# Annual Research Report

# 1999

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# Report by the Director of Research to the Annual General Meeting June 2000

The oil palm industry in Papua New Guinea began with the first planting of oil palm in West New Britain in 1967. Since this time the industry has grown steadily. Oil palm is now Papua New Guinea's largest export crop. The value of the oil palm industry to Papua New Guinea lies not only in its ability to generate a large amount of export revenue every year, but also in its phenomenal impact on rural development. Oil palm is not only the most effective creator of social and economic rural development in the country; it is also the only one that can look, with some certainty, to a history and future of stable growth. This growth however is not irresponsible, the industry's initiatives and actions with regard to environmental responsibility and landowner rights and welfare are a leading model for others to follow.

We are all too used to Papua New Guinea being way down on any international list of achievements or performance and at the top of the list when it comes to problems. Fortunately and proudly we can say that Papua New Guinea is at the top of the international list when it comes to the performance of the oil palm industry. With higher cost structures than other countries, the oil palm industry in PNG must be more productive and more efficient than elsewhere in order to survive; and so it is. In order to achieve and maintain this productivity and efficiency, the industry must constantly strive to improve. Research and scientific technical services are major components in this process. The oil palm industry in its formative years recognized the importance of agricultural research support and created the PNG Oil Palm Research Association (PNGOPRA) to conduct this work.

PNGOPRA was incorporated in 1980 as a not-for-profit research association. The stakeholders of the Association are its Members. The current membership comprises; all of PNG's smallholder growers represented by the Oil Palm Industry Corporation (OPIC), New Britain Palm Oil Limited, the Pacific Rim Plantations Group (Higaturu Oil Palms, Milne Bay Estates and Poliamba Pty Ltd.) and Hargy Oil Palms Ltd. Solomon Islands Plantations Limited (SIPL) was granted membership in July 1998 but because of the civil unrest in the Solomon Islands the Company suspended operations in 1999 and PNGOPRA work at SIPL was also suspended.

It is a strategy of PNGOPRA to remain small in size, especially when compared to the scale and importance of the industry it serves. This policy allows a focusing on quality that in other organisations in PNG is too often compromised by the need to support quantity. In terms of personnel the Association is about the same size as when it was formed in 1980 and the cost of operations today is no greater than it was ten years ago. Despite this, the output is much greater in terms of both quality and quantity. PNGOPRA is geographically devolved with 3 main research centers and 3 sub-stations spread over all oil production areas. This spread of resources makes internal management very challenging but on the other hand it presents a fairer delivery of services to all stakeholders and a closer understanding and response to local problems.

PNGOPRA carries out all agricultural research, with the exception of plant breeding and associated disciplines, for all of PNG's oil palm growers. Plant breeding and seed production is carried out commercially by New Britain Palm Oil Limited. NBPOL's Dami Research Station has a worldwide reputation as producing some of the best oil palm seed material in the world. PNGOPRA works very closely with the plant breeders at NBPOL and as such has no need to duplicate this function.

The research programme of the PNGOPRA is carefully structured to meet the needs of the industry as a whole. The PNGOPRA's Scientific Advisory Committee, on which all Members are represented, meets annually to review and establish research priorities. To maintain PNGOPRA as a small, highly efficient research organisation, the Association is addressing only the most prominent constraints to the production of oil palm. The PNGOPRA Agronomy Sections (one covering the PNG Islands region and one the PNG mainland region) carry out research into crop nutrition and fertiliser management practices. The Association's Entomology Section, based at Dami Research Station, conducts research into pollination and the control of insect and other pests. The Plant Pathology Section, based in Milne Bay, is carrying out world leading research into the control of the Basal Stem Rot of oil palm caused by the *Ganoderma* fungus. All Sections, in addition to conducting research, assist the industry by providing technical support, recommendations and training.

By far the most serious factor limiting oil palm production is the ubiquitous presence of nutrient deficiencies and understanding this problem is the main task of the Agronomy Sections. The single highest cost involved in growing oil palm is fertiliser input. A major part of PNGOPRA's research focus is on the study of the soil chemistry and plant nutrition of oil palm growing on the wide range of PNG soil types, particularly the pedologically young volcanic soils. The major goal of the agronomy research is to develop the most economically optimal fertiliser practices dependent upon soil type, physical environment and economic conditions.

A large programme of formal fertiliser trails exists throughout the country. These trials are used to develop an understanding of the nutrient requirements of the oil palm and the responses to nutrient inputs. They also provide data that allows the extrapolation of findings to other areas, the tracking of fertility characteristics with time, and ultimately economic response models.

During the last year considerable attention has been focussed on developing specific research projects directed towards more fundamental soil studies relating to magnesium deficiency on the variable charge volcanic soils and to improving the efficiency of nitrogen fertiliser inputs by identifying and controlling the main nitrogen loss pathways.

