) during 2007-2009. (Adapted from original data: CTP-TSD).

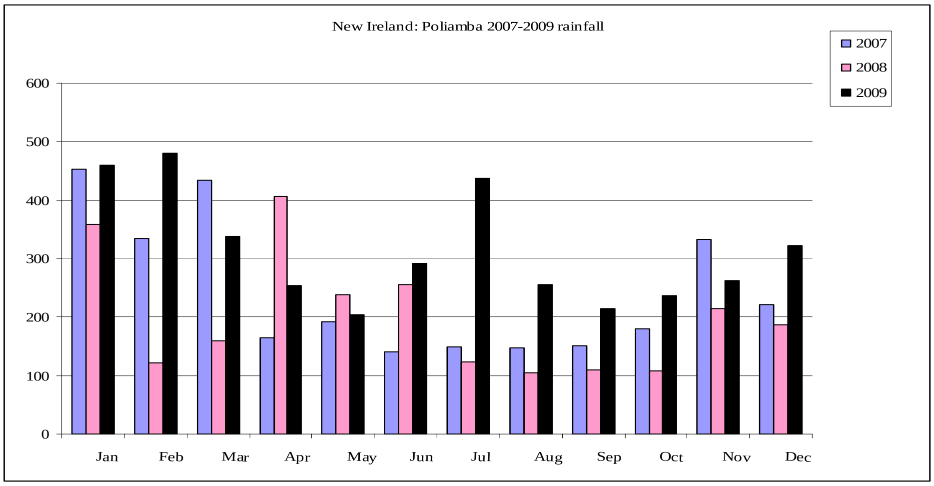



**Figure 17**: Rainfall at Poliamba (New Ireland) during 2007-2009. (Adapted from original data: CTP-TSD).

**REARING OF "SEXAVA" AND STICK INSECTS (RSPO 4.5, 8.1)** (D Putulan).
Four new large moveable wooden cages were built to replace the old cages, as some of the old cages were rotting and were unsafe to use. Two large green shade houses were also built to accommodate different experiments that are being carried out for "sexava".

**Rearing nymphs.**
During non-outbreak periods, it was often difficult to obtain adult "sexava" for experimental purposes and to maintain stock of all stages. "Sexava" can be difficult to collect in the field as they hide deep in the spear cluster during the day, and the sharp remnants and spines on basal leaflets and fronds makes it risky to reach into the spear cluster. 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. Larger cages were built to minimize handling, which has been demonstrated over the years to cause high mortality. The cages were covered partly with black plastic to increase humidity. Young oil palm seedlings and coconut seedlings are put into the cage for nymphs to feed on. Survival has increased and we expect that in several months time, we will have adequate number of "sexava" coming out of cage rearing alone. Rearing of nymphs will also help us elucidate specific microclimates and habitats that influence the survival of the immature stages. Continual attacks by ants causes nymphal mortality, especially when they are moulting.

**Maintenance of adults *"sexava"* and *Eurycantha* (stick insects)**
Maintenance of insects are ongoing for experimental purposes (mainly for insecticide trials) and for providing eggs for rearing experiments. Populations of adults are constantly replenished or boosted by field trips to hunt for "sexava" and stick insects. As rearing of nymphs improves, the need for "hunting" will decrease.

**TARGETED TRUNK INJECTION (TTI) (RSPO 4.5, 4.6, 8.1)**
The organisation for the treatment of oil palm pests in WNB is split between plantations, where each Group of plantations has its own team, managed internally, and Smallholder Affairs (SHA) team, which is managed by NBPOL. SHA is responsible for all treatment of smallholder infestations. Plantations and smallholder affairs require a PNGOPRA Pest Recommendation (PestRec) before they are permitted to undertake targeted trunk injection (TTI) of the palms.

**TTI in West New Britain**
NBPOL Smallholder Affairs Department (SHA) is responsible for undertaking the treatment of all smallholder blocks within the NBPOL areas recommended for treatment by PNGOPRA. All TTI carried out in oil palm during 2009 was done in West New Britain. 4,413ha were treated on smallholder blocks during 2009 (Tables 2A & 2B), with Kavui and Buvussi Divisions responsible for most reports (Table 2B, Table 4 & Fig.18).

The data from SHA shows that in WNB the OPIC Divisions of Kavui and Buvussi both of which are very close to one another required 73% of the TTI input to treat primarily the two main species of "sexava" (*S.decoratus & S.defoliaria*). During 2009, there was a build up of infestation reports later in the year, and, at the weekly IPM meeting held with OPIC (Hoskins Project), we raised concerns that the treatment of infestations was lagging behind the infestations that were recommended for treatment. The original strategy discussed at the weekly meetings for attacking "hot-spots" may require revising subsequently if the current treatment efforts and teams are insufficient to keep on top of the infestations.

Second treatments that were required were seldom followed up due to a lack of staff and in some cases equipment. Areas treated during 2009 are given for both the Hoskins (Table 2A & 2B) and Bialla (Table 3) OPIC Project areas. Smallholder blocks were also treated but at under 17ha during the year.
No insect pest control operations were undertaken in Northern (Oro) Province against oil palm pests.

**Table 2 A&B**: 2009: *Estimated* hectares for treatment using TTI by SHA smallholder teams in both OPIC Projects in West New Britain. (Original data: SHA).

**A-** Hoskins Project – estimated hectares treated.

| Nahavio Division | Kavui Division | Buvussi Division | Siki Division | Salelubu Division | TOTAL Ha treated |
|---|---|---|---|---|---|
| 1,880 | 560 | 1,356 | 544 | 16 | **4,356** |

**B**: 2009: *Actual* hectares treated.

| Nahavio Division | Kavui Division | Buvussi Division | Siki Division | Salelubu Division | Total |
|---|---|---|---|---|---|
| 414 (413.54) | 1,395 (1394.87) | 1,850 (1840.99) | 747 (746.81) | 18 (17.57) | **4,413.78** |

**Table 3:** 2009 Areas treated (ha) in Bialla Project. (Original data: OPIC, Bialla).

| Malasi (Talutu Estate) | Malase (Lavu Estate) | Sale | **Total ha. treated** |
|---|---|---|---|
| 2.85 | 11.61 | 2.15 | 16.61 |

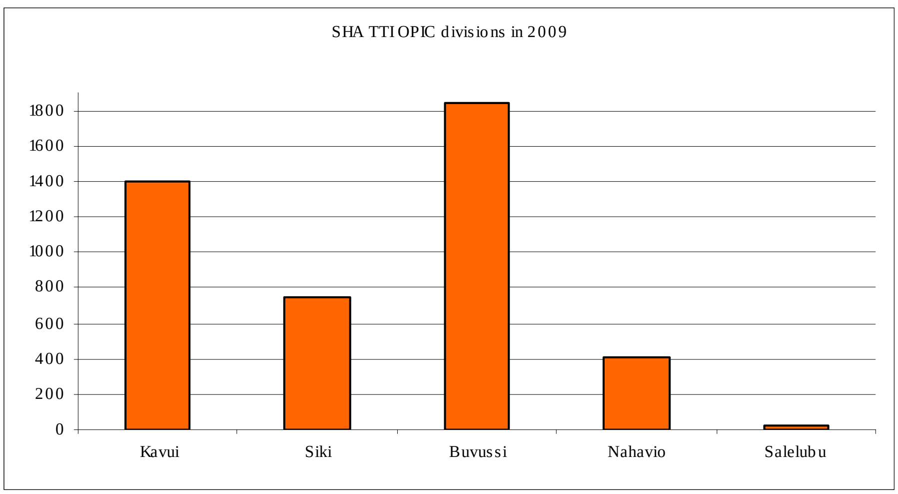



**Figure 18**: OPIC smallholder Divisions treated in West New Britain using TTI (all smallholders). (Adapted from original data: SHA). No TTI undertaken on mainland.

**Table 4**: Hectares requiring TTI on NBPOL Plantations in WNB in 2009. (Adapted from original data: OPRS).

| No. of PestRecs. recommending TTI | Ha. treated | % of recommendations made requiring treatment |
|---|---|---|
| 23 | 1,704.8 | 27.7 |

Hargy Oil Palms also had to treat significant areas of oil palm during the year, although there was only a small increase of 3.8% (Table 5).

**Table 5**. Hectares of oil palm treated by Hargy Oil Palms in 2009, compared with 2008.

| **2008** | **2009** | Increased **ha** treated over previous year |
|---|---|---|
| 1,387.6 | 1,440 | 52.4 |

(Adapted from original data: Hargy Oil Palms).

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

**New Ireland**
There was no control against insect pests undertaken during 2009.

**DESTRUCTIVE PALM SAMPLING (DPS) (RSPO 4.5, 8.1)** (D.Woruba).
The main pests of oil palm are nocturnal, which makes the process of monitoring during sampling very difficult. In plantations, when replanting is due to take place, the old palms are felled mechanically and the fallen palms are windrowed before being overgrown with planted cover crop. To investigate other sampling options it was decided to remove all fronds from a sample of palms before they were felled, and to record the presence of all important pest taxa found on those fronds. An initial analysis was undertaken, however after receiving advice from a biometrician (G Simbahan, pers.comm.), it was decided to re-analyse the data.

**ECONOMIC MONITORING (FFB PRODUCTION) (RSPO 4.5, 8.1)**
Although these data have been analysed from the smallholder blocks at Tunana (Northern (Oro) Province), there does not, on further analysis, appear to be any significant difference in the FFB productivity from the infested blocks. The histogram re-produced in the previous annual report must be regarded as erroneous, as there were errors in the source data. Monitoring of these blocks will continue, and further evaluation of these and on-going records will be made. (We are grateful for data received from Higaturu TSD).

**PEST INFORMATION DATABASE (PID) (RSPO 4.1, 4.5, 8.1)**
Although we had planned to have the PID fully operational by this year, demands on the IS section have delayed the final implementation of the Access based PID, and the Excel spreadsheet continues to be used and data extracted for use as required (Fig.19). Revisions have been completed to the input format and finalisation record sheet, and data transfer is required at this time (end 2009).

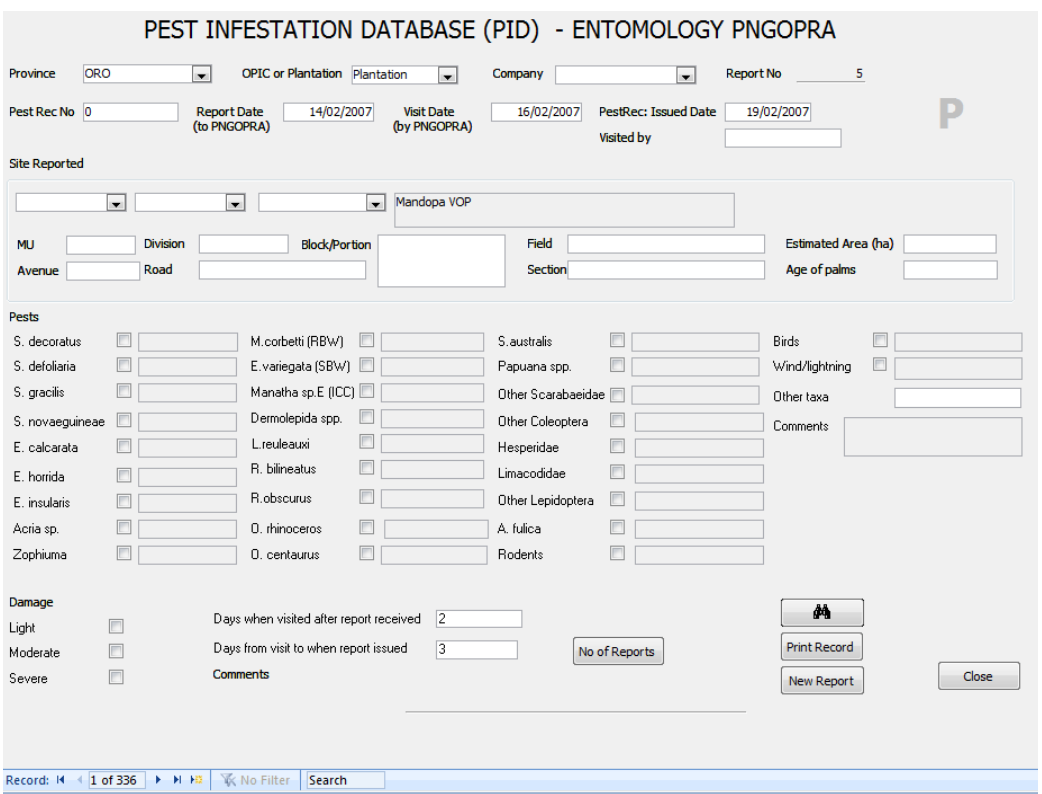


**Figure 19**: Screen shot of entry sheet for Pest Infestation Database (PID)

**METHAMIDOPHOS USAGE DATABASE (MUD) (RSPO 4.1, 4.5, 4.6, 8.1)**
During 2009, 96 records were received from plantations, and 75 reports were sent out, however 21 outstanding records were not traced. The database failed in December due to software failure when entering "nil reports", and, as explained above, our IS section has been unable to find the fault, and it was not corrected by end of the year.

**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 2008 the rearing process was still slow and labour intensive.

**Stichotrema dallatorreanum.**
The Myrmecolacid parasitoid, *Stichotrema* was collected from the field as parasitized adult sexava, *S.defoliaria* (primarily from Hargy areas). Specimens were brought back to Dami lab, and caged with "sexava" of both species. After parasitism was estimated to have taken place, males of the new "sexava" host were released (Table 7). Female "sexava" that were infested were retained to be used for further re-infestation: no infested female sexava were released, as they are still capable of laying eggs until they die. Collaborative work with this parasitoid is discussed below. Work has continued to encourage infection of "sexava" with the release of the abdominal parasitoid *Stichotrema dallatorreanum* to encourage its establishment in other areas of West New Britain. Infested insects are collected from the field, released into the caged material at Dami, and as signs of parasitism are observed, infected male "sexava" are released into the field. This is a slow process, but recoveries have been made, and the release process will continue. 1st recorded recoveries of *Stichotrema* parasitized sexava (*S.defoliaria* only) have been made following laboratory reared and released host material. Parasitized insects were recovered from plantations at Dami in April 2009 and at Bilomi (Kapiura) in August 2009. These signify a continual spread of the parasitoid following releases over previous years. There were no 'wild" recoveries made from *S.decoratus*.

**Table 7**: 2009: Release (and Recovery) of "sexava" infected with *Stichotrema* from the laboratory.

| Date released | Locality of release | Host | Sex of host | TOTAL released |
|---|---|---|---|---|
| 4-April | **Stichotrema recovery** | | | |
| | Dami plantation, field 2004 planting, 1st recovery here | *S.defoliaria* | female | recovery |
| 20-August | **Stichotrema recovery** | | | |
| | Av20-11, 1987 planting, Bilomi 2 | *S.defoliaria* | male (1), female(2) | recovery |
| 15-October | Buluma MU12 1999 | *S.defoliaria* | Males | 21 |
| 03-November | Buluma MU12 1999 | *S.defoliaria* | Males | 18 |
| 20-November | Buluma MU12 1999 | *S.defoliaria* | Males | 21 |
| 15-December | Siki LSS | *S. defoliaria* | Males | 11 |
| 22-December | Siki LSS | *S.defoliaria* | Males | 13 |
| 22-December | Buluma MU12 1999 | *S.defoliaria* | Males | 16 |
| 30-December | Buluma MU12 1999 | *S.defoliaria* | Males | 18 |

***Stichotrema in Northern (Oro) Province.***
The blocks that were regularly monitored for the presence of *Stichotrema* at Tunana smallholder blocks (Oro) indicated an average parasitism rate of 23% throughout the year. Four months of field collections were not undertaken which was unfortunate (Table 8). There was an unexplained drop, although it was reported (R Safitoa) that block sanitation had significantly improved, which may explain the reduction in numbers of sexava found.

**Table 8**: *Stichotrema* infestation rates of *S.novaeguineae*.

| *Stichotrema* | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| % infected | No report | 35 | 19 | 23 | 0 | No report | No report | 23 | 14 | 50 | 20 | No report |

The collaborative project between OPRA and Oxford University (UK) to investigate the genetic make up of *Stichotrema dallatorreanum* began on 16 September 2009, with a Letter of Agreement between Oxford University and PNGOPRA which was signed by MD. Special sterilised tubes containing the chemical "RNA-later" were sent to PNGOPRA and we provided specimens of *Stichotrema* and the host sexava with the heads and elytra removed from each insect which was then cut open dorsally to expose *Stichotrema* females *in situ*. The cadaver was then flooded with the chemical "RNA-later" provided. Specimens were sent to the UK using the export forms approved by Department of Environment and Conservation. (DEC), and the import papers required from UK. A summary report on the work carried out so far by **Dr J Kathirithamby** is as follows:

***Stichotrema dallatorreanum*** **Hofeneder**

***i) Molecular phylogeny of Strepsiptera***
***Aim***
To provide a molecular framework for understanding the evolutionary history of the entomophagous parasitic Strepsiptera. Approximately 4Kb of genomic data was targeted across the most representative genera to produce a robust phylogenetic hypothesis, which began by framing several important questions relating to the evolutionary history of this unusual system. Individual insects were included from 41 strepsipteran taxa, from 16 genera (50% coverage). Stichotrema dallatorreanum Hofeneder was one of these taxa. The resulting molecular phylogeny is now well resolved. By applying a variety of likelihood and Bayesian approaches, the history of specialization that resulted in the emergence of an evolutionarily unique parasitic system are being explored, including an analysis of the timing of divergence, the rate of molecular evolution and the origin of strepsipteran character traits.

*Methods*
Standard protocols were employed for amplification and sequencing the genetic material. The mitochondrial genes cytochrome c oxidase I (COI, cox1), NADH dehydrogenase I (ND1, nad1), small subunit ribosomal RNA (16S rRNA) alongside the nuclear gene small subunit ribosomal RNA (18S rRNA) were targeted for amplification.

*Tentative results*
*S. dallatorreanum* formed a clade with an undescribed male Stichotrema from Thailand within the family Myrmecolacidae. Further detail will be available in 2010. A paper describing the results will soon be submitted for publication by the Oxford scientists.

***ii) Draft Genomic data***
DNA from specimens of *S. dallatorreanum* has been submitted for a draft genome assembly.

*Further work:*
We will begin analysis it as soon as the draft genome assembly is received.

**Sexava egg parasitoids.**
Egg parasitoids of sexava were reared in the laboratory, and adults were released in both plantations and smallholder blocks in WNB and on NI. For both egg parasitoid genera (*D.leefmansi* and *L. bicolor*) there was an improvement in numbers of both taxa released over the previous year (Table 9). To estimate numbers of adult parasitoids released, at the time the main sample is released in the field, a 10% sample of eggs for release is put into a small fly wire bag and placed in the plantation at Dami on a palm trunk; after two weeks the fly wire bag is collected and the eggs checked for parasitoid emergence and other losses. (This monitoring is kept away from the laboratory cultures to avoid the parasitoids returning and attacking laboratory material). This will provide a better estimate of percentage parasitism, and will give a more accurate estimate of field emergence, and therefore the percentage of parasitized eggs put into the field from which parasitoids might be expected to emerge. Results showed that the main losses to parasitized host eggs are caused by rats and ants. We are still working on ways to improve on our laboratory techniques to increase numbers reared for release, as they are far from adequate for the large areas

involved requiring parasitoid enhancement. Laboratory data are being collected on numbers of parasitoids of both taxa emerging from host (sexava) eggs, and will be presented in future reports. Numbers of parasitoids that emerge from parasitized eggs will differ according to the host used, as the eggs of *S.decoratus* are larger than those of *S.defoliaria*.

**Table 9**: Comparative releases *D.leefmansi* and *L.bicolor*.

| Parasitoid | **2008** | **2009** | Increase | % increase |
|---|---|---|---|---|
| *D.leefmansi* | 840,649 ( releases) | 1,995,059 ( releases) | 1,154,410 | 37.3 |
| *L.bicolor* | 240,388 ( releases) | 772,520 ( releases) | 532,132 | 143.0 |

***Doirania leefmansi***

An estimated 1,995,059 laboratory reared *Doirania* parasitoids were released at 67 sites, of which 45 were smallholder blocks and 22 were plantation sites (Table 10) with an average of approximately 166,500 adult parasitoids released per month (Fig.20); this was a 37% increase in releases from 2008. To provide a greater chance of success, more than one release may often have been made at each site. Cumulative monthly release totals are shown in Fig.21. Actual numbers of this parasitoid emerging are very difficult to estimate, and in spite of having had a student (Kingsten Okka) working on this issue in 2008, we are still not able to provide reasonable estimates for numbers released, as there are widely fluctuating numbers emerging, especially of Doirania. There will also be differences in emerging numbers depending upon whether we are dealing with *S.decoratus* (larger eggs) weighing 0.0216gm or *S.defoliaria* smaller eggs weighing 0.0182gm) Clarifying this issue will be a major priority once new staff are in place in 2010, which will enable a more accurate revision of emerging parasitoids. It is likely that estimates of numbers released will increase significantly once results are finalised, as we have tended to underestimate emergence figures.

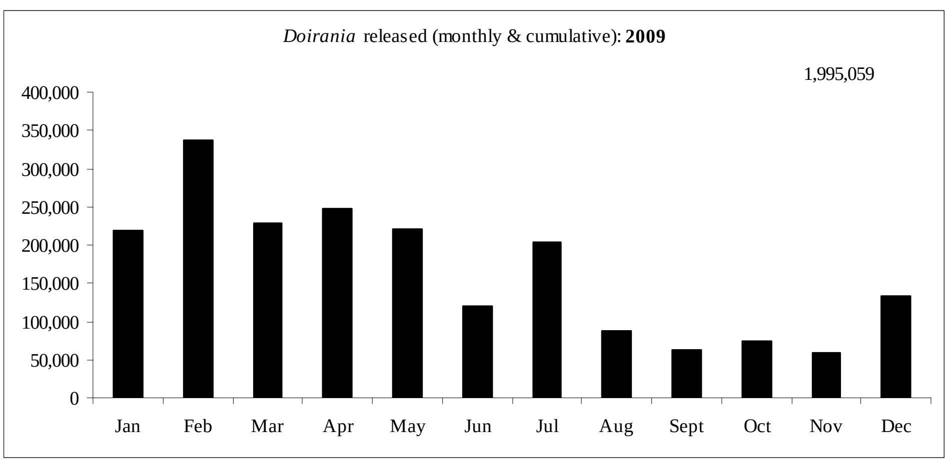



**Figure 20**: 2009 *D.leefmansi* monthly adult parasitoid releases.

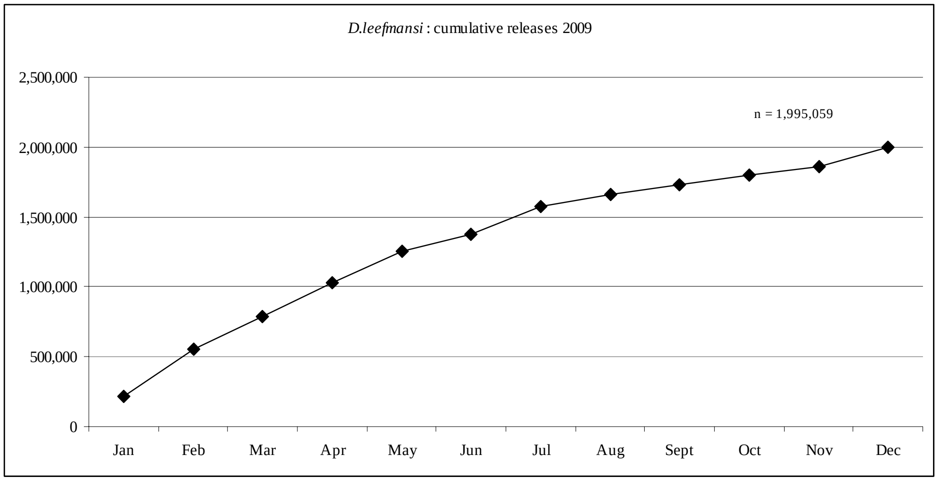



**Figure 21**: 2009, *Doirania leefmansi*, and cumulative releases.

***Leefmansia bicolor***

Sixty-one releases of parasitoids were made (Table 11) with an average monthly release of some 57,703 insects and an annual total of 772,520 (Fig. 22), an increase in released insects of 143%. The continual improvement in parasitoid releases is what we are aiming to achieve (Fig.23).

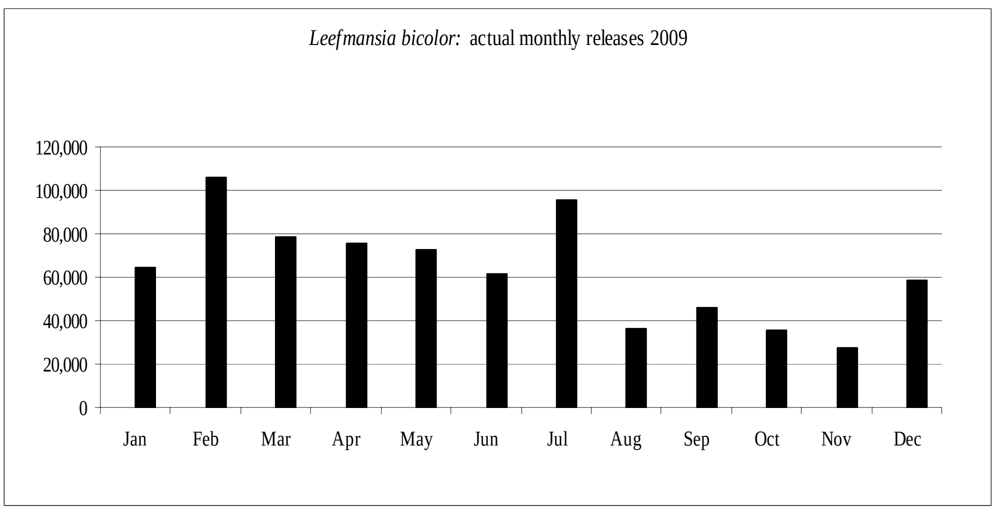



**Figure 22**: 2009, *Leefmansia bicolor*, monthly estimated releases (n=722,520).

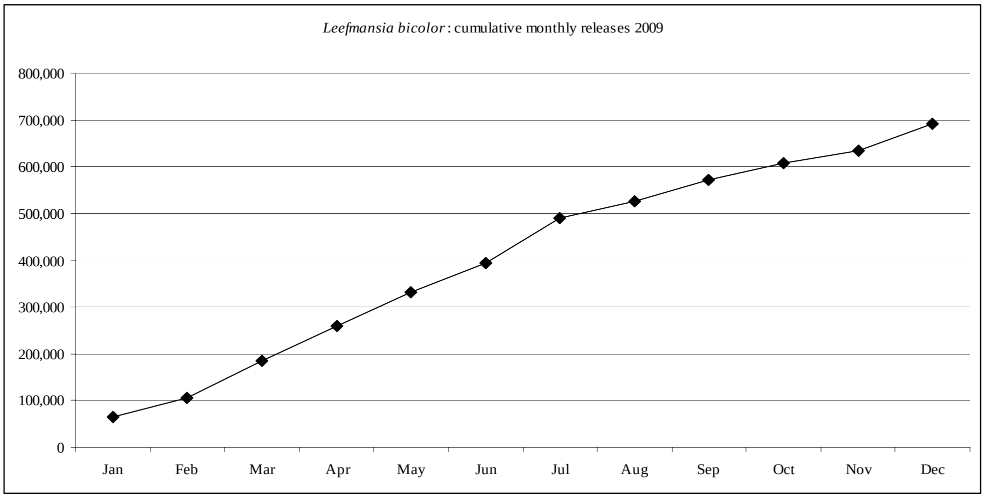



**Figure 23**: 2009, *Leefmansia bicolor*, cumulative monthly releases.

**Host egg availability.**

In spite of the increase in numbers released, there was a drop in productivity of both parasitoid taxa during the period August – November, with an increase in December (this was linked to less sexava eggs available for parasitism during that period Fig. 24).

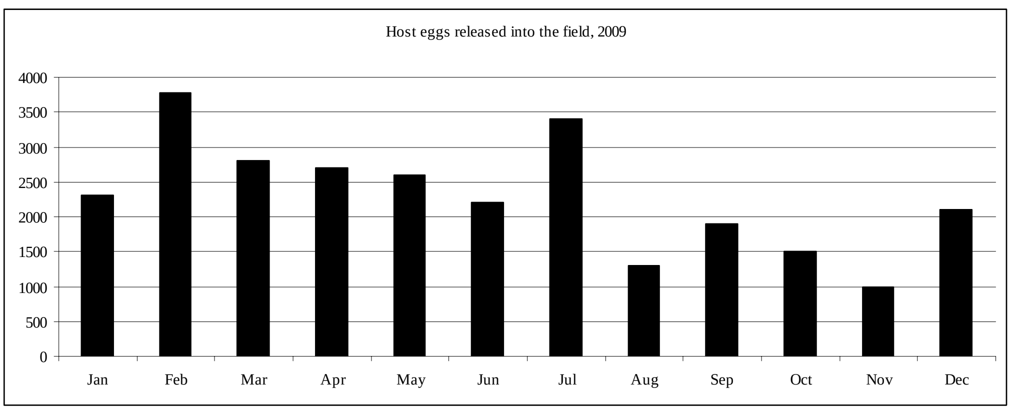



**Figure 24**: 2009  Monthly totals of parasitized host (sexava) eggs released.

**Table 10.** Release sites for *Leefmansia bicolor* in 2009.

| Release date | Releases per month | Release site | Smallholder /Plantations | Host eggs |
|---|---|---|---|---|
| 08-Jan-09 | 11 | Bebere plantation D1, fld.111-02 | P | 140 |
| 08-Jan-09 | | Sarakolok LSS 0796 | O | 150 |
| 12-Jan-09 | | Kavui LSS | O | 240 |
| 15-Jan-09 | | Siki LSS blk 0223 | O | 280 |
| 15-Jan-09 | | Siki LSS blk 2242 | O | 160 |
| 16-Jan-09 | | Mosa VOP | O | 200 |
| 20-Jan-09 | | Bebere plantation D2 | P | 260 |
| 20-Jan-09 | | Mosa VOP | O | 260 |
| 23-Jan-09 | | Banaule VOP | O | 160 |
| 28-Jan-09 | | Porapora VOP | O | 300 |
| 28-Jan-09 | | Tamba LSS | O | 160 |
| **03-Feb-09** | 10 | Buluma VOP | O | 180 |
| 04-Feb-09 | | Banaule VOP | O | 200 |
| 06-Feb-09 | | Kavui LSS | O | 300 |
| 06-Feb-09 | | Kaus LSS | O | 500 |
| 10-Feb-09 | | Siki LSS | O | 500 |
| 13-Feb-09 | | Kapore LSS | O | 500 |
| 14-Feb-09 | | Soi LSS | O | 400 |
| 19-Feb-09 | | Siki LSS | O | 400 |
| 25-Feb-09 | | Tamba LSS | O | 300 |
| 27-Feb-09 | | Waisissi ME | P | 500 |
| **11-Mar-09** | 5 | Volupai plantation (Div.2) | P | 700 |
| 17-Mar-09 | | Kapore LSS | O | 700 |
| 17-Mar-09 | | Kapore LSS | O | 400 |
| 23-Mar-09 | | Haella plantation Div.1 | P | 600 |
| 31-Mar-09 | | Banaule VOP Blk 0119 | O | 400 |
| **08-Apr-09** | 6 | Banaule VOP Blk 0119 | O | 200 |
| 14-Apr-09 | | Alaba ME | P | 400 |
| 14-Apr-09 | | Matanatu ME | P | 400 |
| 28-Apr-09 | | Banaule VOP 015-0119 | O | 500 |
| 28-Apr-09 | | Dami seed garden | P | 400 |
| 30-Apr-09 | | Banaule VOP 015-0069 | O | 800 |
| **07-May-09** | 5 | Kapore LSS | O | 500 |
| 07-May-09 | | Kumbango plantation | P | 500 |
| 19-May-09 | | Navo Estate | P | 500 |
| 22-May-09 | | Banaule blk 0069 | O | 500 |
| 22-May-09 | | Banaule blk 0105 | O | 600 |
| **18-Jun-09** | 3 | Hak VOP | O | 500 |
| 25-Jun-09 | | Kavui & Kapore LSS | O | 1300 |
| 30-Jun-09 | | Siki LSS | O | 400 |
| **02-Jul-09** | 4 | Navo Estate & Novunebea | P | 1300 |
| 07-Jul-09 | | Lavege VOP | O | 400 |
| 22-Jul-09 | | Kavui LSS Blk 1812 | O | 1300 |
| 22-Jul-09 | | Malilimi plantation Div 2 | P | 400 |
| **15-Aug-09** | 3 | Banaule VOP | O | 500 |
| 14-Aug-09 | | Siki VOP | O | 500 |
| 26-Aug-09 | | Kautu plantation Div 3 MU 11 Rd 5 | P | 300 |
| **10-Sep-09** | 4 | Siki VOP | O | 700 |
| 17-Sep-09 | | Kumbango D1 | P | 600 |
| 28-Sep-09 | | Banaule VOP, blk '0012, S2 | O | 200 |
| 28-Sep-09 | | Kumbango D1 | P | 400 |
| **28-Oct-09** | 2 | Banaule VOP ,blk '0119 | O | 700 |
| 29-Oct-09 | | Banaule VOP, blk '0119 | O | 800 |
| **04-Nov-09** | 3 | Malele VOP | O | 400 |
| 05-Nov-09 | | Rerengi VOP | O | 200 |
| 17-Nov-09 | | Malele VOP | O | 400 |
| **17-Dec-09** | 5 | Soi LSS | O | 500 |
| 17-Dec-09 | | Kabaiya LSS | O | 600 |
| 18-Dec-09 | | Kumbango Division 1 | P | 300 |
| 22-Dec-09 | | Kapore LSS | O | 300 |
| 28-Dec-09 | | Kavui LSS | O | 400 |

**Table 11**. Release sites for *Doirania leefmansi* in 2009.

| Release date | Releases per month | Release site | Smallholder /Plantations | Host eggs |
|---|---|---|---|---|
| **08-Jan-09** | 13 | Bebere plantation D1 fld. 1111-02 | P | 100 |
| 08-Jan-09 | | Sarakolok LSS blk 0796 | O | 80 |
| 12-Jan-09 | | Kavui LSS blk. 1814 | O | 260 |
| 15-Jan-09 | | Siki LSS blk. 0160 | O | 262 |
| 16-Jan-09 | | Mosa VOP blk. 0008 | O | 160 |
| 20-Jan-09 | | Bebere plantation D2 | P | 360 |
| 20-Jan-09 | | Mosa VOP | O | 360 |
| 23-Jan-09 | | Banaule VOP | O | 360 |
| 25-Jan-09 | | Tamba LSS | O | 260 |
| 29-Jan-09 | | Dami plantation | P | 260 |
| 29-Jan-09 | | Banaule VOP | O | 260 |
| 30-Jan-09 | | Tamba LSS | O | 280 |
| 30-Jan-09 | | Buvussi LSS | O | 280 |
| **03-Feb-09** | 11 | Buluma VOP | O | 180 |
| 04-Feb-09 | | Banaule VOP | O | 360 |
| 06-Feb-09 | | Kavui LSS | O | 860 |
| 06-Feb-09 | | Kavui LSS | O | 560 |
| 10-Feb-09 | | Siki LSS | O | 380 |
| 13-Feb-09 | | Kapore LSS | O | 560 |
| 14-Feb-09 | | Soi LSS | O | 280 |
| 19-Feb-09 | | Waisissi ME | P | 500 |
| 25-Feb-09 | | Tamba LSS | O | 400 |
| 26-Feb-09 | | Dami plantation | P | 260 |
| 27-Feb-09 | | Banaule VOP | O | 680 |
| **11-Mar-09** | 7 | Volupai (Div 1 Lotomgam) | P | 400 |
| 11-Mar-09 | | Volupai (Div.2) | P | 400 |
| 17-Mar-09 | | Kavui LSS | O | 800 |
| 17-Mar-09 | | Kapore LSS | O | 400 |
| 23-Mar-09 | | Haella Div 1 | P | 600 |
| 24-Mar-09 | | Kumbango Div. 1 | P | 400 |
| 31-Mar-09 | | Banaule VOP Blk. 0019 | O | 400 |
| **08-Apr-09** | 7 | Banaule VOP blk. '015-0119 | O | 600 |
| 13-Apr-09 | | Dami plantation (Buluma fld.) | P | 795 |
| 14-Apr-09 | | Alaba ME | P | 400 |
| 14-Apr-09 | | Matanatu ME | P | 400 |
| 28-Apr-09 | | Banaule VOP blk. 015-0119 | O | 700 |
| 28-Apr-09 | | Dami plantation seed garden | P | 600 |
| 30-Apr-09 | | Banaule VOP 015- 0069 | O | 200 |
| **07-May-09** | 5 | Kapore LSS | O | 600 |
| 07-May-09 | | Kumbango Plantation | P | 600 |
| 19-May-09 | | Navo estate | P | 600 |
| 19-May-09 | | Banaule blk 0069 | O | 700 |
| 22-May-09 | | Banaule blk 0105 | O | 800 |
| **18-Jun-09** | 2 | Hak VOP | O | 600 |
| 25-Jun-09 | | Kavui & Kapore LSS | O | 1200 |
| 30-Jun-09 | | Siki LSS | O | 500 |
| **02-Jul-09** | 4 | Navo Estate & Novunebea | P | 1500 |
| 07-Jul-09 | | Lavege VOP | O | 40 |
| 22-Jul-09 | | Kavui LSS blk 1812 | O | 1200 |
| 22-Jul-09 | | Malilimi plantation Div 2 | P | 300 |
| **15-Aug-09** | 3 | Banaule VOP | O | 400 |
| 19-Aug-09 | | Siki VOP | O | 500 |
| 26-Aug-09 | | Kautu plantation Div 3 Mu 11 Rd 5 | P | 400 |
| **10-Sep-09** | 5 | Siki VOP | O | 500 |
| 17-Sep-09 | | Kumbango pln | P | 400 |
| 28-Sep-09 | | Banaule VOP S2 blk'0015 | O | 200 |
| 28-Sep-09 | | Kumbango D1 | P | 400 |
| 28-Sep-09 | | Kumbango D1 | P | 200 |
| **28-Oct-09** | 2 | Banaule VOP blk '0119 | O | 700 |
| 29-Oct-09 | | Banaule VOP blk. '0119 | O | 700 |
| **04-Nov-09** | 3 | Bereme VOP | O | 400 |
| 05-Nov-09 | | Rerengi VOP | O | 200 |
| 17-Nov-09 | | Malele VOP | O | 400 |
| **17-Dec-10** | 5 | Soi LSS | O | 500 |
| 17-Dec-10 | | Kabaiya LSS | O | 600 |
| 18-Dec-10 | | Kumbango Division 1 | P | 200 |
| 22-Dec-10 | | Kapore LSS | O | 300 |
| 28-Dec-10 | | Kavui LSS | O | 400 |

**STICK INSECTS (PHASMATIDAE) (RSPO 4.5, 8.1)**

**Infestations**

*E.calcarata* were regularly reported however on no occasion were they the primary cause, of a reported infestation. In reports received from smallholder growers, *E.calcarata* was reported in almost as many locations as *S.defoliaria* (Fig.8). This insect is often difficult to find as they may move away from the main oil palm during the day, and hide in fallen logs or holes in old palm stumps and even surrounding bush. Where stick insects are causing recognisable damage, they may also be found hiding during the day in old male flowers, and we encourage the removal of these old flowers where stick insects are found. Care must be taken not to remove male flowers until at least 2 weeks after flowering has finished, as it is where the pollinating weevil larvae/pupae are found. The eggs of stick insect which may be laid in the moss balls growing as epiphytes on palm trunks may simply be dropped on to the ground, and as they are quite large (0.0774-0.0787 gm) they are easily confused with rat faeces. Under laboratory conditions, eggs kept moist hatched at between 9-11 weeks (63-77 days), and when dry they hatched between 8-14 weeks (63-98 days).

**Parasitoids**

No parasitoids of *Eurycantha calcarata* were reared during 2009.

**Life history and feeding trials for *Eurycantha insularis*.**

There were there were two reports from the previously (2008 and previous years) reported sites. Preliminary feeding trials were undertaken during 2009, although there were data collected by R.Safitoa that had not been utilised, and which will be analysed and presented subsequently. The infestations occurring in smallholder blocks at Tunana (Northern Province) were not treated with insecticide, however during the year populations were decreasing (as reported during field collections (S.Nyaure pers.comm.). Reasons for this were not investigated. The results obtained from the rearing of egg parasitoids from *E.insularis* from Higaturu Research Centre were inconclusive and not followed up after the resignation of the Entomologist, Ross Safitoa. The parasitoid specimens reared remain un-mounted and will require mounting and identification.

**COLEOPTERA** (weevils, rhinoceros beetles and white grubs) **(RSPO 4.5, 8.1)**

*Lepidiota reauleuxi:*
No reports were received during 2009.

*Papuana* sp. (*woodlarkiana/hubneri*):
No reports were received during 2009.

**Sugar Cane Weevils** *Rhabdoscelus obscurus* and *R.maculatus.*

During the year, a link was made with Dr Chris Lyall at the Natural History Museum, UK who was investigating the DNA and speciation within the Genus which is very widespread throughout the Pacific region. As mentioned in the last Annual report, this insect is recognised as a pest in Malaysia. Specimens were sent to the NHM, and will be reported upon when results are received.

During a private visit to Sri Lanka, discussions were held with the entomologist at Tropiflora Ltd. on issues of mutual interest concerning the related species *R.maculatus* (which does not yet occur in PNG). They are monitoring this insect using pheromone traps.

**Black Palm Weevil** (*Rhynchophorus bilineatus*).

No reports were received, although 2 adults were collected in flight during the day at Navo (Hargy Oil palms). The specimens were retained for the reference collection.

**Asian Rhinoceros Beetle** (*Oryctes rhinoceros*).

There were no reports of this insect received during 2009.
The report from Hargy Oil palms was confirmed as *S.australis* and not *O.rhinoceros* (see below).

**Larger Rhinoceros Beetle** (*O.centaurus*). Routine monitoring of this insect continued at bimonthly intervals although somewhat erratically, at Higaturu (Table 12). Specimens sent to The Natural Resources Institute in Kent, UK survived well, however no pheromone was recovered. Further shipments will be made using older insects, and attempts will be made to trap them using adults in the field.

**Table 12.**: 2009: Ambogo Estate, Higaturu Oil Palms, monitoring data.

| | Jan | Mar | Apr | Dec |
|---|---|---|---|---|
| Eggs | | | | 24 |
| Larvae | 32 | 18 | 229 | 123 |
| Pre-pupae | 4 | 0 | | 33 |
| Pupae | 8 | 9 | 2 | 9 |
| Adult male | 0 | 0 | 19 | 3 |
| Adult female | 0 | 0 | 28 | 10 |

NB: there are large gaps in the data as a result of staffing issues. Missing data for February were due to the bi-monthly data recording.

**Three-horned rhinoceros beetle** (*Scapanes australis* ssp. *grossepunctatus*).
A report was received of this insect attacking 5-6 yo palms at Hargy Oil Palms, Ibana Field 28, Block 05. The site was visited with all staff involved, and an assessment was made. A single adult female and a last (iii) instar (stage) larva were found and one small larva (ii instar) was collected from the soil just underneath a fallen well rotted log. No adults were found in the palms. It was reported (P. Taramurray, pers.comm.) that one palm was found on an earlier visit with 2 beetles attacking it - both beetles were killed. This palm was very much smaller than the surrounding palms and was reported (by PT) to be the same age but doing badly as it was near the forest edge and shaded. Damage observed was considered to be of no importance, and no treatment recommendation, apart from "winkling" was made (PestRec. #4409). A second report was received from a smallholder VOP at Rerengi (Salelubu Division). No specimens were collected; however the primary pest was *S.decoratus* which was recommended for treatment (PestRec. #4909).

**LEPIDOPTERA (RSPO 4.5, 8.1)**
**Tussock moths** (Lymantriidae).
No reports were received.

**Webworms** (Oecophoridae [Xyloricttidae]),
There were no reports of the Oil Palm Webworm (*Acria* sp nr. *emarginella*) received during the year.

**Bagworms** (Psychidae)
Bagworm infestations were very low during the year, with very few reported infestations (Figs.6 & 7). No bagworm infestations required TTI during the year. Bagworms are controlled naturally by a wide range of parasitoids, predators and entomopathogens (fungi).

It has long been reported that bagworm infestations proliferate during the dry seasons as Syed and Shah (1977) reported that when the rainfall was relatively low, the population of *M. corbetti* in the field tended to increase; however this has been shown not to be the case as a result of work done in Malaysia, where almost half of infestations reported also occurred during the wet, and a key factor was the weather two generations previously (Wood, 1985). Wood (1985) also found that 44.1% of outbreak reports could be associated with prolonged drought (when Evapotranspiration exceeds rainfall over a period of at least 2 months) whereas 45.6% of outbreaks were associated with non-drought periods. We will be following data from our records when new staff arrive. This is another of the situations where generalisations and historical acceptance of earlier events has taken place, and that in fact, infestations are not so strongly linked with dry periods. In WNB there are times of the year when strong winds do occur, and these may indeed be beneficial for the dispersal of the young larvae, however they are so small that even localised wind currents and vehicle passage may help with their dispersal. A more detailed investigation of the relationship between infestations weather and locality will be a practical research topic.

The collaborative study on bagworm taxonomy with Peter Hatenschwiler (Switzerland) proceeded steadily, and a draft working document was produced. Drawings have been completed (as presented to the SAC and Annual Report 2008), and additional material is required to fill in morphological detail (e.g. female ICC, and male of gen. et sp. nov. species D). Surprisingly, there is a great deal of missing biological data, and it is considered that the final reporting will be produced as two papers dealing with taxonomic and biological aspects of these insects. There are clearly three genera of Psychidae that have been reared from oil palm in PNG. One of the new species of Psychidae (*Manatha* sp. C), although found on oil palm, is suspected of being an algal feeder in its larval stage. As a result of the taxonomic revision, we propose that the following names and acronyms be confirmed, and those already in regular use are adopted (1, 2 & 3). New specific names can't be provided here until the taxonomic descriptions are completed:

1. Rough bagworm (RBw), *Mahasena corbetti*
2. Smooth bagworm (SBw), *Eumeta variegata*
3. Ice cream cone bagworm (ICCBw ),will have a new specific name: *Manatha* conglacia (currently sp E)
4. Bishops Field bagworm (BFBw), **Gen.et sp.nov**. (new Genus and species), will be called: Amatissa navaella (currently sp.D)
5. Bilomi bagworm (BBw), will be called: Amatissa bilomia (currently sp.C).

Species numbers **3**, **4** and **5** will be fully described in the proposed paper. (Hattenschwiler & Dewhurst, *in prep*.), although proposed names are given here to illustrate the key, they should **not** be used in publications until the names are formally published.

**_Provisional_ Key for identification of the adult Psychidae (Lepidoptera) species found on oil palm in PNG using bag characteristics only.**

1 Key based on **bags:**

**1** bag longer than 22mm ………………… 2
- bag shorter than 22mm ……………….. 3

**2** bag round in cross section no large pieces of plant material on surface *Eumeta variegata [1]* Fig. 25a
- bag covered with plant material, often quite large pieces, oriented lengthwise *Mahasena corbetti [2]* Fig. 25b

**3** bag, grey brown coated with plant material 4
- bag without any obvious plant material, made from silk; bag with lengthwise ribs, yellowish colour (Fig.25E) *Manatha conglacia* **sp.n**.[5] Fig 25e

**4** bag fine, surface smooth, with plant material tightly attached, not standing proud *Amatissa bilomia* **sp.n**. *[3]* Fig. 25c
- bag rough surface, most plant material outstanding at near right angles *Amatissa navaella* **sp.n.** *[4]* Fig. 25d

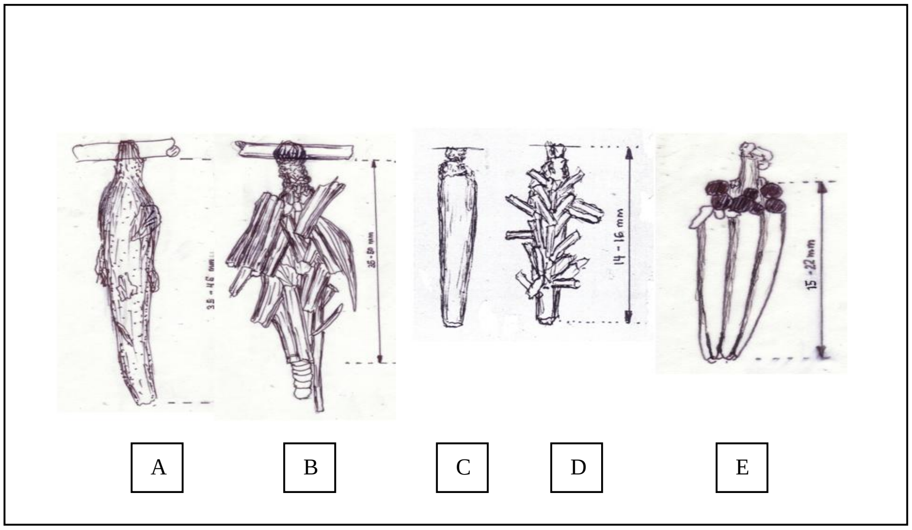



**Figure 25**: A-E, bags of Psychidae reared from oil palm in PNG (Hatenschwiler & Dewhurst in prep.)

**HEMIPTERA (RSPO 4.5, 8.1)**

***Zophiuma lobulata* (causal agent of Finschhafen Disorder)**
Localised infestations of: *Zophiuma lobulata* (Lophopidae) were monitored and used during our research on the ecology and vector potential of this insect. Collection sites from where we collected ample material were at Numundo Plantation (Seaview) and Dami Oil Palm Research Station (OPRS) in WNB. Experimental work was completed during December 2009, and the work is being written up for peer reviewed publication.

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] is in its final year.

A report to ACIAR was prepared by the team and submitted for approval (see Annex below). Dr Catherine Gitau visited the entomology section at the end of the year and the main series of experiments involving FD causality and recovery, parasitism, fecundity and the effect of nectar availability on longevity were completed. Data were collected on parasite taxa that were found attacking the egg masses of *Zophiuma*, and specimens were sent to specialists for identification and publication. Entomology staff assisted with the practical and logistical work to enable the completion of this work.

A first record of the male of the closely related *Z.pupillata* was collected from the hills SE of Madang by CFD, and a re-description of this species and *Z.lobulata* is currently underway, and will be submitted for publication in 2010 (Fletcher, Gitau, Dewhurst and Gurr, *in prep*.). One result of these detailed studies was that Finschhafen Disorder (FD), is manifested as a direct result of feeding pressure by the nymphs and adults of this insect, and is not as a result of the transmission of any transmissible pathogen. Although chlorosis, necrosis and subsequent die-back of the attacked fronds will occur under very heavy infestations and which is reported to affect coconut productivity, destruction of the easily seen egg masses and encouragement (through lab rearing) of parasitoids is likely to result in a reduction of populations of this insect. New growth will remain unaffected by symptoms. Further donor funding to support operational research on the lab rearing and inundative mass release of parasitoids will be sought.