Nutritional problems are particularly serious among the smallholder growers and result in very large reductions in yield. In addition, social and economic problems are confounded with the nutritional problems and result in the average smallholder yield being less than half of that of the plantations. The Association is about to begin a new collaborative study with the Australian National University, and supported by ACIAR, that addresses this complex interaction of factors affecting smallholder productivity. PNGOPRA Agronomists gives close technical support to the efforts of the extension service through smallholder block demonstrations, farmer field days, advisory services and training for extension officers. Agronomy research also addresses other issues such as nursery fertiliser practices, palm poisoning, and assisting in the development of mapping and GIS for the industry.

The Entomology Section at PNGOPRA continues to make significant progress in the research, development and implementation of integrated pest management (IPM) systems for key economic pests of oil palm in PNG, including Sexava, Rhinoceros Beetles and Giant African Snails.

Work on Sexava biological control and IPM began in 1996 as part of European Union project. This involved collaboration with scientists from Oxford University and CABI Biosciences. The first phase of this project was completed in 1999. The IPM system developed had the following components: (1) a knowledge of the biology and ecology of the pest, (2) economic thresholds, (3) monitoring system for the pest, (4) precise targeting of chemical control agents, (5) biological control and (6) cultural and physical control. A second phase of the project, again funded by the EU, was started towards the end of the 1999 and will continue for two years. This involves field trials with the Sexava parasite, *Stichotrema dallatorreanum*, in West New Britain Province. Four trial sites have been established with a further 4-6 planned for later in 2000. Evidence from the trials so far indicates that the parasite is establishing itself in the field populations of Sexava. Successful introductions of the parasite should result in the complete elimination of the need to use chemical insecticides for Sexava control.

Work on the IPM of Giant African Snail is being undertaken as part of a PhD programme by one of the Association's PNG scientists. These studies will involve field trials in Milne Bay Province that will begin in October 2000.

During the later part of the 1999 work began on a project to improve insect pollination of oil palm in PNG. The European Union has agreed to fund this work. The objectives of this project are; (1) to screen the existing *E. kamerunicus* populations within PNG for evidence of infection by the nematodes or other parasites and pathogens, (2) to determine the degree of genetic separation between weevil populations in PNG and natural populations in West Africa and (3) to assess the potential to improve the genetic base of the existing population of *E. kamerunicus* within PNG. This could be done by the introduction of fresh batches of the same weevil species, or possibly by the introduction of one or a number of new species of pollinating insects from West Africa or South America. The preliminary findings of this project indicate that there are nematode infections in the current weevil population in PNG. The nematode parasites will certainly be reducing the fitness and fecundity of the weevils and therefore having a significant impact on pollination.

Training of plantation staff, extension officers and smallholder growers continued throughout 1999 and into 2000. PNGOPRA conducted a total of 37 training days in West New Britain and Oro Provinces.

The PNGOPRA Entomology Laboratory at Dami Research Station was upgraded early in 2000 and provides the Association with a state of the art facility in which to conduct its entomology work. The new laboratory and office will be used as the Centre for both the Sexava and pollination projects.

The idea to establish a Plant Pathology Section within PNGOPRA was formulated in 1994 following identification of basal stem rot in several of the plantations within PNG. A request from the industry to look at the basal stem rot prompted an application to the European Union for funding under the Stabex funding arrangement. Work commenced in mid 1995 with the setting up of the plant pathology laboratory at Milne Bay Estates. The laboratory is capable of both routine mycological work and highly sophisticated molecular research.

Since the early 1960s it was generally accepted that basal stem rot was initiated by root to root contact; however, after thirty years control based on this assumption is still inconsistent. Research in the early 1990s suggested the involvement of basidiospores in the epidemiology of the disease. A suggestion that required a substantial change in the oil palm industry's attitude to the disease and subsequent control strategies. Because of these implications, the initial objective of the Plant Pathology Section was to study the basal stem rot with special reference to the involvement of basiodiospores in the epidemiology of the disease. Following our initial research, all of which confirmed this hypothesis, control strategies were implemented within the large commercial plantations. Research into control of basal stem rot in the low input oil palm production systems of the smallholder grower has now commenced.

Research into biological control of basal stem rot by identifying non-pathogenic organisms that will colonize the natural sites of *Ganoderma boninense*, the causal agent of basal stem rot, is also in progress.

With the start of PNGOPRA membership of the Solomon Islands Plantations Ltd, a further application was made for Stabex funding to support the research in the Solomon Islands. Research commenced in the Solomon Islands in October 1998. With the Solomon Islands Stabex funding, we were asked to work along side staff from the Plant Protection Laboratory at Dodo Creek with the aim of training their staff in a range of plant pathology techniques. Unfortunately this work is on hold pending the outcome of the current civil unrest in the Solomon Islands.

Considerable progress has been made in many areas. The most important being that a control strategy has been implemented. The extent of the progress is best illustrated by the fact that 16 papers have been published during the five-years of the project. An enviable record for any research establishment especially one that has only been operating for five years.

Although the primary aim of the Plant Pathology Section is the research into basal stem rot, the unit is fully equipped and trained to handle any problems that might arise within the industry. There are a growing number of requests for assistance with regard to nursery diseases. In the area of plant pathology, a solid foundation has been laid on which the next few years will build.