**Nectar producing plants:**
Work on the encouragement of use in nectar producing plants in plantations to provide food sources and shelter for parasitoids and predators resulted in the production of a report to (NBPOL) OPRS. Our more detailed research resulted in the production of a poster (Gitau *et al*. 2009), with a conclusion that the plants tested were not as effective at enhancing longevity as honey.

**Outputs:**

Two poster presentations were made, and a major review paper published. Other papers are in various stages of preparation for publication in peer reviewed journals.

Gitau, C.W., Gurr, G M., Dewhurst, C.F., Fletcher, M.J. & Mitchell, A. (2009). Insect pests and insect-vectored diseases of palms. *Australian Journal of Entomology* ***48***, *328-342.*

Gitau, C.W., Gurr, G M., Dewhurst, C.F., Fletcher, M.J. & Mitchell, A. (2009). Parasitoids for biological; control of the oil palm pest *Zophiuma lobulata* (Hemiptera: Lophopidae). Poster presentation (Figure 26)

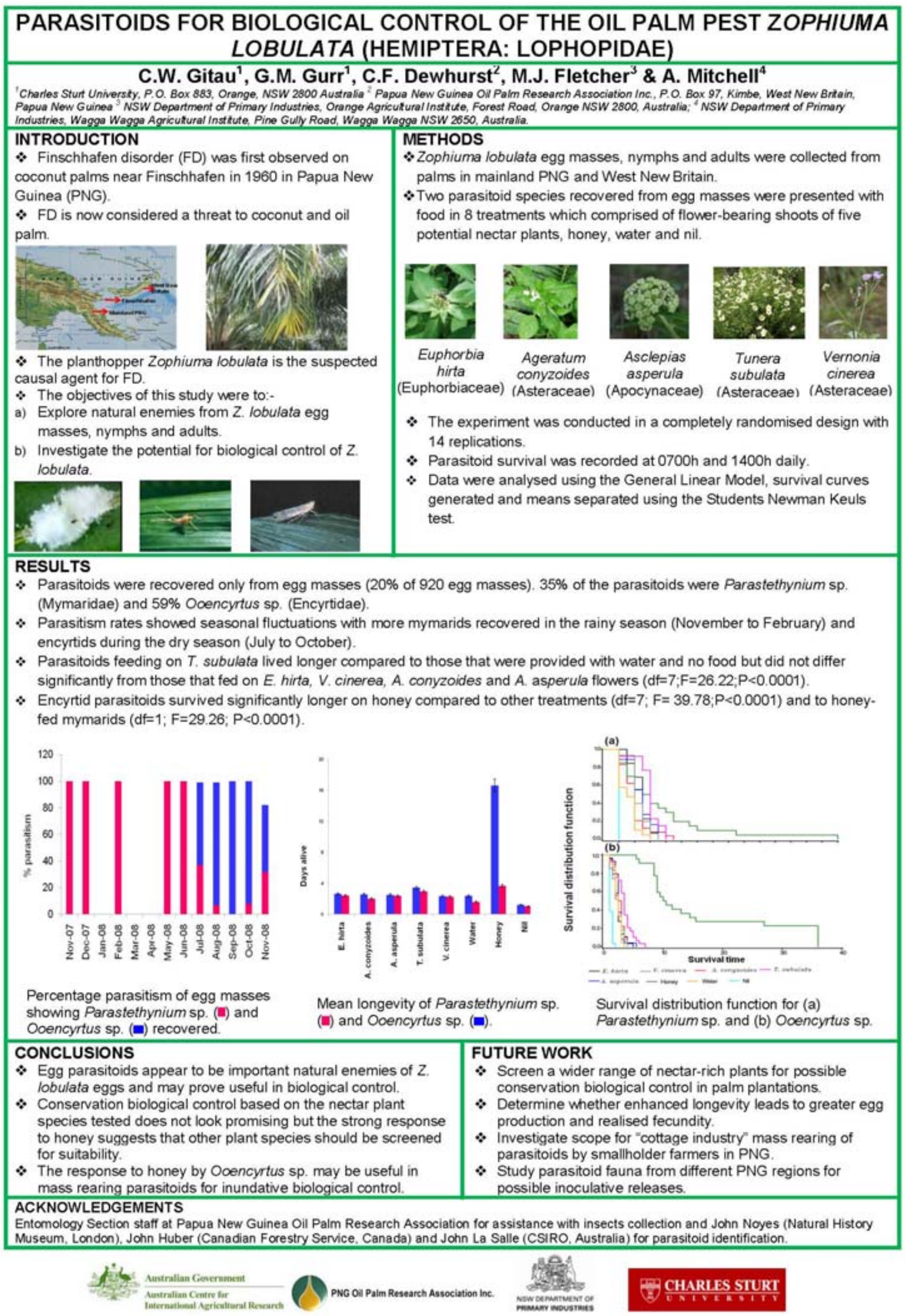



**Figure 26**: Poster showing nectar efficacy; in particular, notice the effect on longevity of honey.

**MYCOPATHOGENS OF *Z.LOBULATA*:** M.Phil study, D Woruba **(RSPO 4.5, 8.1)**

**Fig. 27**: *Z.lobulata* attacked by entomophagous fungus (Photo: PNGOPRA).

Staff member Deane Woruba, was awarded an ACIAR John Allwright Fellowship to study for an M.Phil. Degree in June 2009 and he commenced his Masters studies in July 2009 at Charles Sturt University (CSU), Orange, New South Wales (NSW). He will expect to complete his studies in August 2011.

As a requirement of his fellowship, he is involved in ACAIR Project CP/2006/063: *Integrated pest management of Finschhafen Disorder of oil palm in Papua New Guinea (PNG)*, as described above. His involvement is to investigate the potential for use of entomopathogenic fungi in controlling *Zophiuma lobulata*, the causal organism for Finschhafen Disorder. Dr. Michael Priest, Senior Plant Pathologist at Orange Agriculture Institute, Industry and Investment NSW, and specialist mycologist (Dr Michael Priest) was invited to join the team and co-supervise this work, and to provide specialist advice to back up the advice provided by all team members.

**Project Title:**
Potential for the Management of *Zophiuma lobulata* (Ghauri) using entomopathogenic fungi.

*Activities:*
Initial fieldwork was undertaken in PNG, where collections were made for entomopathogenic fungi of *Z.lobulata* in West New Britain and Milne Bay Province of PNG. Thirty-six (36) fungal samples were collected which will be cultured and encouraged to sporulate in the lab by growing them on specific media.

*Achievements*
Specimens are in culture to provide pure material for identification and subsequent field trials.
A poster presentation was made at an International Conference, and a successful submission of the project proposal to CSU for the M.Phil. Project (See below).

Saprophytic fungi were present in the collected cultures and are being isolated. Two (2) entomopathogenic genera were identified: *Metarhizium* and *Paecilomyces*. A third entomopathogenic fungus in the genus, *Hirsutella*, was believed to have been observed from field collections; however laboratory cultures are not yet suitably developed for morphological identification. Once identified, all fungal samples will be used in laboratory-based bioassays to assess those fungi which may have potential for further development in an IPM strategy for the control of *Z.lobulata*.


**Figure 28**: Poster describing the Management of *Zophiuma lobulata* Ghauri (Hemiptera: Lophopidae) using entomopathogenic fungi.

**Reference**:
Woruba, DN., Gurr,GM., Gitau CW., Priest, M., Dewhurst, CF., Fletcher, MJ., & Mitchell, A. (2009). Management of *Zophiuma lobulata* Ghauri (Hemiptera: Lophopidae) using entomopathogenic fungi. *Australian Entomological Society Congress, Darwin, Australia.*

**OTHER PESTS (RSPO 4.5, 8.1)**

**Giant African Snail** (*Achatina fulica*)
There were no reports of the Giant African Snail causing damage to cover crop, which is the principal reason for its pest status in oil palm plantations.

**Chafer beetle** (*Dermolepida* spp., Scarabaeidae, Melolonthinae):
There were no reports of damaging levels of this complex of beetles, although specimens were occasionally found during other pest inspection visits. They are seldom reported as causing serious damage. Adults are leaflet feeders, while the larvae feed on root material only.

**Rats** and **other vertebrates.**
No reports of rats were received by PNGOPRA, however as previously reported, it is known that rats are routinely reported to OPRS (Oil Palm Research Station at Dami). No further studies were undertaken by PNGOPRA. An unpublished report by a work experience student is available from Entomology Section.

Snakes, especially the two larger pythons (Amethystine and Olive), the major predators of rats in WNB are still being killed unnecessarily; this practice should be actively discouraged by OPIC and Plantation Management in West New Britain, as there are no known poisonous snakes yet recorded from the island.

**Weed pests**

**Mile-a-minute vine**. (*Mikania micrantha*),
Although the main project ended during 2009, further funding is being sought to enable the distribution of plants infected with the rust fungus *Puccinia spegazzinii*. We are working in close collaboration with colleagues at NARI Kerevat, and infected material is sent to us at Dami for release in WNB. Funding for this work is provided through DPI (ACIAR) through the Project Leader, Dr M Day (DPI, Qld.). Distribution of the fungus is anticipated to begin during 2010. A paper is in preparation and will be submitted for publication in 2010. The manuscript is entitled: ***Mikania micrantha* Kunth (mile-a-minute): Its distribution, growth and physical and socio-economic impacts in Papua New Guinea.** Michael Day, Annastasia Kawi, Kiteni Kurika, Charles Dewhurst, Serah Waisale, Josephine Saul Maora, Jenitha Fidelis, John Bokosou, John Moxon, Warea Orapa.

**Siam weed** (*Chromolaena odorata*),
After the ACIAR project on Chromolaena ended, no further specific funding was received, however we still have access to the database, and further gall-fly releases are made on an *ad hoc* basis. The main database is being maintained by Dr M Day at DPI (Queensland). The effects of the gall fly (*Ceccidochares connexa*, Diptera Tephritidae) on this weed in WNB is not as obvious as it is with the control of the weed in East New Britain, although there is a noticeable effect on reduced flowering vigour. This discrepancy as to possible reasons for the less than obvious control will be followed up with the Project leader when he visits in 2010. We will continue to use the demo plot at Dami to monitor the effect of the gall fly on Chromolaena vigour. The demonstration plot at Entomology Office was managed, galls were present, and flower heads were routinely removed, as there are seldom more than a few galls present on a plant at any one time. In ENB, large numbers of galls were present which had a dramatic effect on plant vigour.

**Broomstick weed** (*Sida rhombifolia*)
Having received the Chrysomelid beetles, *Calligrapha pantherina* insects from RAIL, we made releases as follows during the year on WNB (Table 13): The release programme will continue, and new stock will be brought from Ramu in 2010.

**Table 13**: Release of *Calligrapha pantherina* in WNB during 2009.

| Date of rel | Approx. nos. of eggs rele | Adult beetles rele | Locality of rel | Smallholder block or Planta |
|---|---|---|---|---|
| 28 May 20 | 100 | 100 | Numundo Div | Plantation |
| 4 June 200 | 200 | 100 | Siki LSS | Smallholder |
| 19 June 20 | 200 | 100 | Poinini | Smallholder |
| 23 June 20 | 100 | 100 | Mandopa VOP | Smallholder |
| 25 June 20 | 200 | 100 | Buluma VOP | Smallholder |
| 7 July 200 | 100 | 100 | Dami | Plantation |
| 9 July 200 | 100 | 100 | Banaule VOP | Smallholder |
| 19 July 20 | 100 | 100 | Dami | Plantation |
| 28 July 20 | 100 | 100 | Kumbango Div | Plantation |
| 31 July 20 | 200 | 100 | Siki LSS | Smallholder |

**Water lettuce** (*Pistia stratiotes)*
A report was received from Barema Estate (Hargy Oil Palms), that *Pistia* was blocking some of the small waterways. The leaf feeding weevil *Neohydronomus affinis* Hustache (Coleoptera: Curculionidae) and host weed was collected from the old Agricultural Station at Kapore (WNB). A culture of the weevil is maintained at Dami, and when there are sufficient numbers of infested plants, they are returned to Barema and released in the river. This operation was halted after the heavy flooding in early 2010 as the weed had been washed away. The culture is being maintained at Dami.

**Water hyacinth** (*Eichornia crassipes*)
Water hyacinth is cultured in half-200L plastic drums, and is infected with weevils of a different genus, *Neochetina bruchi (*Coleoptera: Curculionidae*)*-the Chevroned Waterhyacinth beetle. Host material is collected from waterways in WNB and infested plants are returned on an *ad hoc* basis. Monitoring of control efficacy is not undertaken.

**INSECTICIDE TRIALS** (D.Putulan)**. (RSPO 4.5, 4.6, 8.1)**
Six trials were conducted in 2009 at Banaule VOP, Waisisi Mini-Estate and Kumbango Plantation. Most of these trials were conducted in Plantations as it was difficult to negotiate trials without a fee when dealing with VOP block owners!

The objective of the trials was to test and quantify the efficacy of alternative insecticides to the current standard which is methamidophos (600EC). Orthene 75%WP, Imidacloprid 200SL, Cypermethrin 2% v/v, Acetamiprid 1%v/v were the systemic insecticides available for these trials (Table 14). Water solubility was an important criterion for selecting systemic insecticides for trunk injection however, most systemic insecticides available in PNG are not readily soluble in water and this meant our options were limited. Mortality was determined through bioassays that involved feeding "sexava" in cages using excised leaves from treated and control palms. The standard observation period was 10 days and the insecticide was considered effective if more than 60% of the "sexava" were dead after 10 days.

Orthene and Methamidophos were compared initially (Fig. 29), and it was clear that fresh material was more effective. This had resulted from workers and growers complaining that methamidophos was not killing sexava.

Treatment with Imidacloprid resulted in mortality of adult sexava (*S.decoratus*); however results from two repeated trials were highly variable, with significantly less rapid mortality in the second trial (Fig. 30 & Fig.31), for reasons that cannot currently be explained. As mortality was determined through lab based bioassays, mortality in cages can be influenced by other factors such as temperature and continuous handling as for example when changing the treated leaflets. Further research is required to verify the efficacy of Imidacloprid as a candidate for trunk injection. Samples of leaflets retrieved from the treated palms four weeks after trunk injection and fed to sexava in cages showed that Imidacloprid slowed down feeding despite no mortality being observed. This verifies the fact that Imidacloprid has longer residual activity. This property of Imidacloprid may be exploited for long term treatment but requires further investigation.

Cypermethrin and Acetamiprid were not effective when injected into palms (Table 14). Cypermethrin is a synthetic pyrethroid while Acetamiprid is a neo-nicotinoid insecticide, both with relatively low toxicity. We appreciate the samples of both chemicals which were supplied by Chemica Ltd. Lae, PNG. Further trails will be conducted as new insecticides become available.

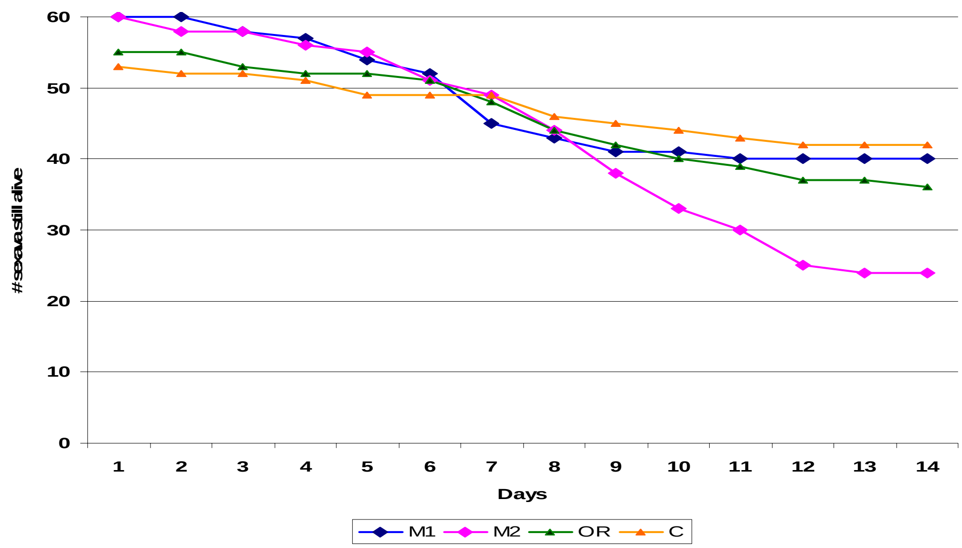



**Figure 29***:* Efficacy of Orthene 750WP and Methamidophos 600EC (M1 old, M2 fresh) against "sexava" applied through trunk injection.

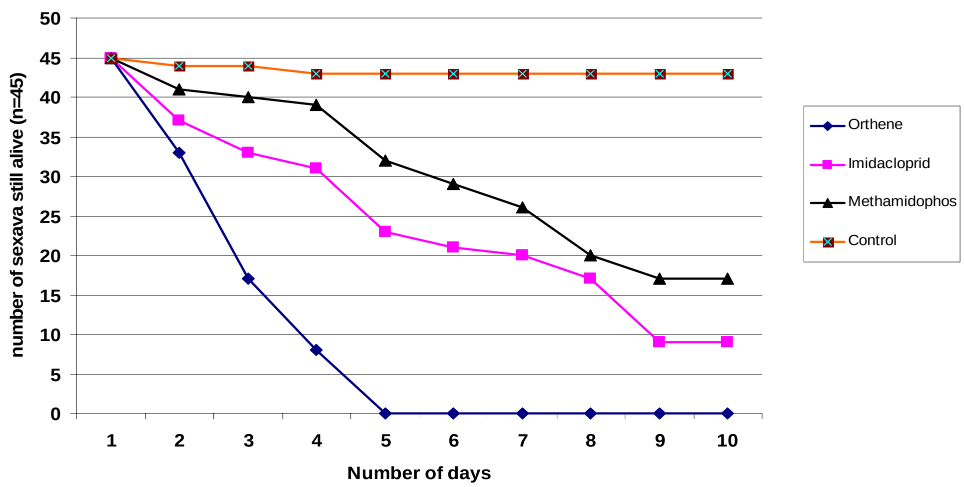



**Figure 30**: Efficacy of Orthene 750WP, Imidacloprid 200SL and Methamidophos 600EC against "sexava" through trunk injection.

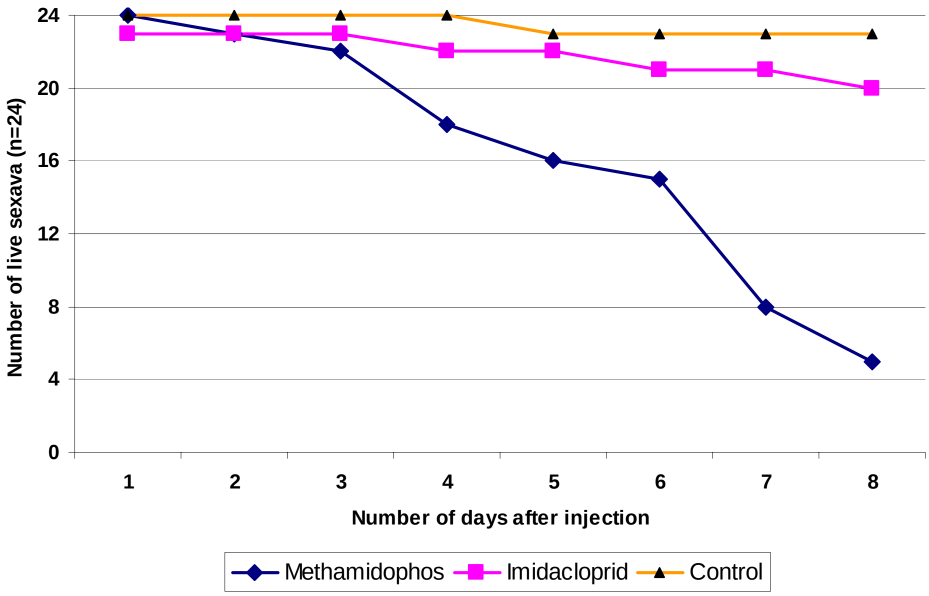



**Figure 31**: Efficacy of Imidacloprid 200SL and Methamidophos 600EC against "sexava" through trunk injection.

**Table 14.** Cypermethrin and Acetamiprid against "sexava" as applied through trunk injection (TTI).

| Treatment | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Cypermethrin (1%v/v) | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 |
| Acetamiprid (20%v/v) | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Untreated (Control) | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |

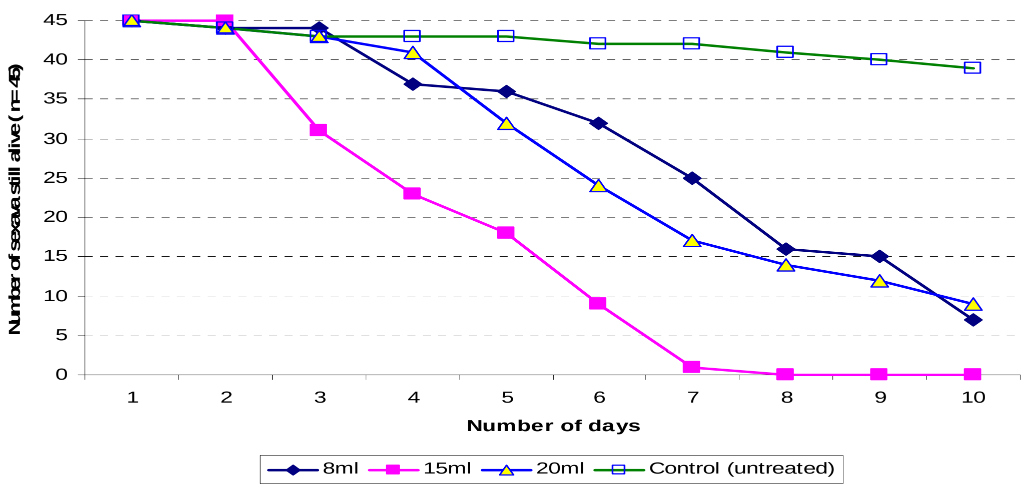



**Figure 32**: Comparison of different rates of Orthene 750WP against "sexava" applied through trunk injection.

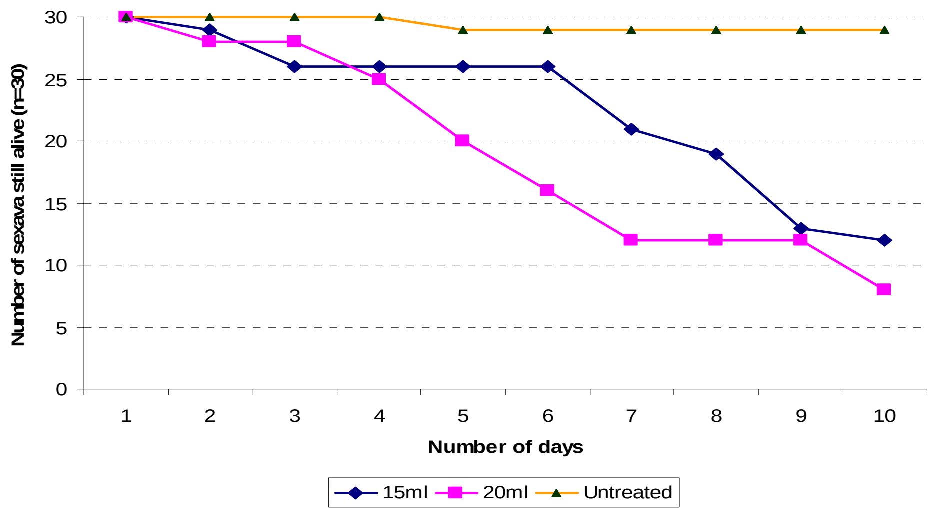



**Figure 32**: Efficacy of two rates (15ml & 20ml) of Orthene 750WP on “sexava” applied through trunk injection.

**Conclusion.**
The main finding from the six trials was that Orthene 750WP was effective at a minimum volume of 15ml (7.5g of active ingredient) injected into a palm in the standard method against “sexava” through TTI (Fig.32). A cost benefit analysis has not been undertaken for this insecticide. The powder form has a better shelf life than the liquid (with approx. 1 year), and if sachet production is an economically viable option Orthene should be considered.

**Observation trial on poor mortality using methamidophos**
There were reports received in December 2009.that no “sexava” mortality was observed a week after trunk injection at Buvussi. It was also reported that “sexava” were not dying quickly from tall palm trees compared to those dying in short palms. An observation trial was set up at Buvussi to verify this claim. Recently trunk injected trees were monitored for “sexava” mortality from both tall and short palms. After three days, dead and “sick” “sexava” were found under both tall and short palms. Although not many dead “sexava” were found, evidence of “sick” and dead “sexava” on the ground indicated that the insecticide was killing the insects.

**NURSERY PESTS**
Due to changes in the nursery and planting schedules at Higaturu, the young palms had become too tall for nursery surveys to be undertaken.

**BOGIA COCONUT SYNDROME (BCS) (RSPO 4.5, 8.1)**
A visit was made to Madang (Bogia) in 2008 and an initial survey made to look for possible vectors. Many coconut palms were attacked by *Oryctes rhinoceros*. Adults of this insect will be collected and checked for being a possible mechanical vector. No other insect taxa were found that could be considered vectors. A detailed report on the current situation was produced by PNGOPRA Plant Pathologist, and circulated to the BCS Technical Committee. No further visits will be made until funds are released to KIK by Government to support the work.

**QUEEN ALEXANDRA’S BIRDWING BUTTERFLY (*Ornithoptera alexandrae*) (RSPO 5.2, 8.1)**
Rules governing the import and analysis of plant material in Australia were altered by AQIS, and the *Pararistolochia* “family” material sent to the James Cook University, Townsville (Prof. B Bowden) will not be analysed until 2010. Collaborative work with OPRS (Tissue culture laboratory) continued with

emphasis on improving propagation techniques based on multiplication of known origin and food plant cutting material.

**POLLINATING WEEVILS (RSPO 8.1)**

**Ghana origin weevils.**
Approval from DEC to release the weevils that was granted during the year following the approval previously granted by NAQIA, cultures continued to be built up in the quarantine laboratory and their release at RAIL will be re-scheduled for 2010.

**Northern (Oro) Province weevil monitoring.**
Weevil monitoring continued during 2009, although there were some omissions during February & July (no reports were done), and for Heropa in December, when the bridge was washed away (Fig.33). Heropa (a grassland site) recorded consistently higher percentages of weevils carrying nematodes, except for the months of October and November. Weevil monitoring will cease at the end of the year, as without a close link with fruit set, there is little use in simply collecting data.

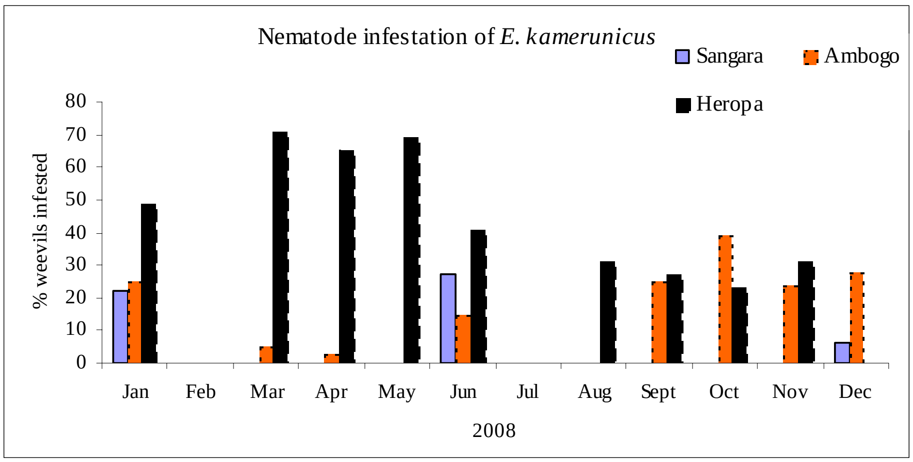



**Figure 33:** 2009 *Elaeidobius kamerunicus* weevils and nematode infestations from Northern (Oro) Province.

Weevil monitoring in WNB continued at a lower level as agreed at the SAC meeting in 2008; however data were collected from the 8yo palms at Dami beach (WNB) (Fig.34).

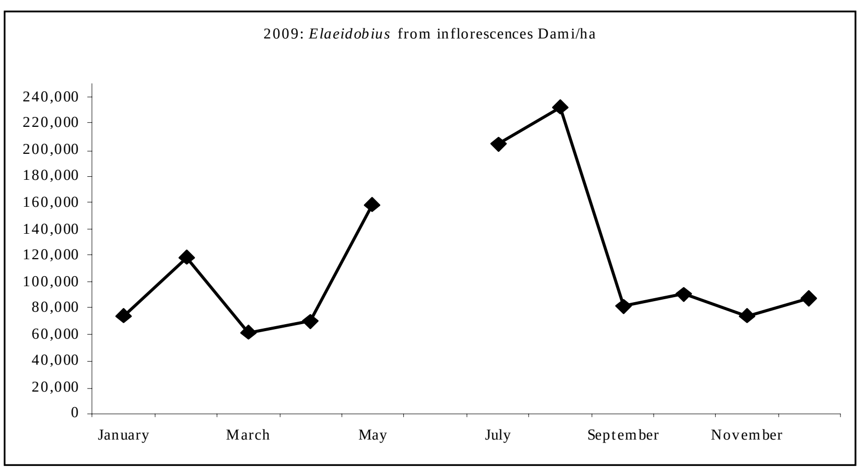



**Figure 34**: 2009 estimated number of *Elaeidobius*/ha from Dami Beach palms (based on 10 male flowers/ha). No collection was made during June.

**SMALLHOLDER AGRICULTURAL DEVELOPMENT PROJECT (SADP).**

A detailed list of equipment requirements for this project was prepared, and will be sent off once the project approval has been granted. The implementation of this project has been delayed by the donor (World Bank).

**REFERENCE AND REPRINT (ENDNOTE) DEVELOPMENT AND INSECT REFERENCE COLLECTIONS (RSPO 8.1)**

**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.

**Publication/Reprint collection**

Seven hundred and sixty-one (761) reprints and associated abstracts have been entered into EndNote database. Every reference is given a unique number and, when entered, is placed into a filing cabinet in numerical sequence. All available Abstract and source reference data are scanned and added on to this fully searchable database. The addition of new material is an on-going process as new scientific papers and grey literature is received.

**TRAINING AND FIELD DAYS (RSPO 1.1, 4.8, 8.1)**

The Entomology team was able to participate in OPIC field days that were scheduled to be held every Tuesday. Entomology staff assisted at 17 OPIC field days involving 1,161 growers. Field days are an important interface between ourselves and smallholder growers and we made sure that correct information was presented through this avenue. Two boards with information and photographs are used at these field days, while staff are available to answer questions. No field days were held by OPIC in Northern (Oro), New Ireland or Milne Bay. Field days in WNB are well attended, and copies of those attending are retained at entomology for audit purposes. During field days, displays of insect pest posters and live examples were used, while brief presentations were made on pest problems and the process of reporting pest infestations through OPIC. Training with encouragement for discussion is given in Tok-pisin by Entomology staff, and questions are encouraged.

The detail given through these training days is minimal, with the aim to get growers to understand what the problems with pests are, what they should look out for and to whom they should report. We do not expect them to become instant experts. Additionally, 10 separate sessions were held at Dami for NBPOL staff on pest Monitoring involving 63 people and there was also 1 school visit of 25 young people to introduce them to the pests and the work we are doing (Table 15).

The “Smallholder guide to growing successful and profitable oil palm”, which was produced by OPIC, PNG-OPRA and plantation companies in 2009, is useful as resource material. The Guide was produced in both English and Tok Pisin, and it covers all aspects of oil palm growing and management.

A single IPM Working Group (IPMWG) meeting was held during 2009.

**Table 15**. OPIC field days attended by entomology staff in 2009.

| Date | Division | Location | Type of training | Targeted group/company | No. of attendees |
|---|---|---|---|---|---|
| **07-April-2009** | Nahavio | Kambili | OPIC Field Day | Smallholder growers | 30 |
| 14-April-2009 | Nahavio | Rerengi | OPIC Field Day | Smallholder growers | 36 |
| 28-April-2009 | Nahavio | Morokea 2 | OPIC Field Day | Smallholder growers | 105 |
| 30-April-2009 | Nahavio | Kimbe Secondary School | Awareness | Students | 25 |
| **02-May-2009** | Dami | OPRA | Pest Monitoring | NBPOL | 4 |
| 05-May-2009 | Siki | Waisisi | OPIC Field Day | Smallholder growers | 75 |
| 06-May-2009 | Dami | OPRA | Pest Monitoring | NBPOL | 12 |
| 12-May-2009 | Siki | Gule | OPIC Field Day | Smallholder growers | 50 |
| 13-May-2009 | Dami | OPRA | Pest Monitoring | NBPOL | 5 |
| 19-May-2009 | Siki | Kololo | OPIC Field Day | Smallholder growers | 94 |
| **02-June-2009** | Kavui | Kavui/Kapore/Gaungo | OPIC Field Day | Smallholder growers | 121 |
| 02-June-2009 | Dami | OPRA | Pest Monitoring | NBPOL | 3 |
| 04-June-2009 | Dami | OPRA | Pest Monitoring | NBPOL | 5 |
| 05-June-2009 | Dami | OPRA | Pest Monitoring | NBPOL | 4 |
| 05-June-2009 | Dami | OPRA | Pest Monitoring | NBPOL | 3 |
| 23-June-2009 | Kavui | Kaus/Banaule/Dilima/Buluma/Mai | OPIC Field Day | Smallholder growers | 91 |
| 30-June-2009 | Kavui | Mosa/Mandopa/Kavui 1 & 2 | OPIC Field Day | Smallholder growers | 42 |
| **07-July-2009** | Salelubu | Ubae/Lavege | OPIC Field Day | Smallholder growers | 50 |
| 10-July-2009 | South | Nonopai | OPIC Field Day | Smallholder growers | 100 |
| **04-August-2009** | Buvussi | Bubu/Lilimo | OPIC Field Day | Smallholder growers | 50 |

**Extension: Radio Programmes.**
Four OPIC sponsored national radio programs involved the Entomology team. This was an important time for the programmes to be aired, as there were many outbreaks and the growers had to be made aware of our progress in relation to the management of these outbreaks. Radio programmes are scheduled through OPIC and are tailored to cover relevant topics at each session. Entomology provides expertise in the area of pest management.

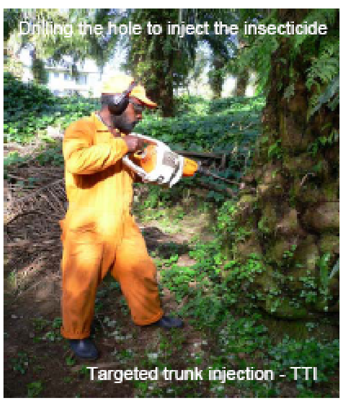
**IPM poster for OPRS**
A poster covering general the general IPM process was prepared for OPRS (Request from Sustainability Section) Fig.35.

## Integrated Pest Management (IPM)

•Knowledge of biology & ecology of the pests (insects & weeds) is essential, through awareness & training.
•Monitoring & reporting of pests & encouragement of beneficial organisms (nectar producing plants and natural enemies).
•Four types of long-horned grasshoppers (sexava), and two stick insects, all feed at night & hide during the day.
•Can cause serious damage to oil palm leaves, heavy infestations result in reduced crop (FFB) production.
•Improving an understanding of acceptable loss **below** economic threshold for oil palm.
•Timely & precise application of pesticide (TTI) by well trained operators (see photo below) is essential.



•Eggs of sexava like grains of brown rice, eggs of stick insects like oval seeds scattered on the ground, just below the surface or in mosses take a long time to hatch (up to at least 10 months).
•The young (nymphs), pass through 5 or 6 moults over a period of about 4 months.
•Many natural enemies (birds, mammals, snakes, frogs, many other insects, spiders), attack young & adults.
•All natural enemies are known as "beneficials", and some are reared at Dami and released to boost wild populations.




Other important insect pests of oil palm are:-
•**Bagworms (rough),** two kinds of **rhinoceros beetles,** but there are others….
•Bagworm larvae (caterpillars) live in hanging "bags" and when the larvae feed they make holes in the leaflets. Males are rarely seen as they only fly at night.
•There are two main types of rhinoceros beetles: *Oryctes*, and *Scapanes*: adults cause damage to oil palm by boring into the crown of young palms (young stages not a pest).
•.
•Cover crop (*Pueraria* & *Calopogonium*) should be planted to grow over the fallen trunks so speed breakdown, and re-cycle nutrients.

•Usually, no insecticide control is required, adults may be hand collected by "winkling".

### Integrated Weed Management (IWM)

•Herbicides are used to keep circles around the palms free from weeds. This allows the loose fruit to be clearly seen, and is a signal for timely harvesting. Beneficial weeds should not be sprayed to provide food & shelter for natural enemies.
•Paths must be kept clear to permit easy access to the palms, for harvest, FFB collection & for treatment teams.
•Sap-sucking insects, & physical control are used to manage *Mimosa* spp.
•A gall producing fly has been introduced to suppress the Siam weed (*Chromolaena odorata*).
•*Mikania micrantha* (mile-a-minute weed), is being controlled by using a specific "rust" fungus.
•Any signs of these weed plants should be reported to PNGOPRA.

PNG Oil Palm Association September 2009

**Figure 35**: IPM poster for OPRS Sustainability Section

**OPRAtive Word**

The OPRAtive Word
Technical Note 16
November 2009

## An alternative method for palm plugging during targeted trunk injection (TTI): Saving costs – observations using old palm nuts.

Deane N Woruba, Charles F Dewhurst & Simon Makai, PNGOPRA Entomology, Dami, WNB

### OBJECTIVE

To identify an alternative material to plugging treated palms with hardwood plugs that is durable, cost effective & environmentally acceptable.

### INTRODUCTION

Targeted trunk injection (TTI) is the term coined when trunk injection is used for the control of leaf-eating pests of oil palm or to poison unwanted or aged palms. This technique is used in oil palm plantations in Papua New Guinea (PNG). The holes in trunk-drilled oil palms are currently plugged with wooden plugs primarily to prevent water ingress and to prevent the subsequent invasion of the wound by insects and possibly fungi, when the insecticide effect has worn off after about 60 days.

OPRAtive Word Technical Note 3 (2004) addresses issues concerning the safe handling of the systemic insecticide methamidophos, while OPRAtive Word Technical Note 9 (2006) provides recommendations for the trunk drilling procedure as TTI.

Current recommendations for the control of leaf-eating pests of oil palm in PNG are that once the insecticide is injected, the drilled hole is plugged with a 20mm x 20mm square piece of hardwood cut to 10cm lengths, which is tapped into the hole in the trunk of the palm. Large sacks of plugs are taken into the field and "pluggers" need to replenish their carry packs regularly from a central area. They are also heavy and awkward to carry around and only a part of the wooden plug is tapped into the drill hole in the trunk, while most part sticks out. The plugs are sometimes maliciously removed, or fall out naturally as the drill hole edges rot back exposing people to potentially dangerous chemicals and leaving the hole in the palm at risk from contamination.

There are alternatives to wooden plugs for use in TTI. These include sand and water in Colombia and clay and petroleum tar in Malaysia. Petroleum tar is not readily biodegradable, may be toxic to the palms and it is heavy and awkward to carry. It is unlikely to be accepted by the palm oil industry in PNG due to the ISO-14001EMS and RSPO environmental standards. Clay is often used for plugging poisoned palms at replanting time in PNG, and although it is locally available, it is heavy and cumbersome to carry. Currently, in oil palm plantations in New Ireland and in some parts of WNB, wild shrubs are cut to make plugs. Although they are readily cut from the bush, plugs are usually not uniform in thickness, and most have to be sharpened to fit tightly into the hole in the palm. Preparing the plugs takes time, and is environmentally unacceptable. When forest shrubs are used, the wood is usually soft and rapidly breaks down. The sharpened plug also increases the risk of insecticide splash back to the operator when hammered into the drill hole. On mainland PNG, rotten fruits are often used to plug drill holes.

### TRIAL 1: INITIAL INVESTIGATION ON NEW IRELAND

#### Methods:

On Poliamba plantation, New Ireland Province, a small trial using 3 palms was set up, where the palms were drilled using the currently recommended trunk drilling procedure for TTI.

Each palm was plugged using either (1) native forest wood, (2) oil palm nut and (3) not plugged after drilling, leaving the hole exposed. These palms were felled after 12 months using a chainsaw, and checked to assess the fate of the plug options (Figs. 1-3 below). The felled palms were sectioned and photographed in July 2008 by one of us (DNW), with assistance of the field staff at Poliamba (CTP).

#### Results :

One palm had the wooden plug removed by person or persons unknown, while the nut remained intact and in place in the second palm. Extensive rot was observed around the drilled area in the palm that had not been plugged (Fig. 1), and in the palm where the wooden plug had been removed (Fig.2). The palm which had been plugged with the nut showed minimal comparable rot damage (Fig. 3). There were no data available on the comparative efficiency of uptake of insecticide in any of the palms.

Figure 1: Section of cut palm to show tissue rotting in an unplugged drill hole.

Figure 2: Section of palm to show drill hole plugged with forest cut plug (removed) to show decay.

Figure 3: Drill hole plugged with palm nut (nut removed to show minimal decay).
Note - the drill angle is incorrect in this photo as the section of palm has been removed for photography.

## TRIAL: 2: FIELD TRIAL AT NUMUNDO, WEST NEW BRITAIN

Oil palms approximately 15 years old that were suffering from an infestation of *S. decoratus* ("sexava") were drilled, injected with methamidophos and plugged using standard TTI procedures on 18 November 2008. Drilled palms were checked again on 28 May 2009, 191 days later.

### Methods

Two rows of adjacent palms (with 32 palms/row), were plugged using palm nuts while two subsequent rows (32 palms/row), were plugged after insecticide injection using the standard wooden plugs. After six months, all palms (64 palms) were checked, and the effectiveness of the plugs assessed.

A standard treatment team was used (driller, injector, plugger and supervisor). The time taken to drill, inject & plug a row (32 palms) was recorded for the four rows (128 palms), when either the palm nuts or hardwood plugs had been used.

### Results:

There was no significant difference between the time taken to complete the palm treatment process using the wooden plugs or the palm nuts. Both rows taking about 20 minutes, although one of the rows plugged with nuts was completed in 19 minutes.

The nuts and plugs were checked six months later (May 2009), and their condition assessed. Of those palms plugged with nuts, only two nuts were missing (2/32), while from the palms plugged with the square pegs, in seven palms (7/32), the plugs were very loose and easily dislodged, and were barely serving a hole-plugging function.

### Economic considerations.

Although the cost of the hardwood plugs might seem insignificant, with the number of palms being treated during pest management operations by plantation teams and Smallholder Affairs (SHA) teams in PNG, the cost becomes significant (Table 1).

### Cost Implications:

New Britain Palm Oil Ltd. (NBPOL) plantations and smallholder growers (through SHA) in West New Britain treated more than 20,000-ha of oil palm between 2005 and 2008 using wooden plugs made from sawn 10 x 2cm hardwood timber at a plug average cost of K0.15, (K0.15 in 2006, K0.14 in 2007, K0.16 in 2008). The current (2008) price for one linear metre of hardwood 2cm x 2cm is one plug is K1.60, this equates to K0.16 for each plug (we have calculated costs on the three year average cost of plugs).

Palm kernels tested as possible alternatives for palm plugging are those that are rejected and normally disposed of by NBPOL Seed Production Unit, so do not have any saleable value. We have given a nominal value (see calculations below in Table 1, based on the cost of nut oil) to a nut which is estimated to be worth about K0.0006. This is an equivalent value of some 250 nuts for the cost of one hardwood plug (average over three years is K0.15), which equates to 250 palms that may be plugged for the cost of one hardwood plug.

A 2ha block will therefore cost K40.96 using hardwood plugs, while with nuts the cost will be K0.14 (a saving of K40.82 per block.

For plantations, the cost of hardwood plugs required for a 30ha field will be K614.40 while using nuts will cost K2.15, a saving of K612.25 per field.

These costs do not however take into account the additional costs of labour, transport, fuel, or maintenance.

Table 1: Cost estimates for smallholder blocks. (NB. these totals will change as exchange rates and operating costs vary: the entire calculation is available if required).

| **Plug cost estimates per smallholder 2ha block** | | |
|---|---|---|
| Cost of one hardwood plug | 0.16 | Kina |
| 1 FFB | 25 | kg |
| Bunches per tonne | 40 | bunches/t |
| Kernels per bunch | 1500 | kernels/bunch |
| Total kernels in 1 tonne FFB | 60000 | kernels/tonne |
| Value kernel oil (Kimbe) | 370 | US$ |
| KOER (kernel oil extraction rate) | 3 | % |
| Value kernel oil in 1 tonne FFB in US$ | 11.1 | US$ |
| Exchange rate $ to Kina | 0.33 | |
| Value kernel oil in 1 tonne FFB in Kina | 34 | Kina |
| Cost of one kernel as plug | 0.0006 | kina |
| Size of field | 2 | ha |
| Palms per ha | 128 | p/ha |
| **Field of size** | 2 | ha |
| **Cost for hardwood plugs** | **40.96** | **Kina** |
| **Cost of kernel plugs** | **0.14** | **Kina** |

**Table 2**: Cost estimates for plantation field. (NB. these totals will change as exchange rates and operating costs vary & the entire calculation is available if required).

| **Plug cost estimates per 30ha plantation field** | | |
|---|---|---|
| Cost of one hardwood plug | 0.16 | Kina |
| 1 FFB | 25 | kg |
| Bunches per tonne | 40 | bunches/t |
| Kernels per bunch | 1500 | kernels/bunch |
| Total kernels in 1 tonne FFB | 60000 | kernels/tonne |
| Value kernel oil (Kimbe) | 370 | US$ |
| KOER (kernel oil extraction rate) | 3 | % |
| Value kernel oil in 1 tonne FFB in US$ | 11.1 | US$ |
| Exchange rate $ to Kina | 0.33 | |
| Value kernel oil in 1 tonne FFB in kina | 34 | Kina |
| Cost of one kernel as plug | 0.0006 | kina |
| Size of field | 30 | ha |
| Palms per ha | 128 | p/ha |
| **Field of size** | **30** | **ha** |
| **Cost for hardwood plugs** | **614.40** | **Kina** |
| **Cost of kernel plugs** | **2.15** | **Kina** |

## RECOMMENDATIONS AND CONCLUSIONS

These calculations (Table 1) show that for the cost of one hardwood plug, 250 palms may be plugged by nuts as opposed to a single (1) palm using the standard wooden plugs. The drill sizes are smaller and cheaper, and the interior surface area within the drill hole will be better covered with insecticide for the same volume of insecticide injected.

Although only a very small sample of palms was used for the preliminary trial in New Ireland, the larger trial at Numundo showed that it will be worth using nut plugging using the tougher "Dura" palm nuts for plugging palms that are also available for the same cost estimate. These palm nuts for distribution will be washed in bleach (not costed) and then dried in a hot room at 39-42$^{0}$C for a month before being used as plugs, as a precaution against possible germination and fungal contamination, however nuts from the mill which will have already been sterilised could also be used.

It is recommended that the supervisor be given the task of making sure that the drill site are clear of epiphytic growth (using a chisel to remove vegetation or obstructing frond bases) before hole drilling takes place, and that drill holes are all made on the same side of the palm. This will speed up the process of checking that TTI was effectively carried out. If needs be, the plug might be sprayed using white marker paint, however if supervision is effective, this should not be necessary.

It is also recommended that a smaller size drill bit (14mm) be used when the current drill bits are replaced. This is to ensure a tight fit of the nut into the hole to take into account peripheral tissue breakdown that occurs with time.

## ACKNOWLEDGEMENTS

We are very grateful to all who read this note and gave constructive criticism, especially Dr T K Lim, NBPOL, Dr Harm van Rees, PNGOPRA, David Mather, then GM, Hargy Oil Palms and Roger Benzie, Hargy Oil Palms and Mr Philip Vovola, Manager, Seed Production Unit, NBPOL, Dami.

Ruud Engbers, then GM, CTP Poliamba is also thanked for his support.

The CTP Poliamba Technical Services Department (TSD), NBPOL Smallholder Affairs (SHA) treatment team and Jim Kombuk, NBPOL Numundo Plantation Manager, are all gratefully acknowledged for their help.

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For Further Information Contact:
Head of Entomology
Papua New Guinea Oil Palm Research Association Inc.
P.O. Box 97, Kimbe, West New Britain Province, Papua New Guinea
Tel: +675 9854009 • Fax: +675 9854040 • Email: info@pngopra.org.pg

**Figure 36**: OPRAtive Word, Technical Note Number 16, November 2009.

## 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, no samples were received from NAQIA requiring identification.

**Pest Lists**
A pest list for oil palm in Papua New Guinea continues to be updated. Updating of the list continues to be made. A draft to be sent for comment to NBPOL Head of Research is expected to be completed during 2010.

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## ANNEX: IPM OF FINSCHHAFEN DISORDER (RSPO 4.5, 8.1)

*Integrated Pest Management for Finschhafen Disorder of Oil palm in Papua New* Guinea [CP/2006/063].

**Progress Summary from Annual Project Report 2009 (submitted to ACIAR)**.
The overarching aim of this project is to protect the viability of the important oil palm industry and the economic and social benefits that flow from production on plantations and smallholdings in Papua New Guinea. Specifically, the work concerns Finschhafen Disorder (FD), a problem that was first observed on coconut palms near Finschhafen, Morobe Province, Papua New Guinea (PNG) in 1960, and is now a potential threat to the production of palm oil. The very limited amount of previous research suggested that FD may be a direct consequence of feeding by a native PNG planthopper *Zophiuma lobulata* Ghauri (Hemiptera: Lophopidae). Previous studies however, pre-dated the availability of molecular biology methods that enable detection of possible plant pathogens. *Z.lobulata* belongs to a group of insects widely implicated in vectoring plant pathogens in other crops.
A full time Postdoctoral Fellow (Dr Catherine Gitau) and the project leader (Prof. Geoff Gurr) visited PNG to work with Charles Dewhurst Head of Entomology at PNG Oil Palm Research Association three times in the last year. Molecular biology and taxonomic expertise have been contributed by the ongoing involvement of Drs Andrew Mitchell and Murray Fletcher, respectively, of NSW Department of Primary Industries.

The first objective of this project is to develop a comprehensive biological understanding of the causes of FD. In pursuit of this, bibliographic information on FD and *Z.lobulata* as well as similar disorders and pests has been sourced from various scientific databases and an electronic library has been compiled using a proprietary 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 has been synthesised into a comprehensive review article that has been submitted for publication into the Australian Journal of Entomology.

The identity of *Z.lobulata* has been confirmed by comparing specimens collected from a range of locations in West New Britain with the formal taxonomic description for specimens from various parts of mainland PNG. This project has employed morphological characters, particularly male genitalia, and molecular methods using the CO1 gene. Results so far indicate consistency of all morphological and molecular characters and there was no evidence found for additional or cryptic species. Another congeneric planthopper to *Z.lobulata* namely *Z.pupillata* is currently being compared with *Z.lobulata* using both morphological taxonomy and bar-coding.

Screening of *Z.lobulata* and palm material for possible microbial pathogens was conducted. Pathogens screened were BLO's and Phytoplasmas well advanced and a series of large insect-proof cages has been constructed to establish an experiment to elucidate the role of *Z.lobulata* and its relationship with FD. Laboratory studies have shown that planthoppers will feed on a 5% sucrose solution presented through a semi-permeable membrane. This will enable samples of saliva to be collected from individual planthoppers for DNA testing for the presence of potential pathogens.

Field work aiming to identify natural enemies of *Z.lobulata* that could be used as biological control agents resulted in the collection of several taxa of parasitic wasps belonging to the family Mymaridae and Encyrtidae. These were common parasitoids of *Z.lobulata* egg masses on West New Britain. Samples of the Mymaridae were sent to Canada and UK for identification and revealed that they are new species. Mymarids are *Parastethynium* sp. near *P. mayeri* and the Encyrtids are *Ooencyrtus* near *minor* or *major* Perkins. amples of *Z.lobulata* that had been killed by insect diseases especially fungus have been collected from various sites in West New Britain and preserved material delivered to Australia. Preliminary identifications suggest most are a species of *Sporothrix* whilst others are from *Gliomatix* or similar genus. Further taxonomic and pathogenicity studies are planned. Monthly monitoring of *Z.lobulata* numbers and FD symptoms on betel nut, oil and coconut palm has been running since January 2008 and continued until February 2009 on a small holder oil palm block in West New Britain. Analysis of results is ongoing.

Work on the second objective of the project - to develop preliminary control methods for FD is contingent on the findings of the first objective.

A variety of coloured sticky traps have been evaluated in the field for monitoring adult *Z.lobulata* but proved to be ineffective. Laboratory experiments have taken place to evaluate the influence of nectar rich ground cover plants on the lifespan of the mymarids. Results showed that adults lived longer with access to the flowers compared with those that were fed on water alone. Further work will be conducted after establishing with certainty the link between *Z.lobulata* and FD.

# 3. PLANT PATHOLOGY RESEARCH

### HEAD OF SECTION: CARMEL PILOTTI

## OVERVIEW

The main laboratory for the Plant Pathology Section is part of PNG OPRA's Milne Bay Research Centre. Here, the Agronomy Section overseeing the Milne Bay trials is also based. In 2009 the Milne Bay Research Centre and the Plant Pathology Section underwent some changes with staff and projects.

**Staffing levels and changes in 2009**

| Name | Section | Status |
|---|---|---|
| Emmanuel Gorea | P/Pathology | New recruit, Assistant Plant Pathologist |
| Levi Tiriau | P/Pathology - DAMI | Transferred from Agronomy Section **at Dami** |
| Rachel Pipai | Agronomy | Relocated from Dami to Milne Bay |
| Carol Cholai | IS | Relocated from Dami to Milne Bay |
| Caleb Sagati | IS/GIS | New recruit – GIS/mapping |
| Tula Kini | Administration | New recruit – Office Supervisor |
| Maria Kome | Plant Pathology | Promoted to Senior Technical Officer |
| **Permanent staff at the MBRC** | **Agronomy 5**<br>**Plant Pathology 6**<br>**IS 2** | |
| **Total number of staff** | **13** | |

## DONOR PROJECTS

Two new externally –funded projects for the Plant Pathology Section commenced in 2009 and will terminate at the end of 2010. The first Project funded by the Agricultural Innovations Grant Scheme (AIGS), an AusAid beneficiary, commenced in 2009. This project provides funding for the development of Trichoderma species as biological control agents for Ganoderma. The second Project is funded by ACIAR and has a large component of the activities based in Solomon Islands where disease levels are high. This project commenced in June 2009 and will run for 5 years.

## THE EPIDEMIOLOGY OF BASAL STEM ROT (RSPO 4.5, 8.1)

### Objectives:

(1) To determine the mechanism(s) of secondary spread of Ganoderma within plantations in PNG and to apply this data to refine control methods.
(2) To generate epidemiological models from survey data that will allow growers to make predictions of crop loss and economic thresholds in future plantings.

### Introduction

Both qualitative and quantitative disease data from current plantings are required in order to assess the effects of disease on future generations of oil palm on the same sites. Data is collected on an annual basis through surveys carried out by plantation personnel and/or data submitted after rouging rounds.

### Methodology

All data presented here has been obtained from Milne Bay Estates Ltd., Poliamba Ltd. and New Britain Palm Oil Ltd. Survey data has been corrected where possible and only disease incidence data detected in the 2009 surveys but summaries also include palms that became symptomatic in 2008 but were not removed by 2009. Data has also been filtered to exclude inadequately sanitized stumps, sterile and standing, dead palms. Disease data for the OPRA study blocks was collected by OPRA personnel in biannual (Milne Bay) or quarterly (West New Britain) surveys.

**Disease progress in first generation oil palm:**

***Milne Bay***

The total disease incidence for 2009 expressed as the number of diseased palms per hectare for all Divisions in Milne Bay is shown in Figure 1. The highest incidence was recorded for Naura Division with 5.8 palms/ha being identified as infected in 2009. All other Divisions recorded less than 5 palms/ha with Ganoderma in 2009. Due to the late submission of data from the plantations, audits were not done on many of the blocks and hence errors are inherent in the data presented.

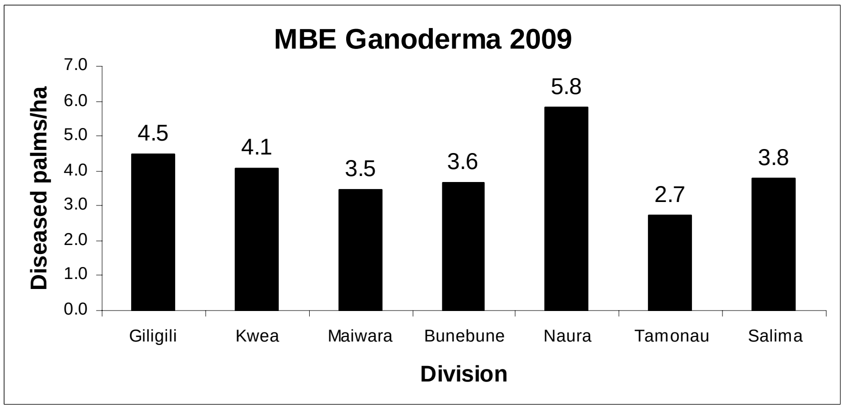


**Figure 1**. Number of diseased palms (per ha) detected in all Divisions in Milne Bay in 2009.

When viewed by category, the number of suspect palms appears to be increasing compared to the number of palms detected with brackets of Ganoderma in all Divisions in Milne Bay (Figure 2). In Mariawatte (Younger plantings), palms with brackets have not been detected.

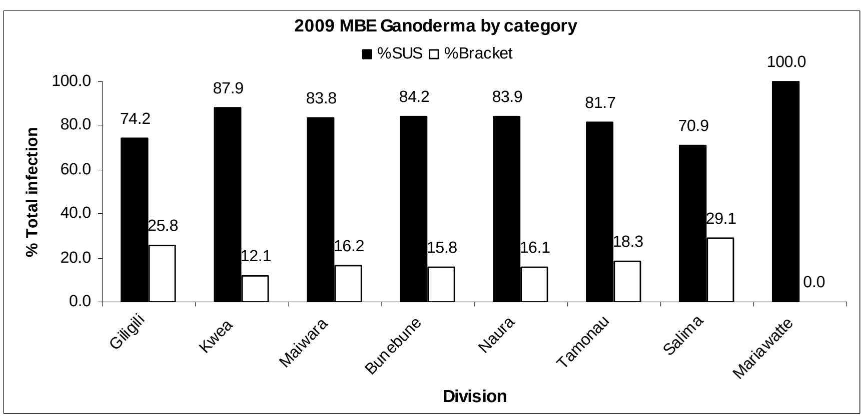


**Figure 2**. Disease incidence data (expressed as diseased palms/ha) by category for each Division in Milne Bay in 2009.

Ganoderma disease data collected from all blocks in all divisions in Milne Bay are shown in Figures 3 to 7. In Giligili Division, 36% of blocks recorded infections above 5 palms/ha in 2009 (Figure 3). Block 7205 recorded the highest incidence of 9.5 palms/ha. Disease data for Kwea Division is shown in Figure 4. Infection levels in the blocks surveyed ranged from 1 to 5 palms per ha.

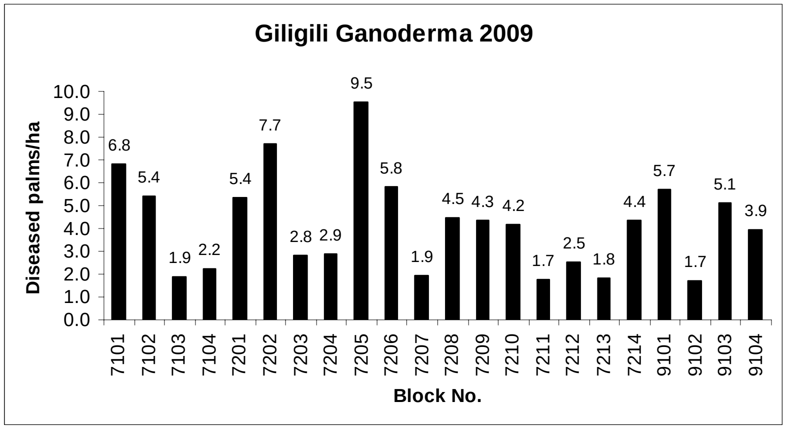


**Figure 3.** Disease incidence expressed as the total number of diseased palms per hectare including palms with basal and upper stem rot and suspect palms for Giligili Division, Milne Bay in 2009.

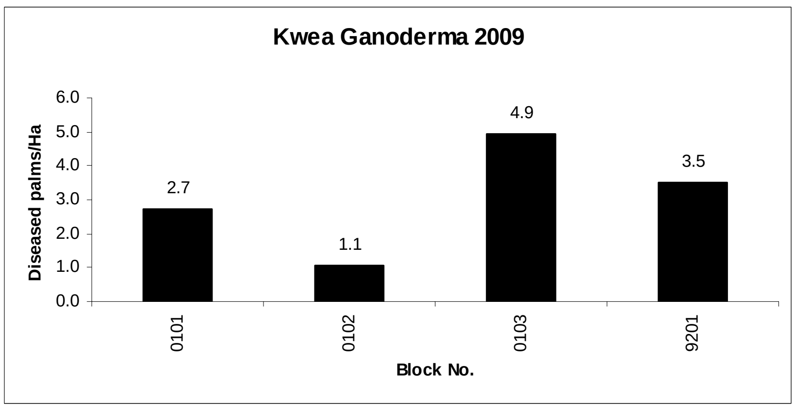


**Figure 4.** Disease incidence expressed as number of diseased palms per hectare for Kwea Division, Milne Bay in 2009. Total number of palms includes basal stem rot, upper stem rot and suspect palms.

Surveys were completed in only 60% of blocks within Naura Division in 2009 (Figure 5). The highest incidences were obtained for Blocks 6404 and 6505 with 7 to 8 palms per hectare recorded as infected. Most of the blocks in this Division are due for replant in 2010and 2011.

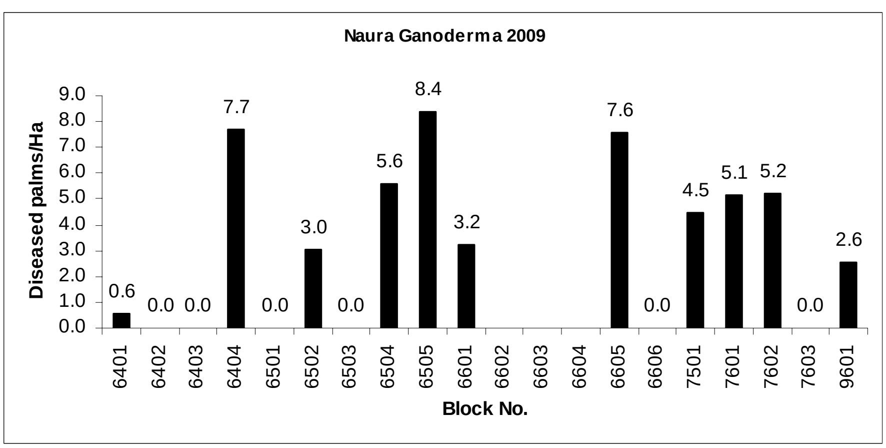


**Figure 5**. Disease incidence expressed as number of diseased palms per hectare for Naura Division, Milne Bay in 2009. The total includes palms with basal stem rot, upper stem rot and suspect palms. Blocks without bars were not surveyed in 2009.

The highest recorded disease incidences for Bunebune and Maiwara Divisions in 2009 were in the vicinity of 9-10 palms/ha, an increase on 2008 figures (Figures 6 and 7). The majority of other blocks in these Divisions recorded below 3 palms/ha infected in 2009.

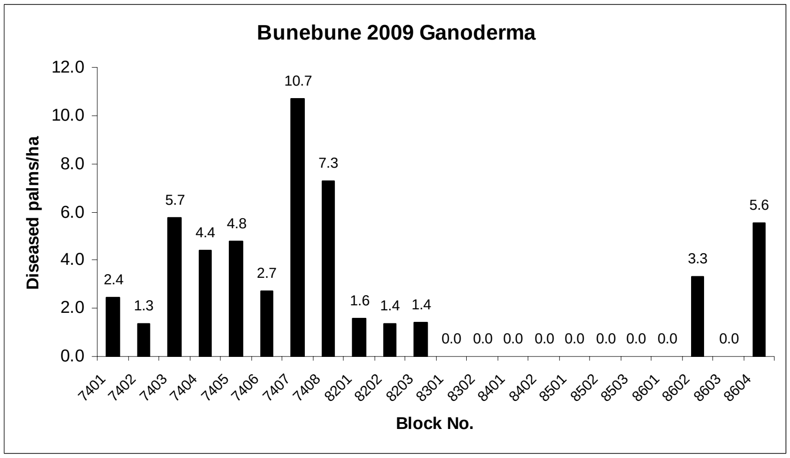


**Figure 6.** Disease incidence expressed as number of diseased palms per hectare for blocks in Bunebune Division, Milne Bay in 2009. Total includes palms with basal stem rot, upper stem rot and suspect palms. Blocks without bars were not surveyed in 2009.

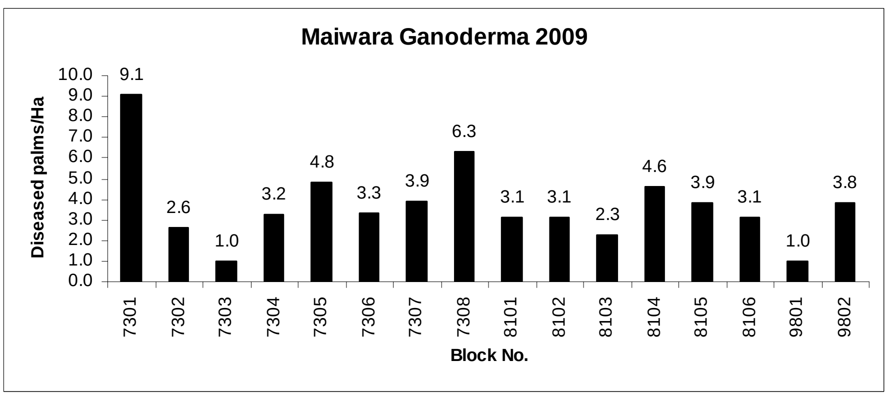


**Figure 7**. Disease incidence expressed as diseased palms/ha for Maiwara Division, Milne Bay in 2009. Total includes palms with basal and upper stem rot and suspect palms.

Disease progress curves for palms planted in 1986 and 1987 in Milne Bay are shown in Figure 8. Disease progress in these older plantings has been continuing in a non-linear fashion since about 2005 and the average level of infection in 24 year old palms is now 21% a significant increase of 4% from 2008.

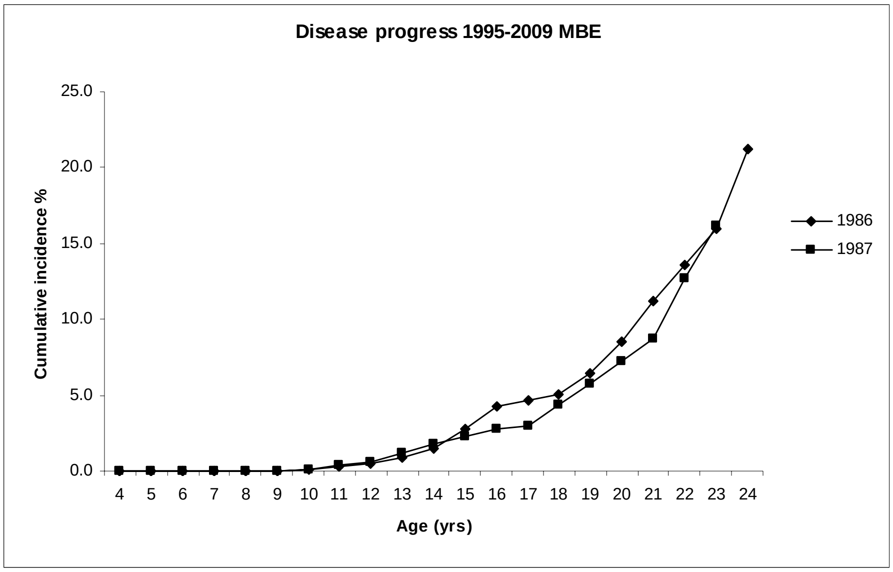


**Figure 8**. Cumulative disease incidence (1995-2009) for palms planted in 1986 and 1987 in Milne Bay.

*Disease progress in Ganoderma study blocks*

Updated disease incidence and progress curves for the six blocks in Milne Bay that are monitored by OPRA are shown in Figures 9a and 9b. Block 6503 recorded the highest disease levels in 2009. The sudden increase of over 5% in 2009 appears erroneous and the block is currently being audited to determine the cumulative incidence. For the remaining blocks the annual increase from 2008 was lower, ranging from 1.7% to 2.8%) and this could be a reflection of the higher efficiency of the control programmes within these blocks in previous years.

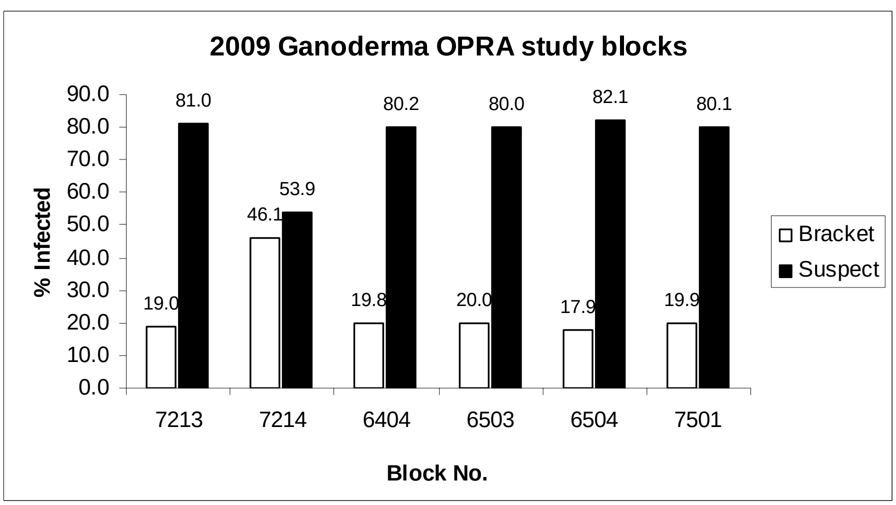


**Figure 9a**. Ganoderma disease incidence in the six study blocks in Milne Bay showing the numbers of palms with and without Ganoderma fruiting bodies.

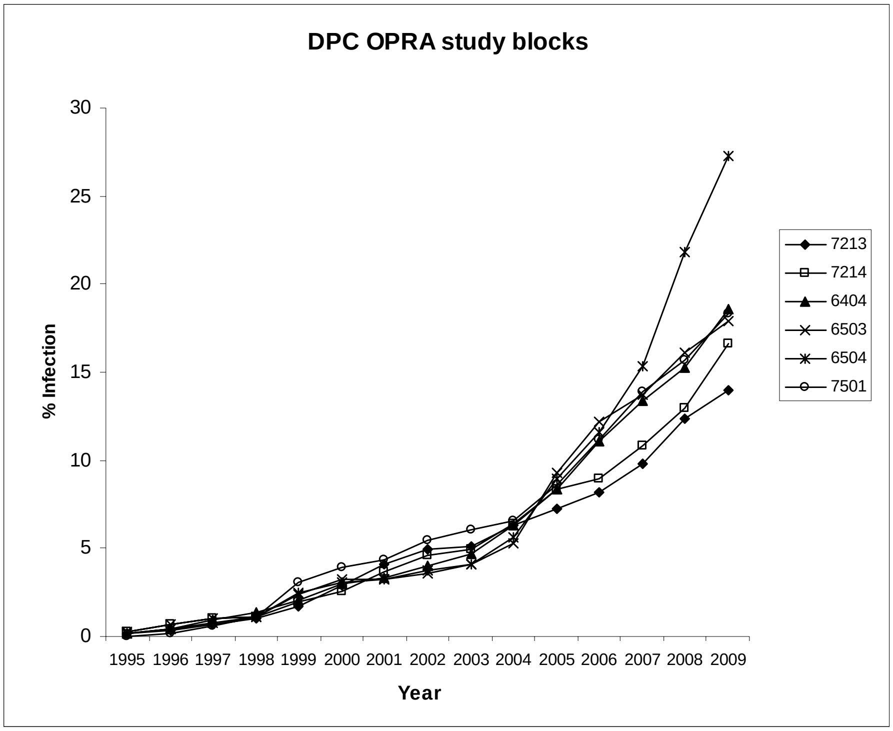


**Figure 9b** Disease progress curves from 1995 to 2009 for the six blocks selected for study in Milne Bay.

The disease incidence for Block 6404 is now at 18.6%, 6503 at 12.9% and 7501at 18.3%. Blocks 7213 and 7214 continue to record the lowest rates with the cumulative disease incidences now being 14% and 16.6% respectively. The disease rate for 7213 decreased in 2009 from 2008 and this is attributed to the very efficient sanitation being carried out in this block as part of the BMP trial.

*Disease control*

Removals in 1986 and 1987 plantings are lagging behind and many of the suspect palms are not being removed from year to year (Figure 10). In 2009, only Maiwara Division achieved over 90% removals. In the other Divisions, removal of infected palms was not completed in 2009; however the majority of infected palms still in the field from 2008 were removed. Infected palms still remaining in the field for 2009 should be removed in early 2010. Removals in the OPRA study blocks showed a significant improvement in 2009 with some blocks achieving 100% removals (Figure 11).

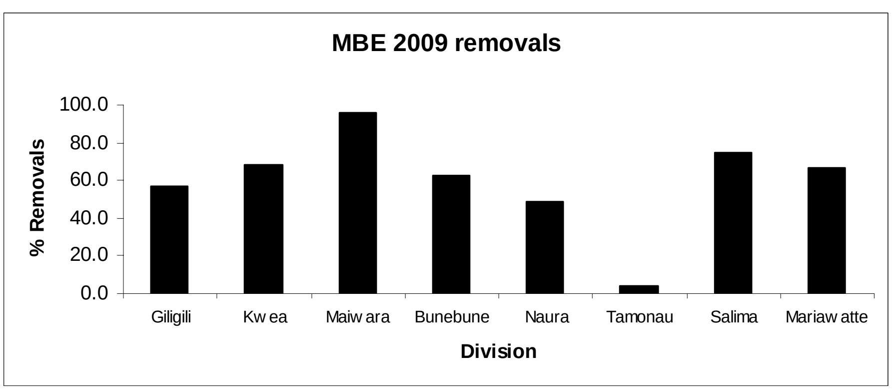


**Figure 10**. Removal efficiency for all Divisions in Milne Bay in 2009.

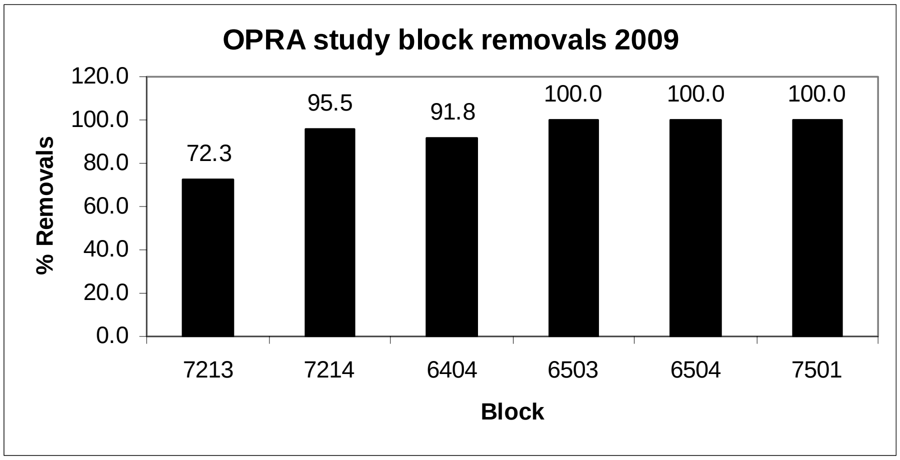


**Figure 11.** Removal efficiency in the OPRA study blocks, Milne Bay in 2009.

***New Ireland***
Surveys and Ganoderma infection levels for each estate at Poliamba in 2008 are shown in Figures 12 and 13.

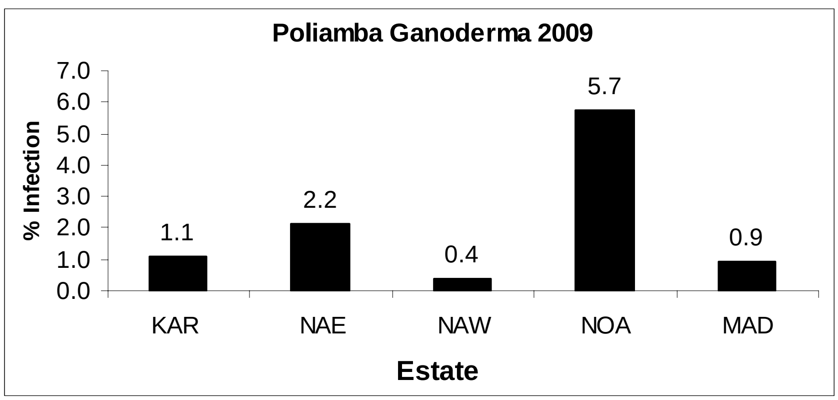


**Figure 12**. Ganoderma infection levels for all Estates at Poliamba New Ireland for 2009 expressed as the number of diseased palms per hectare.

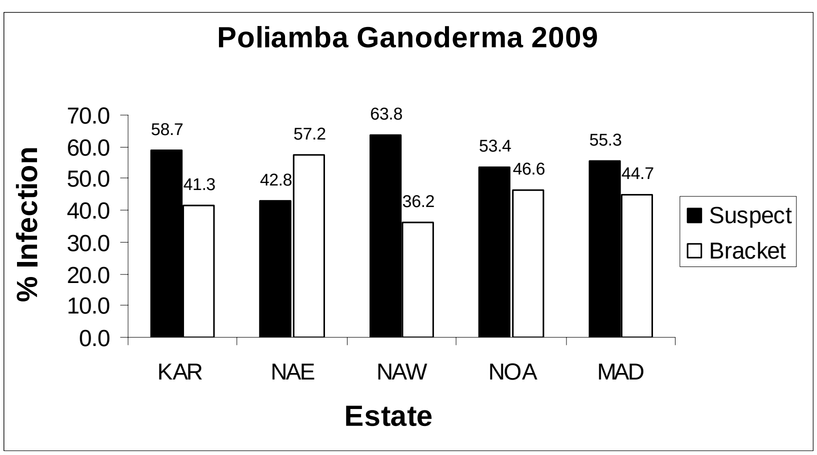


**Figure 13**. Infection levels by category for each Estate at Poliamba , New Ireland in 2009.

The highest Ganoderma levels for Poliamba in 2009 (5.7 palms/ha) were recorded for Notsi Division. All other divisions recorded less than 2 palms/ha infected in 2009 (Figure 12). At Poliamba, the number of palms with Ganoderma brackets was roughly equal to the number of suspect palms unlike the disease structure in Milne Bay (Figure 13)

*Disease control*
Surveys were not completed for any of the Estates except Kara Estate in 2009 where all blocks were surveyed (Figure 14).

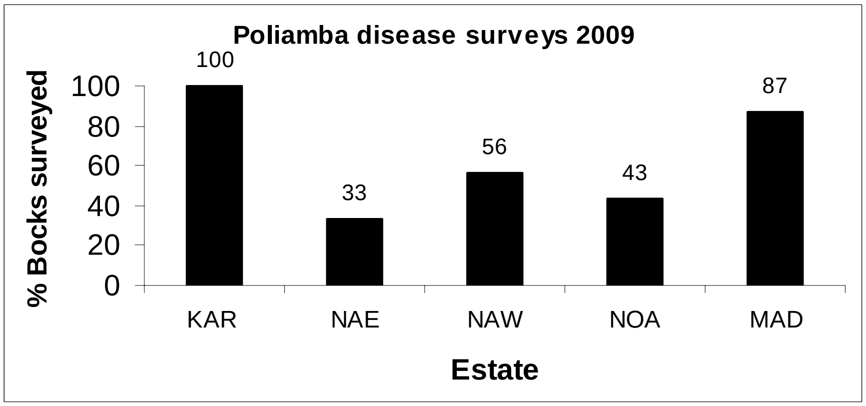


**Figure 14**. Blocks surveyed in 2009 for all Estates at Poliamba, New Ireland.

There were improvements in disease control in 2009 with all Divisions achieving a high efficiency compared to previous years (Figure 15). In Madak Estate, all infected palms identified in the surveys for Semesters 1 and 2 in 2009 were removed in the same year.

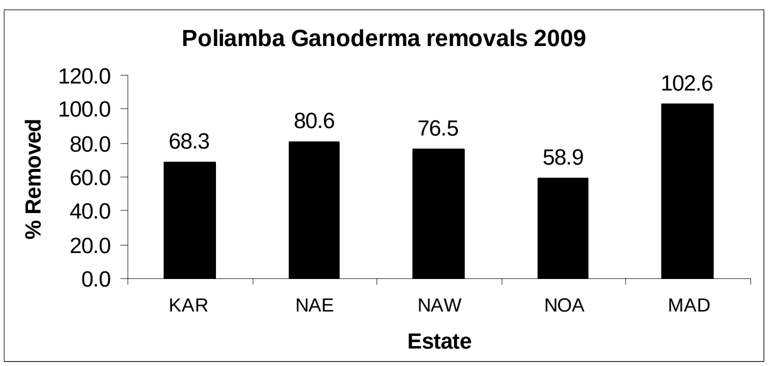


**Figure 15**. Removal efficiency for all Estates at Poliamba, New Ireland, for 2009.

***West New Britain***
Annual disease rates decreased at in 2009 for all E fields at Numundo except for E4 and E5 (Figure 16 which shows an increase in the disease rate from 2008). The reason for the marked increase in disease levels in Fields E4 and E5 is not known however, it may have been due to an inaccurate survey of the infected palms in 2008 or no-removal of 2008 infections which were taken up in the 2009 survey. Disease data collected through OPRA surveys suggests that the level of infection in E4 and E5 is lower than that presented.

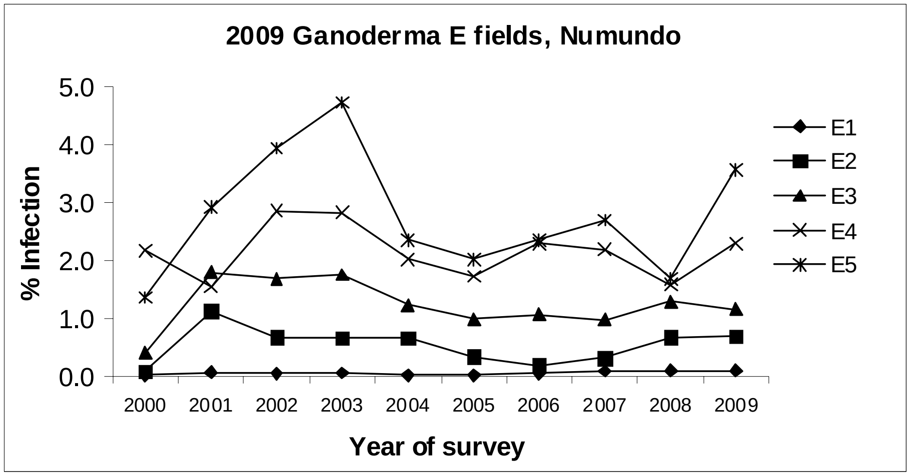


**Figure 16**. Annual disease incidence in 1994 Numundo E Fields, West New Britain from 2000-2009.

Disease progress curves for the period 2000-2009 show the continuing linear trend in infection levels in the E Fields (Figure 17). Field E5 continues to have the highest incidence which is now at 28%, followed by E4 with 22% cumulative incidence in 2009. Levels of infection in Field E1 remain below 1%. The reason for the lower incidence in Fields E1, E2 and E3 is still unknown.

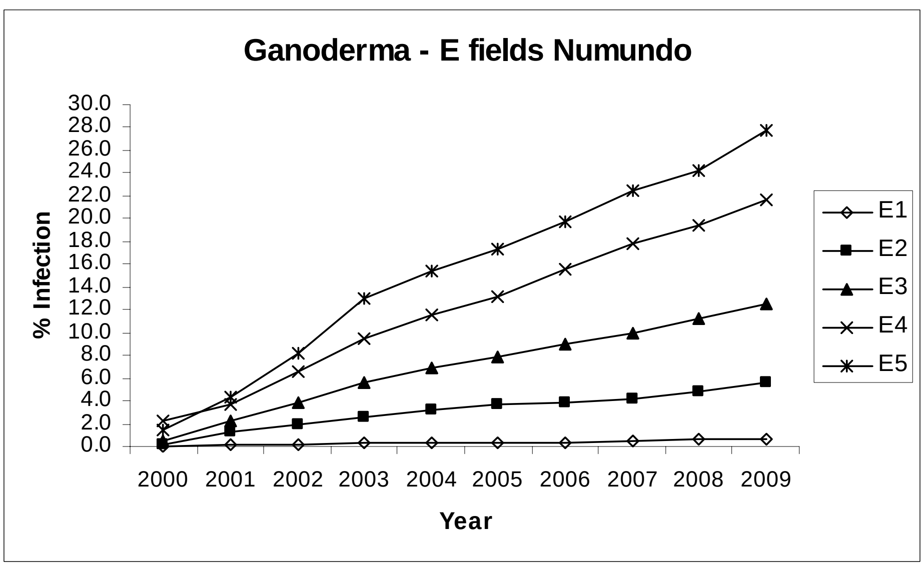


**Figure 17**. Disease progress curves for the 1994 E fields at Numundo, West New Britain Province from 2000-2009

In terms of management units (MUs), as expected the highest cumulative disease incidence (22%) was recorded in MU3 which comprises the worst affected Fields of E4 and E5 9Figure 18). This figure is above the theoretical threshold level of 20% and some yield loss was observed in 2008.

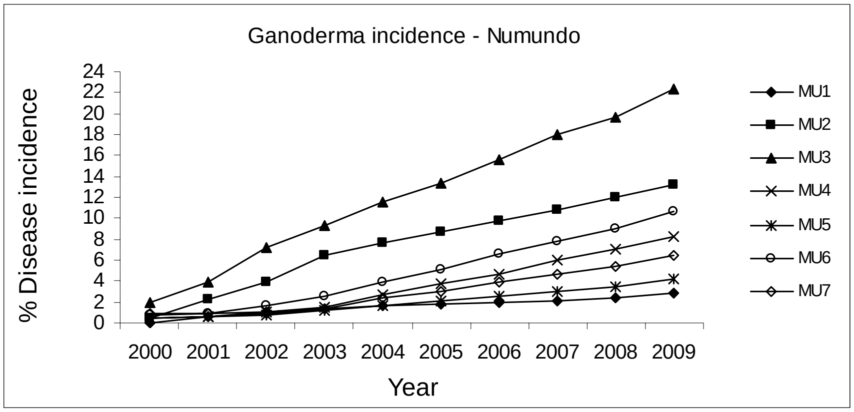


**Figure 18**. Disease progress curves for the period 2000-2009 for Numundo, West New Britain by Management Unit (MU). MU3 is comprised of Fields E4 and E5.

In contrast, the adjacent F fields recorded a steady disease rate in 2009 except for Fields F3 and F5 where disease levels increased slightly in 2009 (Figure 19). Disease levels are well below that of the worst affected E fields and range from 3.8% in Field F2 to 11.8% in Field F3 (Figure 20).

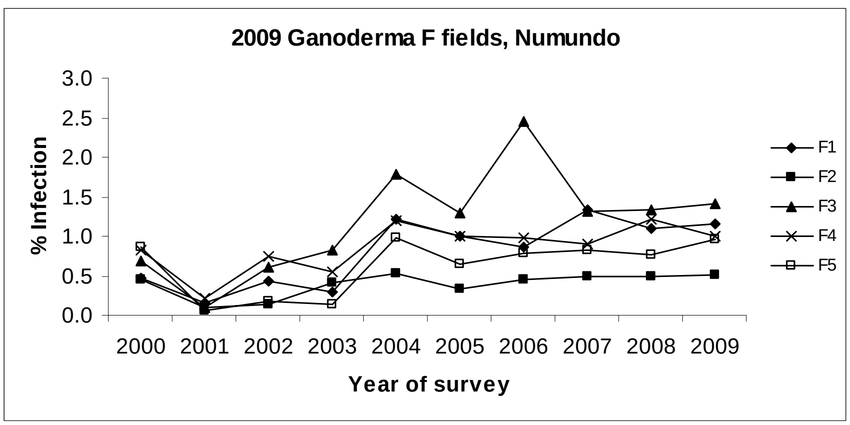


**Figure 19**. Annual disease losses for 1995 F Fields at Numundo, West New Britain Province from 2000-2009.

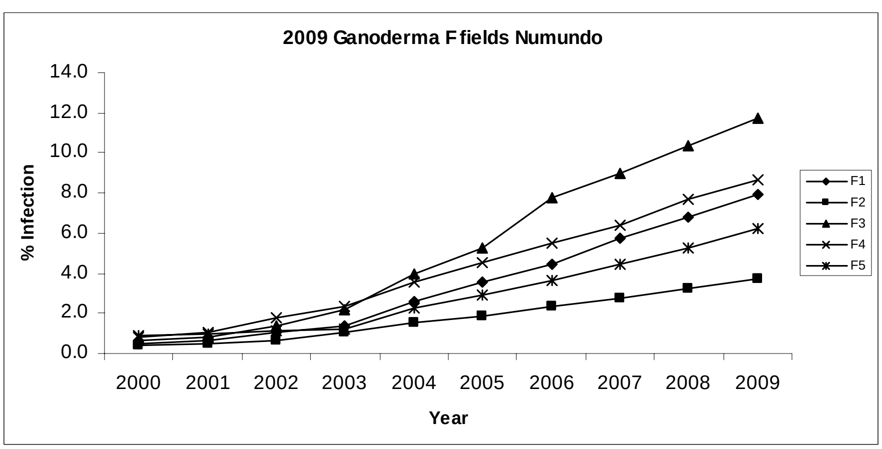


**Figure 20**. Disease progress for the period 2000-2009 for 1995 F fields at Numundo, West New Britain.

*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 per palm for selected MU3 in West New Britain shown in Figure 21. Yield data for Milne Bay has not been verified and therefore will not be presented here. The yield decrease observed in 2008 for MU3 at Numundo appears to have been reversed in 2009 with an average yield of 0.3 tonnes per tree. Yield data has been provided from the plantations and will be verified.

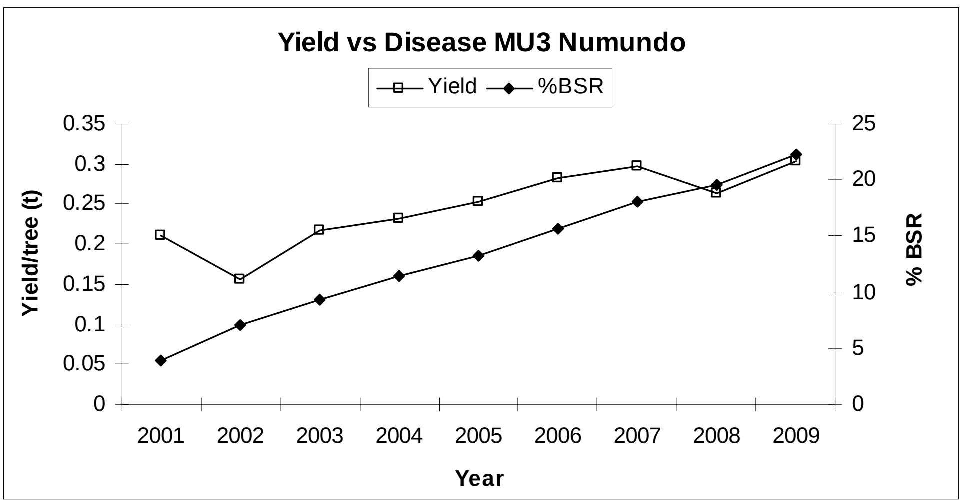


**Figure 21**. Effects of Ganoderma disease on palm production in fields with the highest infection levels (MU3) at Numundo, West New Britain from 2000-2009. Yield curve is derived from plantation data.

All study blocks in Milne Bay recorded a yield increase despite increases in disease levels except for Block 6503 which showed a decrease in production 2009 (data not shown).

**Ganoderma BMP blocks**
In 2008, blocks were selected in Milne Bay for treatment as *Ganoderma* BMP blocks. It was anticipated that if the efficiency of removal could be increased in selected blocks, the disease incidence data should provide some means of comparison against blocks in which removals were low and irregular. After 12 months, there does not appear to be a significant difference in the levels of disease between BMP blocks and other blocks within the plantation (data not shown). This is partly because the removals in the BMP blocks have not been satisfactory. Longer term evaluation is warranted in order to assess the effectiveness of regular removals.

**Epidemiology**

*Mapping for replant*
All of the six OPRA study blocks were mapped in anticipation of replant in 2010. Disease points were located using GPS and maps generated by the newly formed GIS unit. These maps will be used to

monitor the spread of Ganoderma in the new plantings. Maps will continue to be updated until the blocks are replanted. An updated map for Block 7213 to 2009 is shown below (Figure 22).

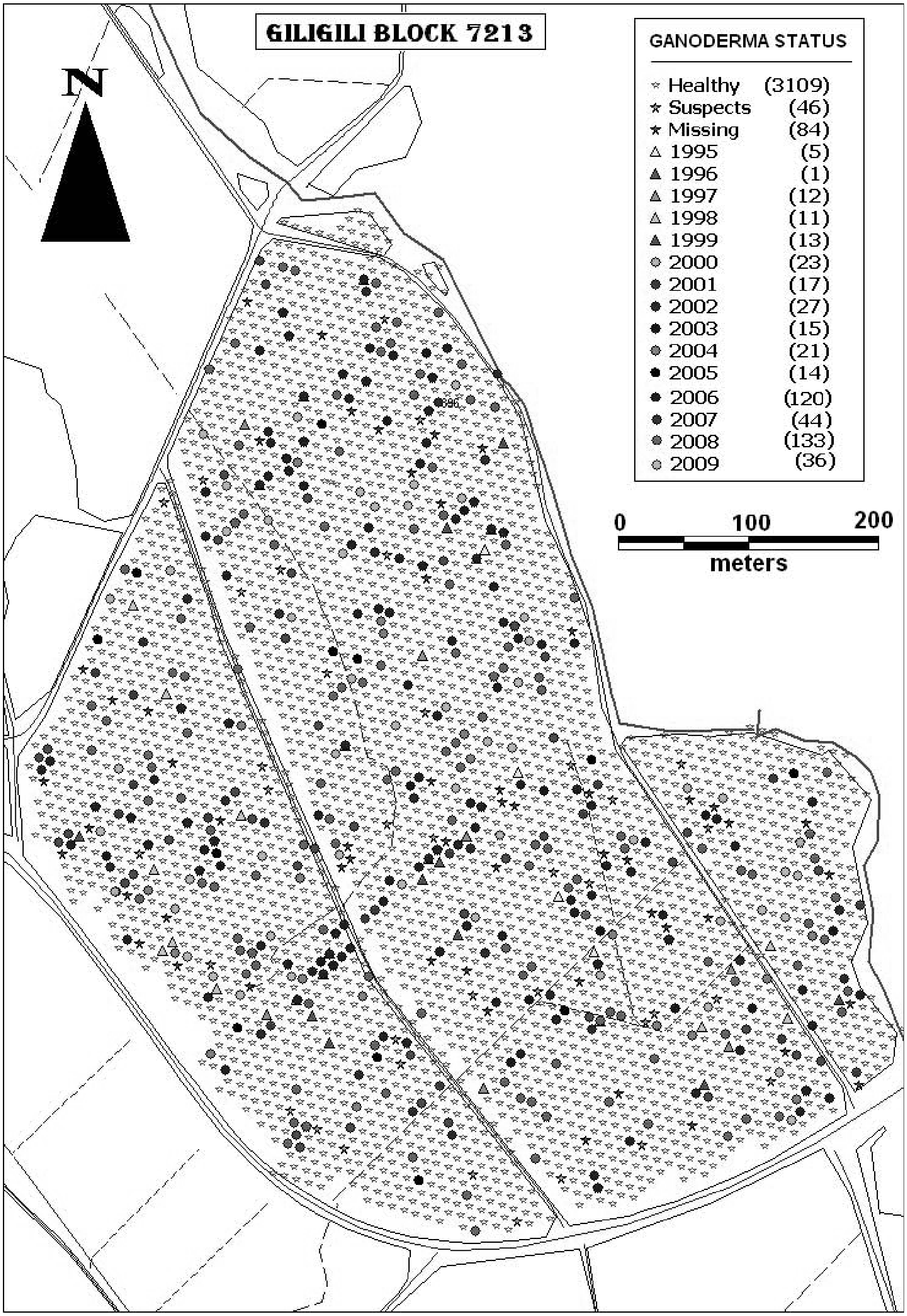


**Figure 22**. Map of Ganoderma infections from 1995 to 2009 for Block 7213.

## THE POPULATION DYNAMICS OF *G. BONINENSE* ON OIL PALM (RSPO 4.5, 8.1)

**Objectives:**
(1) To determine temporal changes in the population structure of *G. boninense* on oil palm
(2) To determine the secondary mode(s) of disease spread

**Introduction**
Knowledge of the structure of the *Ganoderma* population and changes in this structure over time are an important part of understanding the epidemiology of basal and upper stem rot. The study of the population has been conducted over a ten-year period in selected blocks in Milne Bay to determine the primary agents of disease spread. More recently, study areas in New Ireland (Poliamba) and West New Britain (Numundo) have been added to this study as a means of comparison.

**Methodology**
Surveys are conducted bi-annually by the plantations in Milne Bay and New Ireland and quarterly in West New Britain. Ganoderma specimens are collected from infected palms in the selected fields and mycelium is isolated from these in the laboratory. Spore prints are also obtained from all Ganoderma brackets in Blocks 7213 and 7214 in Milne Bay. Mating tests are then carried out between spore isolates from different fruiting bodies. Where spores are not collected, vegetative compatibility tests are carried out between selected isolates collected from different palms.

**Results**

***The population in Milne Bay***
As in previous years, bi-annual surveys of the six designated Ganoderma study blocks in Milne Bay were completed in 2008 and samples were collected for laboratory studies only from blocks 7213 and 7214. The number of isolates collected from each block is shown in Table 1.

**Table 1**. Areas surveyed and number of Ganoderma isolates collected in the 2009 surveys at Milne Bay (OPRA blocks only).

| Block # | Ha surveyed | No. isolates collected |
|---|---|---|
| 7213 | 29.9 | 17 |
| 7501 | 69 | 65 |
| 6404 | 63.9 | 58 |
| 6503 | 76 | 36 |
| 6504 | 36 | 47 |

Crosses amongst isolates from Block 7213 were discontinued in 2009 in order to give priority to other areas of research hence test data is not available.

***The population in West New Britain***
The number of isolates collected in 2009 from Fields E4 and E5 at Numundo are given in Table 2. Due to the large number of infected palms at Numundo, only the isolates obtained from neighbouring, infected palms or palms in the same row were tested for mycelial compatibility in 2009. The results of some of these tests are presented in Table 3 and show that all isolates are genetically distinct except for isolates 2293 and 2182, 2710 and 2731 and 2718 and 2719 from three pairs of adjacent palms. This result indicates a direct relationship between isolates from the two pairs of palms and possibly a common source of infection.  These results are currently being verified with a view to further investigation.

**Table 2**. Ganoderma isolates collected from infected palms at Numundo, West New Britain Province in 2009.

| Location | Ha surveyed | No. of isolates collected |
|---|---|---|
| Field E4 | 59.05 | 160 |
| Field E5 | 28.10 | 64 |

**Table 3**. Vegetative compatibility tests amongst isolates from Ganoderma brackets collected from neighbour palms in Fields E4 and E5, Numundo, West New Britain Province in 2009.

| Isolates | Result | Isolates | Result | Isolates | Result |
|---|---|---|---|---|---|
| 2306:2305 | *incompatible* | 2367:1775 | *incompatible* | 2393:1914 | *incompatible* |
| 2306:2112 | *incompatible* | 2367:1765 | *incompatible* | 2182:1978 | *incompatible* |
| 2306:2004 | *incompatible* | 2367:1622 | *incompatible* | 2182:1914 | *incompatible* |
| 2305:2004 | *incompatible* | 2367:1599 | *incompatible* | 2375:2376 | *incompatible* |
| 2305:2112 | *incompatible* | 2368:2369 | *incompatible* | 2375:1786 | *incompatible* |
| 2305:1816 | *incompatible* | 2368:2271 | *incompatible* | 2375:2293 | *incompatible* |
| 2333:2355 | *incompatible* | 2368:2105 | *incompatible* | 2375:2182 | *incompatible* |
| 2335:2336 | *incompatible* | 2368:2271 | *incompatible* | 2375:1978 | *incompatible* |
| 2335:2357 | *incompatible* | 2368:2105 | *incompatible* | 2375:1914 | *incompatible* |
| 2357:1740 | *incompatible* | 2368:1778 | *incompatible* | 2376:1786 | *incompatible* |
| 2336:1741 | *incompatible* | 2369:2271 | *incompatible* | 2376:1787 | *incompatible* |
| 2337:1741 | *incompatible* | 2369:2105 | *incompatible* | 2377:2184 | *incompatible* |
| 2359:1632 | *incompatible* | 2369:1778 | *incompatible* | 2377:2185 | *incompatible* |
| 2360:2361 | *incompatible* | 2271:2105 | *incompatible* | 2377:1915 | *incompatible* |
| 2361:1892 | *incompatible* | 2271:1778 | *incompatible* | 2377:1788 | *incompatible* |
| 2361:1893 | *incompatible* | 2105:1778 | *incompatible* | 2185:1915 | *incompatible* |
| 2361:1744 | *incompatible* | 2370:1908 | *incompatible* | 2185:1788 | *incompatible* |
| 2361:1745 | *incompatible* | 2370:1909 | *incompatible* | 2378:1916 | *incompatible* |
| 2362:2267 | *incompatible* | 2371:2177 | *incompatible* | 2380:1567 | *incompatible* |
| 2362:2268 | *incompatible* | 2371:1975 | *incompatible* | 2381:2294 | *incompatible* |
| 2267:2268 | *incompatible* | 2372:2347 | *incompatible* | 2282:1992 | *incompatible* |
| 2363:2362 | *incompatible* | 2372:2346 | *incompatible* | 2282:1807 | *incompatible* |
| 2363:2267 | *incompatible* | 2372:2179 | *incompatible* | 2383:2111 | *incompatible* |
| 2363:2340 | *incompatible* | 2372:1911 | *incompatible* | 2383:1994 | *incompatible* |
| 2363:2268 | *incompatible* | 2347:2346 | *incompatible* | 2111:1994 | *incompatible* |
| 2293:2182 | *compatible* | 2347:2179 | *incompatible* | 2384:1997 | *incompatible* |
| 2710:2731 | *compatible* | 2347:1911 | *incompatible* | 2385:2386 | *incompatible* |
| 2718:2719 | *compatible* | 2346:1911 | *incompatible* | 2385:2302 | *incompatible* |
| 2340:2288 | *incompatible* | 2373:1617 | *incompatible* | 2385:2065 | *incompatible* |
| 2364:1972 | *incompatible* | 2374:2375 | *incompatible* | 2385:1813 | *incompatible* |
| 2364:1973 | *incompatible* | 2374:2293 | *incompatible* | 2385:2002 | *incompatible* |
| 2364:1905 | *incompatible* | 2374:2182 | *incompatible* | 2385:1611 | *incompatible* |
| 2364:1760 | *incompatible* | 2374:1978 | *incompatible* | 2385:1569 | *incompatible* |
| 2386:2302 | *incompatible* | 2374:1914 | *incompatible* | 2386:2065 | *incompatible* |
| 2386:2162 | *incompatible* | 2393:2182 | *incompatible* | 2386:2002 | |

## BIOLOGICAL CONTROL OF GANODERMA USING INDIGENOUS ISOLATES OF *TRICHODERMA* SPP. Incorporating AIGS project N-0854 (RSPO 4.5, 8.1)

**Objective**:
To utilize *Trichoderma* spp. as natural antagonist of Ganoderma to prevent Ganoderma infection through pruned frond bases and other oil palms substrates in field situations.

**Introduction**
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. In 2006 a collaborative project was set up between staff from the University of Kent and PNG OPRA to investigate the possibility of using indigenous isolates as biocontrol agents for Ganoderma on oil palm. This study was completed

in 2007. 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 2009 under the new AIGS Project.

**Methodology**
As described in previous reports, *Trichoderma* isolates were obtained from Milne Bay in 2004 from soil samples by baiting or direct isolation. Some isolates were obtained from pieces of oil palm wood in the field.

Species identifications based on traditional morphological characterization and groupings based on molecular genomics were carried out at Kent University as well as the *in-vitro* tests against Ganoderma.

**Results**

***In-vitro Testing***
*Liquid culture trials*
Further trials were carried out using different culture media in order to assess the most suitable medium for conidia and mycelial development. In the first experiment, selected *Trichoderma* isolates were grown in 3 different media and the weights of conidia produced in each of the media were determined (data for one isolate only is shown, Table 4). In the second experiment, different media were tested against selected fast-growing isolates of *Trichoderma*.

**Table 4**: Yield of spores obtained for Trichoderma culture SP5A under both stationary and shaking culture.

| | **SP5A** | |
|---|---|---|
| Media solution | Shaker culture | Stationary culture/NUV |
| TJB | 9mg/100ml | 9mg/100ml |
| RBB | 9mg/100ml | 20mg/100ml |
| YEM | 5mg/100ml | No result |

*Results*
A higher number of conidia were produced with RBB media during stationary culture. This is probably due to the fact that stationary cultures were also exposed to light to enhance the production of conidia. TJB was the medium of choice when cultures were grown with shaking. Good conidial production was observed after 7 days incubation at 150rpm (Table 5)

**Table 5**: Conidia production in *Trichoderma* cultures in different media after 7 days on a shaker @ 150rpm

| | B | | BN | |
|---|---|---|---|---|
| | mycelium | spores | mycelium | spores |
| TJB1 | + | + | + | + |
| TJB2 | + | + | + | + |
| TJB3 | + | + | + | + |
| RBB1 | + | - | + | - |
| RBB2 | + | - | + | - |
| RBB3 | + | - | + | - |
| YEM1 | <+ | - | + | - |
| YEM2 | <+ | - | + | - |
| YEM3 | + | - | + | - |

***Trichoderma: Ganoderma* incompatibility**

*Experiment 1*

Trichoderma isolates SP5A, Bu and C were each challenged with *Ganoderma dikaryons* #1026, #1301, #1326 and #1320 for 2 weeks. After 1 week and 2 weeks of incubation an agar plug was removed 1 cm away from the original Ganoderma inoculum and subcultured to GSM for 1 week.

*Results*

In all the agar challenges with the four different dikaryotic isolates, SP5A consistently inhibited the growth of each Ganoderma dikaryon to an average length of 0.1 cm. The maximum growth of the Ganoderma culture was not more than 0.5 cm. After 1 week of incubation together with the Trichoderma cultures, the Ganoderma had lost viability. After 2 weeks, however, cultures removed from the plates containing #1301 vs C, #1320 vs Bu and #1326 vs C tested positive for Ganoderma on GSM indicating that the Ganoderma had not been killed during the testing (Table 6).

**Table 6**: Length of different isolates of Ganoderma after 1 week incubation on agar with different isolates of Trichoderma.

| Trichoderma vs Ganoderma | Length of Ganoderma (cm) (Mean of triplicate plates) | GSM after 1 wk | GSM after 2 wk |
|---|---|---|---|
| #1026 vs Bu | 0.3 | | |
| #1026 vs C | 0.3 | - - - | - - - |
| #1026 vs SP5A | 0.1 | - - - | - - - |
| #1301 vs Bu | 0.3 | - - - | - - - |
| #1301 vs C | 0.1 | - - - | - - - |
| #1301 vs SP5A | 0.1 | - - - | - + + |
| #1320 vs C | 0.2 | - - - | - - - |
| #1320 vs SP5A | 0.1 | - - - | - - - |
| #1320 vs Bu | 0.2 | - - - | - - - |
| #1326 vs Bu | 0.1 | - - - | +++ |
| #1326 vs C | 0.4 | - - - | - - - |
| #1326 vs SP5A | 0.1 | - - - | - - + |

*Experiment 2*

The growth of Ganoderma dikaryon #1031 on oil palm rachis tissue was tested against Trichoderma isolates SP5A, Bu and C. Rachis blocks (x12) were autoclaved and allowed to cool to room temperature. Agar plugs of a *Ganoderma* and a *Trichoderma* culture were placed at each end of the rachis blocks. Cultures were incubated for 2 weeks before final measurement were made. Assays were done in triplicate.

*Results*

Growth of Ganoderma isolate #1301 was severely restricted with over 80% inhibition. However, after 2 weeks, the Ganoderma culture was still viable (Table 7).

**Table 7:** Growth of Ganoderma isolate #1301 after 2 weeks incubation on rachis blocks with different cultures of *Trichoderma.* Data were expressed as % of control colonies without antagonist and values are average of 3 replicates.

| Treatment | Mean length (cm) of Ganoderma isolate # 1301 | Inhibition Effectiveness (%) | GSM Result #1301 |
|---|---|---|---|
| SP5A | 1.1 | 87.4 | - + + |
| Bu | 1.4 | 83.9 | + + + |
| C | 1 | 88.5 | - + + |
| Control | 8.7 | 0.0 | + + + + |

*Experiment 3*
Trichoderma isolates SP5A, Bu and C were each tested against Ganoderma isolate # 1326 on rachis blocks for two weeks. At the end of the challenge, measurements were taken on the length of the Ganoderma culture. The Ganoderma culture from each of the blocks was later subcultured onto GSM to ascertain if it was still viable.

*Results*
After 2 weeks incubation with Trichoderma cultures SP5A, Bu and C, the Ganoderma culture was killed and no longer viable. The Trichoderma cultures effectively prevented the growth of Ganoderma with over 90% inhibition (Table 8).

**Table 8**: Growth and viability of *Ganoderma* dikaryon #1326 incubated with selected Trichoderma cultures on oil palm rachis tissue for 2 weeks.

| Treatment | Length (cm) of Ganoderma isolate # 1326 Two weeks growth | Inhibition Effectiveness (%) | GSM Result #1326 |
|---|---|---|---|
| SP5A | 0.13 | 93.16 | - - - |
| Bu | 0.10 | 94.74 | - - - |
| C | 0.10 | 94.74 | - - - |
| Control | 1.90 | 0.00 | |

*- = nil growth of the Ganoderma isolate*

*Ecological studies*
The diversity of fungi on frond bases was examined in order to assess the potential for competition with and Trichoderma cultures applied as biological control agents. Twenty-three different fungi were isolated and tentatively identified from rotting frond bases on mature pams.(Table 9).

**Table 9**. Fungi isolated and tentatively identified from oil palm frond butts collected in Milne Bay.

| Sample # | Isolate | Tentative identification |
|---|---|---|
| 1 | FS2- F6 | Trichoderma sp. |
| 2 | FS6- F3 | Penicillium sp. |
| 3 | FS1- F5 | Aspergillus sp. |
| 4 | FS1- F1 | Trichoderma sp. |
| 5 | FS2- F4 | Trichoderma sp. |
| 6 | FS1- F2 | unknown |
| 7 | FS6- F11 | Trichoderma sp. |
| 8 | FS2- F5 | Unknown basidiomycete |
| 9 | FS6- F4 | Unknown basidiomycete |
| 10 | FS7- F4 | Rhizoctonia sp. ? |
| 11 | FS1- F4 | Thielaviopsis sp. |
| 12 | FS9- F1 | Rhizoctonia sp. ? |
| 13 | FS6- F6 | Trichoderma sp. |
| 14 | FS1- F2 | Aspergillus sp. |
| 15 | FS7- F1 | Penicillium sp. |
| 16 | FS6- F7 | Thielaviopsis? |
| 17 | FS4- F2 | RHizoctonia sp. ? |
| 18 | FS6- F5 | unknown |
| 19 | FS2- F7 | unknown |
| 20 | FS4- F4 | Trichoderma sp. |
| 21 | FS3- F5 | basidiomycete |
| 22 | FS3- F2 | Pythium sp. ? |

**Frond base fungal isolates and *Trichoderma* spp.**
Fungal isolates from the frond butts were the used to assess their interaction with Trichoderma isolates being developed for use as biological control agents.

*Results*
The majority of fungi isolated from the frond butts did not significantly affect the growth of the Trichoderma isolates used. However, three isolates (FS-2, FS-5 and FS-20) either out-grew or grew

equally as fast as all four Trichoderma cultures. These fungi have the potential inhibit the growth of sprayed formulations and need to be identified for further investigations.

**Table 10**. Growth of frond butt fungal isolates on agar in the presence *Trichoderma isolates* BN, SP5A, C and B.

| Isolate | Observation | | | |
|---|---|---|---|---|
| | BN | SP5A | C | B |
| FSI-1 | 14mm: 6mm | 13mm: 5mm | 14mm: 7mm | 14mm: 6mm |
| FSI-2 | 0.5mm: 15mm | 8mm: 5mm | 5mm: 10mm | 10mm: 4mm |
| FSI-3 | 17mm: 1mm | 16mm: 2mm | 17mm: 1mm | 16mm: 1mm |
| FSI-4 | 13mm : 7mm | 14mm : 6mm | 13mm : 7mm | 12mm : 7mm |
| FSI-5 | 10mm: 10mm | 10mm: 10mm | 10mm: 10mm | 10mm: 10mm |
| FSI-6 | 18mm: 1mm | 15mm: 1mm | 16mm: 1mm. | 10mm: 3mm |
| FSI-7 | 13mm: 7mm | 12mm: 8mm | 13mm: 7mm | 13mm: 7mm |
| FSI-8 | 18mm: 1mm | 18mm: 1mm | 18mm: 1mm | 18mm: 1mm |
| FSI-9 | 14mm: 2mm | 14mm: 2mm | 8mm: 4mm | 13mm: 1mm |
| FSI-10 | 10mm: 5mm | 10mm: 5mm | 14mm: 0mm | 10mm: 4mm |
| FSI-11 | 18mm: 2mm | 18mm: 1mm | 18mm: 2mm | 18mm: 2mm |
| FSI-12 | 13mm: 2mm | 13mm: 1mm | 13mm: 1mm | 10mm: 1mm |
| FSI-13 | 14mm: 6mm | 13mm: 5mm | 14mm: 6mm. | 14mm: 6mm |
| FSI-14 | 12mm: 2mm | 17mm: 3mm | 10mm: 3mm | 11mm: 3mm |
| FSI-15 | 14mm: 2mm | 12mm: 1mm | 14mm: 1mm | 13mm: 1mm. |
| FSI-16 | 15mm: 0mm. | 15mm: 0mm | 14mm: 0mm | 10mm: 0mm |
| FSI-17 | 17mm: 3mm | 15mm: 5mm | 17mm: 3mm | 17mm: 3mm |
| FSI-18 | 13mm: 1mm | 12mm: 2mm | 13mm: 1mm | 12mm: 1mm |
| FSI-19 | 8mm: 4mm | 10mm: 2mm | 13mm: 0mm | 7mm: 6mm |
| FSI-20 | 10mm: 10mm | 10mm: 10mm | 10mm: 10mm | 10mm: 10mm |
| FSI-21 | 10mm: 2mm | 13mm: 2mm | 18mm: 3mm | 14mm: 2mm |
| FSI-22 | 17mm: 1mm | 17mm: 1mm | 17mm: 1mm | 17mm: 1mm |

**Field trials with Trichoderma suspensions**

Several sets of field trials were undertaken in 2009. The results of these trials have not been summarised as yet but generally, variability due to weather conditions is an inhibiting factor. Trials are continuing.

**QUARANTINE (RSPO 4.5, 8.1)**

**Nursery inspections**

The two quarantine nurseries at Milne Bay were inspected on a regular basis in 2009 and no major problems were reported.

**Bogia Coconut Syndrome**

In 2008, a disorder affecting coconuts in Bogia, Madang Province was reported by CCI and in November 2008, PNG OPRA staff were invited to the first meeting of a Technical Committee to investigate the matter as a precaution against any movement of biotic agents to oil palm. A collection of samples in Madang Province in May 2009 was made, processed and a selection sent to New Zealand for analysis. A report was written and circulated to relevant stakeholders. A condensed version is attached at the end of this report.

**PUBLICATIONS, CONFERENCES, TRAVEL AND TRAINING (RSPO 1.1, 4.8, 8.1)**

**Travel**

1) Visits were made to the following locations during 2009 by C. Pilotti:
2) Poliamba Ltd., New Ireland for training and Ganoderma control audits
3) NBPOL - Dami/Numundo West New Britain Province - for trial sampling
4) (GPPOL, Solomon Islands - for site selection of trials and sample collection in June and November 2009
5) CCI Stewart Research Station and Bogia, Madang Province - for discussions on Bogia Coconut Syndrome (BCS)

6) Madang (Bogia) for sampling of coconuts in May 2009.

**Publications**
An OPRAtive Word bulletin was prepared for distribution.

**OTHER ACTIVITIES**

**AIGS Ganoderma Project (RSPO 4.5, 8.1)**
General administration of this Project throughout the year. The report on the activities of this project are provided above.

**ACIAR Ganoderma Project – The control of basal stem rot caused by Ganoderma in Solomon Islands**
The Project Proposal was finalized in early 2009 and the project officially commenced in June 2009. Partners in the Project are the University of Queensland, Australia and GPPOL in Solomon Islands. As part of the activities in 2009, the two sites selected for Ganoderma disease trials were surveyed and disease maps drawn (Figure 23). Samples of the progenies were also taken and sent to the University of Queensland for molecular typing.

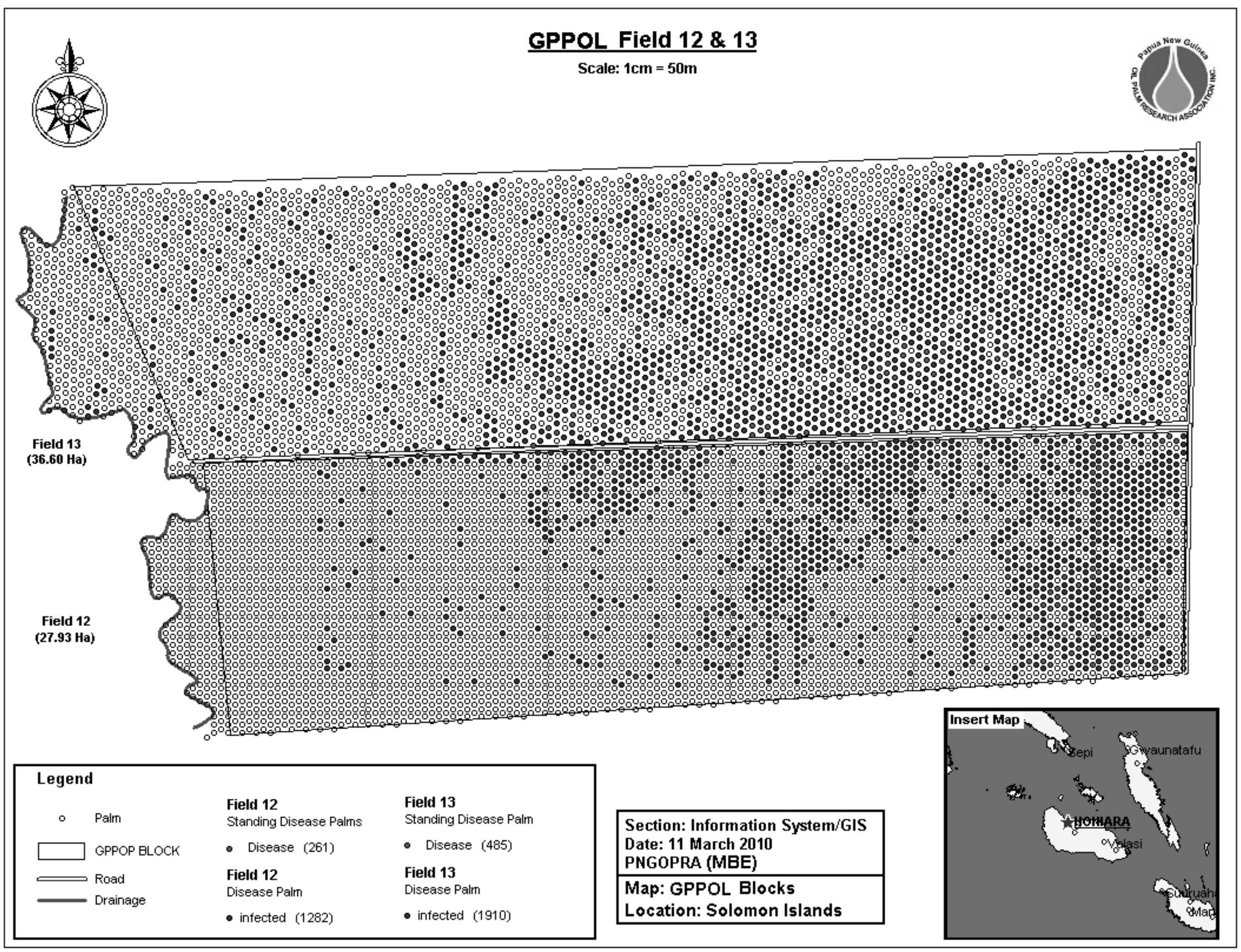


**Figure 23**. Map of Fields 12 and 13 at Ngalimbiu, GPPOL, Solomon Islands, showing the disease points.

**DISEASE REPORTS (RSPO 4.5, 8.1)**

**Table 11**. Disease reports attended to in West New Britain in 2009.

| LOCATION/ BLOCK | DESCRIPTION |
|---|---|
| 002-0501/Tamba | 1 palm infectected by G.boninense-light |
| 002-0503/Tamba | 1 palm infectected by G.boninense-light |
| 975/ Sarakolok | 1 palm infectected by G.boninense-light |
| 003-0941/ Sarakolok section 6 | 1 palm infectected by G.boninense-light |
| 023-0135/ Waisisi | 1 palm infectected by G.boninense-light |
| 004-1403/ Buvusi | 2 palm infectected by G.boninense-light |
| 004-1488/ Buvusi | 1 palm infectected by G.boninense-light |
| 015-0045 / Banaule | 1 palm infectected by G.boninense-light |
| 015-0047 / Banaule | 1 palm infectected by G.boninense-light |
| 1.006- 1768 / Waramari/Kavui | 5 palm infectected by G.boninense-severe |
| Togulo Plantation/ MU4A | 4 palms infected by Wet Stem Rot - Severe |
| 35006/ Ewasse VOP | 8 palms severely infected by G.boninense |
| Soi VOP | G.tornatum growing on a a felled palm |
| Area 9 block 6 | 9 palms affected by crown disease |
| 017-0152 /Gaongo-Section 2 | 1 palm infectected by G.boninense-light |
| 001 -0270 / Kapore - Section 1 | 1 palm infectected by G.boninense-light |
| 022-0522 / Tamba- Section 8 | 1 suspected palm |
| 006-1755 / Kavui Sect.1, Road 40 | 1 palm infectected by G.boninense-light |
| 006 - 1798 / Kavui Section 1 | 1 palm infectected by G.boninense-light |
| 002 - 0464 / Tamba | 1 palm suspected to have wet stem rot |
| 001 - 0349 / Kapore Section 8 | 1 palm is dead due infection by G.boninense |

**BOGIA COCONUT SYNDROME REPORT (RSPO 4.5, 8.1)**

## STATUS REPORT ON BOGIA COCONUT SYNDROME IN THE MADANG PROVINCE

Carmel A. Pilotti

**INTRODUCTION**

An apparent decline of coconut palms in the Bogia District of the Madang Province was reported by the Coconut and Cocoa Institute (CCI) staff in 2007 and further investigated by CCI staff at the Stewart Research Station in Madang (CCI Internal Report 2008). In June 2008, staff from the National Agricultural Quarantine & Inspection Authority (NAQIA) along with a member of the Australian Quarantine & Inspection Service (AQIS) traveled to the area and collected a small number of samples for testing. Subsequent testing in Australia revealed that about half of the samples tested positive for phytoplasmas but sequencing was not successful and the identity of the organism was not confirmed (unpublished report by Richard Davis). In November 2008, further samples were collected by NAQIA from Bogia District and sent to the Commonwealth Agricultural Bureau International (CABI) for testing. The results from CABI indicated the presence of a phytoplasma from the 'Coconut Lethal Yellowing' group (CLY). This result raised alarm within the palm crop industry and at a meeting of the Technical Committee (formed in November 2008) in January 2009, it was decided initiate a more comprehensive survey and sampling in the Bogia District and other districts within the Madang Province in order to confirm the earlier findings. The survey was carried out by CCI Madang and NAQIA staff and completed in April 2009 (CCI Internal Report 2008). This was followed by sampling of a further fifty (50) coconut palms by both CCI and PNG OPRA in the Madang Province in May 2009 and subsequent testing of these samples at the Ministry of Agriculture & Fisheries (MAF) Biosecurity Laboratory in New Zealand. This report provides details of the sampling and testing and a discussion of the results.

**RESULTS**

Samples were collected from the meristem, young non-emergent flowers and young spear leaves of symptomatic coconuts. They were kept cool and frozen within 10 hours of collection, freeze-dried and sent for testing. All results are shown in Table 1. This table provides details of the symptoms as observed in the field prior to sampling, other details recorded during sampling and the results of testing for phytoplasmas and if applicable, sequencing for confirmation. Of the fifty (50) tissue samples collected, ten (10) samples were from apparently healthy coconut palms (highlighted in blue) and 40 samples were collected from symptomatic palms with varying degrees of severity from early to advanced foliar symptoms. The column labeled 'PCR result' is the result of a nested PCR reaction using the general phytoplasma primer pair P1/P7 and the universal ribosomal gene primer pair R16F2n/R16R2. Of the 50 samples tested, 33 tested positive for phytoplasmas by PCR but only 27 positive results were from symptomatic palms. Of these, 17 were subsequently sequenced. **Thirteen (13) samples obtained from symptomatic palms were negative and 6 of the apparently healthy palms tested positive**. This could possibly be due to cross-contamination during sampling. Four out of the 17 samples sequenced (23%) were found to be other prokaryotes and not phytoplasmas. One sample was found to be Candidatus *Phytoplasma australiense*, not previously found in PNG and another is unknown. The other 11 samples that were sequenced all had similarity to CLY group phytoplasmas but could not be assigned to any of the known groups as the similarity was only 95%. Eighteen samples that tested positive by PCR were not sequenced. Nearly half of the samples (23/50) had confirmed *Oryctes* damage and this was particularly prevalent in the areas where a large number of palms were affected.

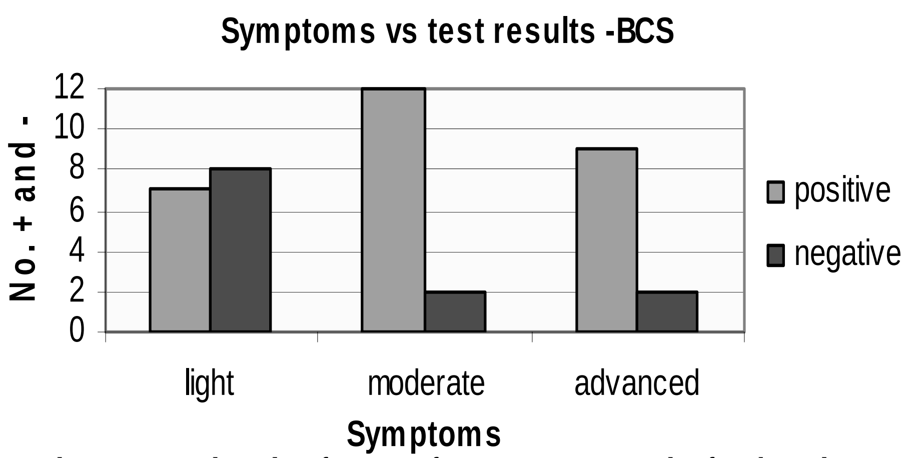


**Figure 1**. Host description and results of testing of coconut tissue samples for phytoplasma.

**Table 1**. All eleven betel nut samples in the same and other areas with similar symptoms tested negative for phytoplasma.

| Betel nut | Results |
|---|---|
| **1** | negative |
| **2** | negative |
| **3** | negative |
| **4** | negative |
| **5** | negative |
| **6** | negative |
| **7** | negative |
| **8** | negative |
| **9** | negative |
| **10** | negative |
| **11** | negative |

**Table 2**. Testing of coconut meristem samples for phytoplasma indicating the high percentage of palms that also exhibited spear damage by *Oryctes*.

| # symptomatic palms tested positive | # symptomatic palms tested negative | # healthy palms tested positive | # palms with *Oryctes* damage | # symptomatic palms with *Oryctes* tested negative |
|---|---|---|---|---|
| 31 | 9 | 6 | 20 | 3 |

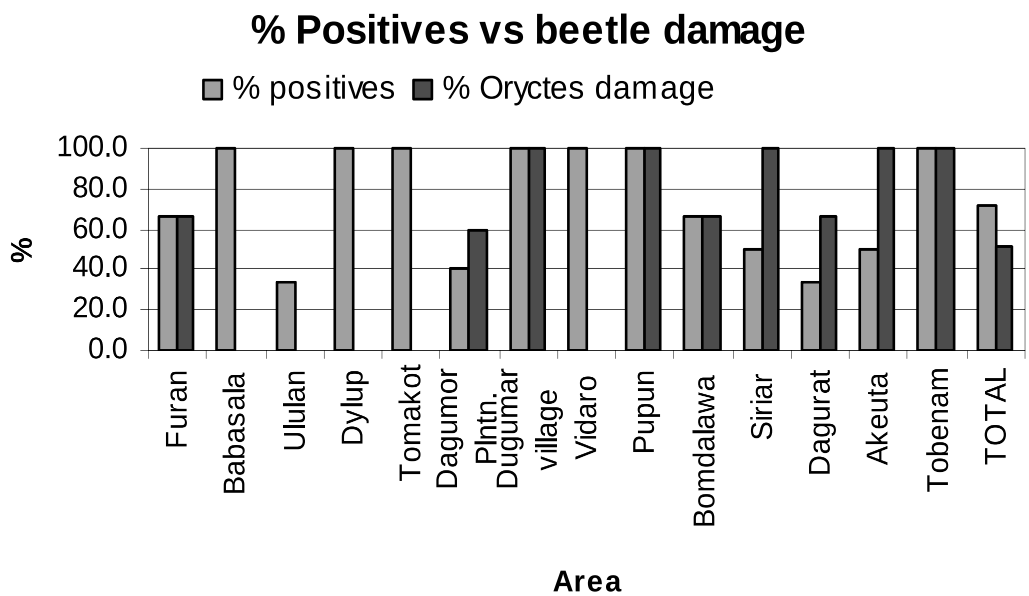


**Figure 2**. Percentage of palms testing positive to phytoplasma compared to the percentage of palms with *Oryctes* damage in each of the areas sampled.

**DISCUSSION**

Symptom expression could not be reliably related to the presence of phytoplasmas in the apical tissues of coconut palms. Even palms with moderate to advanced symptoms tested negative (see Table 1). In addition, over half of the apparently healthy palms tested positive. Clearly, there are other causes of the decline in many of these palms and these could be related to age, poor root systems or beetle attack. That is, the presence of phytoplasmas may not be the primary cause of the symptoms in many of the palms. Attack by *Oryctes* was also evident in a large number of the palms and this may have contributed to the confusion in the foliar symptoms observed (Table 2 and Figure 1). It's not likely that *Oryctes* is a vector, however the possibility of passive transmission via infected tissue on beetle body parts cannot be ruled out. The presence of phytoplasmas in coconut meristem tissue has been confirmed by testing. However, the results clearly indicate that sequencing is essential, even after nested PCR, in order to rule out the possibility of contamination by saprophytic *Mollicutes* or other bacteria. Sequencing of some of the products from the nested PCR indicated that three different types of phytoplasmas were present in the coconut tissue but the majority fell into a single group, possibly related to CLY. However, the products sequenced were small (500bp) and larger products using LY specific primers need to be sequenced before identifications can be confirmed. Sequencing of sample number 4-2 was not completed at the time of writing.

**CONCLUSIONS**

The presence of phytoplasmas in coconut palms in the Madang Province has been confirmed by sequencing in 24% of samples. However, the identification of 11 sequenced samples is yet to be confirmed. The pathogenicity (or otherwise) of these phytoplasmas is also unknown and requires

further investigation. Symptomatic palms were identified from near to Madang town (Furan) to the Bogia area (Dugumar Plantation). Symptom expression does not correlate with the presence of phytoplasmas.
Further work is required to capture and test possible vectors in order to confirm the transmission of the causal agent.

**RECOMMENDATIONS FOR FURTHER WORK**

1. Insect trapping to collect possible vectors for testing
2. Control of *Oryctes* in the affected areas
3. Surveys in the Ramu valley of coconuts and other palms for symptoms and sampling of these palms for testing
4. Additional sequencing of PCR products obtained by the MAF Laboratory in New Zealand to confirm the identity of the other positive samples.

**RECOMMENDATIONS FOR CONTAINMENT TO BE IMPLEMENTED BY NAQIA**

1. Movement of planting materials out of Madang Province is to be prohibited.
2. Surveys in bordering Provinces (Sepik and Morobe) are to be undertaken

# 4. SOCIO-ECONOMICS RESEARCH

**HEAD OF SECTION: JESSE ANJEN**

**OVERVIEW**

The socioeconomics work in the oil palm has evolved and gained prominence during the past decade. In 2009, PNGOPRA created the Socio-economics section to continue the initiatives introduced and to harness the strategic partnership and support of external guidance and inputs particularly from the Curtin University of Technology in Australia.

The section supports agronomy, entomology and others to develop, validate and promote appropriate innovations, approaches and knowledge systems. The development, adaptation and adoption of appropriate agricultural technologies are influenced by both biophysical and socio-economic circumstances of the farmers and other stakeholders. It therefore focuses on participatory research with regard to adoption and impact for economic viability and socio-cultural acceptability. Furthermore, the focus on smallholder research is becoming more important with the rapidly changing socio-demographic context of smallholder production (population growth, generational change, land tenure issues, food security and the growing threat of HIV/AIDS), the high rates of under-harvesting amongst smallholders and conformity to RSPO Principles and Criteria. These may affect patterns of production, the distribution of incomes and wealth, the way in which people behave (both in terms of purchase decisions and the way in which they choose to spend their time), and the overall quality of life. These can further have indirect effects on social attitudes and norms.

The socioeconomics research operates through several programs/projects and activities involving sister research institutions, development agencies, industry partners, and other stakeholders. A donor funded project "Commercial sector/smallholder partnerships for improving incomes in the oil palm and cocoa industries in Papua New Guinea. ACIAR Project ASEM/2006/127" began in 2008 and is now in its second year of implementation. Attention has been given to identifying the main land tenure issues affecting production of smallholder oil palm planted on customary land and various tenure type arrangements that condition land use particularly the Customary Land Use Agreement.

Smallholder socio-economic research currently has several components including:

- Examining the socio-economic factors affecting productivity among smallholders.
- Improving smallholder agronomic and farm management strategies.
- Understanding smallholder livelihood strategies and their influence on smallholder production.
- Analysing recent socio-agronomic changes occurring among smallholder households
- Monitoring and evaluating smallholder interventions.
- Examining land tenure issues (e.g. customary land developments).

**BIALLA MOBILE CARD SCHEME (RSPO 6.2, 6.5, 6.10, 6.11, 8.1)**

**Background**

In mid December the OPRA socio-economic team made two field visits to Bialla to assess the progress of the Mobile Card Scheme. The main purpose of these visits was to review the progress of the Mobile Card Payment scheme following concerns that the number of Mobile Cards in use in Bialla had declined to 56 from a peak of 138 Mobile Cards during the 2007 trial of the scheme.

Several meetings were organised with key participants in the Mobile Card Scheme, including meetings with the OPIC Bialla Project staff and Hargy Oil Palm Limited. A community meeting was held at Wilelo subdivision at which hired labourers and leaseholders using the Mobile Card and those who had opted out of the scheme were interviewed. Two OPIC extension Officers were initially engaged under the Mobile Card Project in 2006 to promote the adoption and uptake of the scheme by the smallholders. After the project ended, the two officers were formally absorbed into OPIC operations. Since then, there has been no one actively involved in promoting the scheme in the Bialla Oil Palm project area. They are the only officers in the project who are fully aware of how the mobile card scheme operates.

The initial trial did show that there was an incentive to work by people looking for gainful employment in the informal sector. There is a guarantee of payment since there is a contract between the mobile worker and the owner of the block. This is further confirmation that payment will be forthcoming because the split of the mobile card is processed by the company payroll system based on the contract. Over time, it showed that total production increased from the blocks engaging the mobile card workers.

**Some Presupposition**

It was presumed was that most of the officers were aware of how the system worked. The OPIC officers were ideally positioned to create awareness and promote this scheme. After the discussions with them in the training awareness on the mobile card, it was obvious that there was some misunderstanding of how the mobile card worked. Some block holders were also afraid that if they hired a labourer on a continuing basis, the worker may attempt to make ownership claims on their block. . It was reemphasized that tenure is secure as the mobile card contract clearly indicates that the workers engaged are actually labourers employed by the block-owners and are paid for doing the work. The split is also made in such a way that the primary card is still responsible for repayments of all company loans including seedlings, fertilizers and others.

It was also presumed that they were busy with the replants and fertilizer delivery among other activities and that they did not have the time to engage more farmers to start using this system based on the needs

**Why has the number of Mobile Cards in use not expanded?**

Three main reasons were found for the decline in the numbers of leaseholders using Mobile Card labour to address labour shortfalls:

***Many Mobile Card workers (sons of leaseholders and hired labourers) were grossly overpaid with the result that leaseholders were reluctant to renew contracts when they expired. This is the key factor explaining why the scheme has not expanded.***

The main reason for non-renewal of contracts was that there was a change in the way the Mobile Card fruit was weighed and recorded at the time of pick-up, and /or how the percentage split was calculated at the smallholder payment office at the mill. Rather than recording separate weighings for the Mobile and Papa Cards, Mobile and Papa FFB were weighed together and the percentage split between leaseholder and Mobile Card worker was calculated on the total FFB from the block rather than only on the portion of FFB harvested by the Mobile Card worker. The effect was that Mobile Card labourers were receiving payments much higher than they were entitled to while leaseholders were receiving incomes much less than they anticipated. Understandably, this led to disappointment and disenchantment with the Mobile Card payment system among leaseholders, and the reluctance to renew contracts. The perception that Mobile Card workers were being grossly overpaid discouraged many other leaseholders from recruiting Mobile Card labour to address labour shortages on their blocks. Because extension officers were not aware that the overpayment problem was due to the percentage split being calculated in the smallholder payment office on the total production of the block, they were unable to address the problem.

A reason for this problem emerging is that there are quite a few Caretaker blocks using the Mobile Card. In these cases the percentage split is based on the total production of the block because the Caretaker is responsible for harvesting all the fruit and for carrying out all block maintenance tasks. In contrast to the Caretaker situation, leaseholders who recruit labour (sons or labour from outside the block), generally continue to harvest FFB themselves while allocating a phase or two to the Mobile Card worker. In these situations there should be three separate weighings with three separate dockets: 1) FFB weighed on the Papa Card; 2) FFB weighed on the Mobile Card; and 3) loose fruit weighed on the Mama Card.

***Limited promotion of the Mobile Card after the trial ended.***

A further reason why the Mobile Card scheme has not expanded is because the two extension officers employed during the trial to monitor and promote the Mobile Card were absorbed into normal OPIC duties when the trail ended, leaving no extension officer specifically responsible for promoting the Mobile Card scheme amongst growers. Also, the two Mobile Card officers employed for the trial were the only officers who had a detailed knowledge of how the Mobile Card worked and its potential benefits and problems. When the two officers were absorbed into normal OPIC duties their knowledge was not sufficiently passed on to other officers to promote the scheme.

***There is some misunderstanding among the OPIC Divisional Managers and extension officers on how the Mobile Card works.***

Areas of misunderstanding include how the percentage split operates, debt repayments on the Papa Card, how the Mobile Card benefits both the block-owner and labourer and how the Mobile Card operates differently on a Caretaker block (the percentage split is calculated on the total production of the block) compared with a block where the Mobile Card is used by a hired labourer or family member (the percentage split is calculated on that portion of the FFB harvested by the Mobile Card worker, NOT the total FFB harvested from the block). A percentage split on the whole block production will only work effectively on: i) caretaker blocks and, ii) on blocks where the elderly papa has handed over management and production to the son, and the father receives a small ‘pension’ (papa/pension/retirement levy) from the block (e.g. 10% split on the total production of the block.

Three separate docket system (papa, mama & mobile card) is the only way in which the Mobile Card system can maintain incentives for high production where hired labourers or sons are working on a section of a block, and the block-holder continues to harvest another section of the block. Therefore, there would need to be a system in place for the FFB harvested by the labourer/son to be weighed separately from FFB harvested by the papa of the block, otherwise disincentives to production would be introduced. If all the FFB harvested is weighed together on one docket with a percentage split based on the total production from the block, then incentives are introduced for under-production by both the papa and the mobile card worker (the son or hired labourer). On the other hand, with a split based on the total production of the block, a son or hired labourer holding a mobile card who decides not to do any work in a particular harvest round will still get paid – whatever is the agreed percentage of the total production of the block. Similarly, if the papa of the block does not work, and the mobile card worker does his work (e.g., harvests Phase 3 as per his contract), the block-holder will still receive a share of the payment even though he does no work on the block, and his proportional share of the total production is much greater than if he had actually worked on the block. Overall, where the block-holder and mobile card worker are both working on the same block, a system that uses a percentage split on the total production for the block will introduce disincentives to production.

For instance, a 6 ha block is fully planted to oil palm where the mobile card worker is to receive 50% of the crop from the third phase (2 ha), and each phase is capable of yielding 2 tonnes per harvest round if fully harvested, or 6 tonnes in total for the block each harvest round. Three scenarios can be assessed for this example: 1) both papa and mobile card work hard and fully harvest their respective phases; 2) the papa does no work but the mobile card worker fully harvests Phase 3; and 3) the papa fully harvests Phases 1 and 2, but the mobile card worker does not harvest Phase 3.

*Scenario 1 Both work hard:* With separate weighings for block-holder and mobile card worker (total block production is 6 tonnes). Papa harvests 4 tonnes and mobile card worker harvests 2 tonnes. After the 50% split, papa receives 4 + 1 tonne = 5 tonnes; mobile card worker receives 2-1 tonnes = 1 tonne.
*Scenario 1 Both work hard.*: Percentage split based on total production from block (i.e., mobile card worker receives half of 33%) (total block production is 6 tonnes). Papa will receive 5/6 (83.33%) of total production, i.e., 5 tonnes; mobile card worker receives half of 33% or 16.65% of total production, i.e., 1 tonne.

Both systems give the same outcome.

*Scenario 2 Papa does no work, but mobile card fully harvests Phase 3:* With separate weighings for block-holder and mobile card worker (total block production is 2 tonnes). Papa harvests nil tonnes and mobile card worker harvests 2 tonnes. After 50 % split, papa receives 0 + 1 tonne = 1 tonne; mobile card worker receives 2-1 tonnes = 1 tonne.
*Scenario 2 Papa does no work, but mobile card fully harvests Phase 3:* Percentage split based on total production from block (total block production is 2 tonnes). Papa will receive 5/6 (83.33%) of total production, i.e., 1.67 tonnes; mobile card worker receives half of 33% (or 16.65%) of total production, i.e., 0.33 tonnes.

On a percentage split on the total production from the block, the mobile card worker is grossly underpaid and receives only one-third of what he is due. The block-holder receives a much higher share of the value of the mobile card worker's production than was intended in the contract. The mobile card worker's incentive to produce is thus reduced (underpaid) and the block-holder's incentive to under-produce is increased.

*Scenario 3 Papa fully harvests Phases 1 and 2, but mobile card does not work:* With separate weighings for block-holder and mobile card worker (total block production is 4 tonnes). Papa harvests 4 tonnes and mobile card worker harvests nil tonnes. After 50% split, papa receives 4 + 0 tonne = 4 tonnes; mobile card worker receives 0 tonnes.
*Scenario 3 Papa Papa fully harvests Phases 1 and 2, but mobile card does not work:* Percentage split based on total production from block (total block production is 4 tonnes). Papa will receive 5/6 (83.33%) of total production, i.e., 2.67 tonnes; mobile card worker receives half of 33% or 16.65% of total production, i.e., 1.33 tonnes.

In scenario 3 with a split based on the total production from the block, the mobile card worker is actually paid more for not harvesting than if he were to harvest Phase 3 as specified in his contract. *He is paid more the less he does on the block*. There is also a greatly reduced incentive for the block-holder to recruit mobile card labour.

The outcomes of the three scenarios are summarised in the table below.

| | Separate weighings for Papa & Mobile Card* | | Percentage split on total production for block** | |
|---|---|---|---|---|
| Scenarios | Papa | Mobile Card | Papa | Mobile Card |
| Papa & Mobile fully harvest | 4+1=5 | 2-1=1 | 5 | 1 |
| Papa does not harvest; Mobile fully harvests | 0+1=1 | 2-1=1 | 1.67 | 0.33 |
| Papa fully harvests; Mobile does not harvest | 4+0=4 | 0-0=0 | 2.67 | 1.33 |

*The mobile card worker is contracted to harvest Phase 3 with a 50% split between blockholder and mobile card worker on the production from Phase 3.
**The mobile card share is based on % split of the total production, i.e., half of 33% of total production of three phase block.

During the trial the block-holders, mobile card workers or mobile card extension officers were usually on site at FFB pickups to ensure that weighings were recorded on separate dockets. The increase in production from use of mobile card labour was substantial. To assist drivers and data entry payroll staff, we suggest the following:

- The erection of signs at the fruit collection point of blocks where Mobile Card workers are engaged. This will signal to truck drivers to be alert for fruit to be weighed on the Mobile Card.
- Design an easily recognisable weigh docket for Mobile Card fruit to reduce the probability of data entry errors in the smallholder payment office. A coloured docket might offer the simplest solution (green or yellow). Hargy may also wish to consider introducing a coloured docket for loose fruit weighings so that the three types of payments for fruit are easily distinguished from each other. There was some discussion that Hargy was intending to introduce a card system for smallholder pickups. This would be the easiest option as there could be separate cards for Mobile Card workers for weighing their fruit.

The caretaker situation, of course is different, in that the % split is based on the total production of the block. Drivers don't need to worry about these blocks as the % split will be done in the payroll office.

Finally, whilst the percentage split system may seem initially complicated, it was noted in the report on the Bialla Mobile Card trial that the separate weighings with the percentage split only on the mobile card fruit is preferred to a set payment for labour for the following reasons:

- Payment for labour with a specified fixed rate of pay (e.g., kina per task per hectare) may reduce the Mobile Card labourer's incentive to fully harvest a block. For example, difficult to harvest fruit bunches on very tall palms or on palms at the rear of the block may not be harvested once a perceived value of work (e.g., K200/4 hectares) has been completed. The ratio method maintains an incentive to fully harvest a phase/block — the more one harvests the more one earns.
- A proportional split seems to be more suitable for the payment of family labour as there is no 'fixed' rate of payment operating among family members and payments for oil palm work have little relationship to formal market rates for hired labour. Instead, 'payment' rates are often determined by a range of factors such as price of oil palm, age of the father, marital status of co-resident sons and daughters, other income sources of family members, individual family needs and other socio-economic circumstances on the block. Also, how the Papa payments are distributed among other co-resident households may determine the proportional split agreed to by the father and the son holding the Mobile Card. In deciding upon a percentage split, such factors in addition to current oil palm prices and the amount of work to be done are taken into consideration. By allowing block-holders to choose the pay rate for family labour (the percentage split) the Mobile Card will be flexible enough to accommodate the diverse socio-economic circumstances of families, especially those on highly populated blocks.

**Recommendations**

- Design an easily recognisable weigh docket for Mobile Card fruit to reduce the probability of data entry errors in the smallholder payment office. For instance, a different coloured docket for pickups of FFB harvested and weighed on the Mobile Card, to ensure FFB is not mistakenly weighed on the Papa Card. Also the erection of signs at the fruit collection point of blocks where

Mobile Card workers are engaged will signal the truck drivers to be alert for fruit to be weighed on the Mobile Card.

- 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 Hargy are advised by the leaseholder to terminate the contract.
- Modify Section 4 of the Mobile Card contract to ensure that tasks for the Mobile Card worker can be allocated to specific phases (e.g. Phase 3 at the rear of the blocks were under-harvesting rates are higher). The revised section of the contract might appear as follows:

| WORK CONTRACT APPLIES TO THE FOLLOWING PHASES | #1 | #2 | #3 | #4 |
|---|---|---|---|---|
| AGREED TASKS (IF APPLICABLE) | | | | |
| Under Brush | ☐ | ☐ | ☐ | ☐ |
| Pruning | ☐ | ☐ | ☐ | ☐ |
| Circle Weed | ☐ | ☐ | ☐ | ☐ |
| Harvesting | ☐ | ☐ | ☐ | ☐ |
| Fertiliser | ☐ | ☐ | ☐ | ☐ |
| Other | ☐ | ☐ | ☐ | ☐ |

- Implement a Mobile Card awareness program, initially on 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. Field days, educational material, testimonies and radio programs explaining the Mobile Card could form the basis of the awareness program. Staff from OPRA's socio-economic section would assist with the awareness program (see below).
- 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. Initial targeting should focus on caretaker blocks and labour-short blocks. On the December visit to Bialla, elderly growers at a community meeting expressed great interest in the Mobile Card. Elderly leaseholders are sometimes reluctant to handover production to the next generation because they fear they will lose control over the income from the block. These growers were interested in the scheme because they saw it as a way to hand over production to their sons while ensuring they continued to receive an income (pension) from the block (e.g. 10% of the income from the block). As part of the Mobile Card payment system, it is proposed that elderly parents who have handed over the management of the block to their sons should be encouraged to sign a Mobile Card contract to allow them to receive a percentage of the crop. On these blocks the Mobile Card would operate similar to a Mobile Card on a caretaker block: that is <u>all</u> the FFB harvested would be subject to a percentage split. This would be noted on the Mobile Card contract.
- Apart from elderly growers, low producing blocks should be targeted to take up the Mobile Card. The palm census data can be used to identify low production blocks with less than 10 tonnes per hectare for targeting.

- In the longer term, attention should be given to mobilising harvesting teams employed on Mobile Card contracts to target consistently low-producing VOP blocks. Harvesting teams can be made up of labourers from youth, sports or church/community groups. These Mobile Card work groups can also be organised and contracted for short term commitments for upkeep, general maintenance and harvesting. Large low producing oil palm blocks owned by the Church, schools or clan groups should also be encouraged to recruit Mobile Card work groups to improve block management and production.

**Concluding Remarks**
Despite the above operational and awareness problems, smallholders remain very interested in concept of the Mobile Card as a means of paying outside labourers and family members.

**HOUSEHOLD SOCIO-ECONOMIC SURVEYS (RSPO 6.1, 6.2, 8.1)**

In 2009, some household survey instruments were designed and updated from the earlier studies in 2000. These questionnaires were targeted at Land Settlements Schemes (LSS) and the Customary Rights Purchase Blocks (CRPB) with land shortage problems for food production and other livelihood sources. These questionnaires were field tested and training was undertaken for the two smallholder supervisory staff in the socioeconomics section and OPIC extension officers in Hoskins and Popondetta. Some surveys were completed in 2009 in the major Oil palm projects in Bialla, Hoskins and Popondetta and will be continued in 2010.

**CUSTOMARY LAND USE AGREEMENTS (CLUA) (RSPO 2.2, 6.2, 6.4, 8.1)**
While the core of the work on the CLUA has been presented in the 2008 annual report, additional consultations and discussions have been continued in 2009 to review and update the CLUA to reflect the dynamics of customary land use dealings. When oil palm opened up in the villages with the development of oil palm estates next to the villages, outsiders wanted to buy land and grow oil palm. The villagers in need of money began selling land individually but clan leaders had to approve the CLUA (through OPIC facilitation). With changes in social dynamics, there is no respect for traditional land owners. Unscrupulous practices have emerged whereby some people trying to get quick money were selling land secretly to outsiders without the knowledge of the clan leaders and other villagers. On the other hand, it is hard to resettle migrants back in their home village especially on the Land Settlement Schemes and in the settlements popping up in the urban areas. These people are beginning to buy traditional land to settle and in some cases, cultivating it for oil palm production. Such dealings in land have always ended in disputes over payment and ownership issues. There is no tenure security for people buying land and so it is necessary to ensure consent and mutual understanding from both parties.

The work covered some of the following areas:

- Areas where customary land is being sold to outsiders and other villagers for oil palm development
- Areas where land disputes are common, especially on VOP and CRPB
- Talk to landowners and buyers and revisit land deals done within the last two years.

The feedback from these discussions have been continuously updated to the revised CLUA form to make it comprehensive to cover all aspects of dealing in land matters particularly on selling of village land to other villages and migrants from other parts of the country.

# Appendix 1

**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.