PNGOPRA is self administered and managed by a small team comprising the Director of Research, an Accounts Superintendent, an Administrative Officer, two Accounts Clerks, and a Secretary, all based at Dami Research Station. It is a deliberate policy to limit the size of the support operation and foster an emphasis on the research functions of the organisation. Although this does place a considerable strain on the administration and accounting staff, the system does work well.

Financing of PNGOPRA comprises 69% levy from Members and 31% grants from international aid sources and the PNG Government. This ratio is too high, ideally the ratio of levy to external grants would be about 60:40. Considerable effort is being invested in trying to increase the level of external financing. In late 1999 the European Union approved two-year extensions to the Ganoderma and Sexava projects. In 2000 the European Union approved the financing of the proposed Pollination Project and ACIAR approved the financing of the proposed collaborative smallholder study with ANU. Submissions for two other projects, the nitrogen loss study and the magnesium study, have been submitted for consideration.

There was considerable delay in setting the rate of the levy in 1999. Although the expenditure budget was approved, the supporting levy was only agreed to in August 1999; the 1998 levy rate was being charged until this time. This had the effect of creating a severe cash flow problem. One of Management's biggest problems at this time was having the means to pay executive salaries each month. By the end of 1999 these problems had been resolved.

The smallholder levy was set at 56t/t FFB in 1996 and remains at this level (the Member companies are currently paying K2.07/t FFB). The PNGOPRA Board of Directors agreed in April 2000 that the smallholder levy should be increased to 90t, however this appears to be a difficult change to implement. The smallholder FFB price is indirectly linked to the US$ and so the effect of the severe devaluation of the PNG Kina over the last few years means that the smallholder growers are effectively paying less than half the PNGOPRA levy they were when the 56t rate was introduced. The Member companies have had to cover the difference.

PNGOPRA remains small in size; however its research output undoubtedly places PNGOPRA as one of the most effective research organisations in Papua New Guinea. Over the last few years PNGOPRA has greatly increased both the quantity and quality of it's scientific output and increased the level of technical services and training provided to the industry. With input from the industry the Association is constantly adapting to meet the needs of the industry it serves and is set to continue to do so in the future.

Ian Orrell
Director of Research
June 2000

# 1. PNG ISLANDS REGION AGRONOMY

(B. Toreu. & A. Oliver)

## INTRODUCTION

The agronomy work program in the Islands region of PNG including the provision of support services such as leaf sampling, field inspection visits and the conduct of field days in collaboration with OPIC and the Small holders, progressed well despite of a number of changes to our staffing in 1999.

## STAFF

Early in 1999 Mr. Peter Tarramurry was transferred from the Mainland region to the Islands region as assistant agronomist at the Bialla sub-station. Mid way through the year Mr. Graham King – formerly the Islands Region Agronomist was appointed Senior Agronomist responsible for smallholder related work and based at Popondetta. Mr. Barnabas Toreu took over from Mr. King as Agronomist in charge of the research trials in the Islands region.

Mr. Kelly Naulis was transferred from the Bialla sub-station to be the Field Supervisor at the Kapiura sub-station following the departure of Mr Gen Konia who was then the Field Supervisor at Kapiura. Mr. Wawada Kanama continued as Field Supervisor at Poliamba and Mr. Graham Bonga continued as Field Supervisor at Dami.

## TRIALS & RESEARCH PROJECTS

Management of the research trials continued to be our major activity in all station/sub stations. All activities associated with this work were attended to as set out in the yearly work program. One new research project was initiated based on the Mg project proposal submitted to the 1998 SAC meeting and Board of Directors. The project started through consultative discussions with Dr Gavin Gillman and CSIRO in Townsville. Dr Gillman latter visited PNGOPRA at Dami (financed by ACIAR) in order to develop the project proposal. ACIAR are interesting in supporting the project if extended to incorporate a similar proposal by NARI.

## LEAF SAMPLING

Plantation Leaf Sampling for most estates was completed for New Britain Palm Oil, Hargy Oil Palms and Poliamba Pty Ltd at the time they were scheduled. Weather conditions, especially in the Hoskins area, affected to some degree the commencement and the duration of leaf sampling operation.

## SMALLHOLDERS

PNGOPRA has participated well in field days organised by OPIC to assist growers in managing and looking after their blocks; 1999 was no exception. Most emphasis was directed to fertiliser usage and block maintenance. There was high level of attendance by smallholder growers. PNGOPRA's representation at Local Planning Committee (LPC) meeting at Nahavio, Bialla and New Ireland has continued.

**Trial 125 SOURCES OF NITROGEN FERTILISER TRIAL AT KUMBANGO PLANTATION.**

PURPOSE

To investigate the relative effects of different types of nitrogen fertiliser available in PNG on oil palm. Of particular interest is the effect of the various nitrogen fertilisers on potassium and magnesium nutrition. The results of the trial will be used in formulating fertiliser recommendations.

DESCRIPTION

Site One or more of field numbers c4, c5 or c6, Division II, Kumbango Plantation, Nr Kimbe, WNBP.

Soil Young coarse textured freely draining soils formed on alluvially re-deposited andesitic pumiceous sands and gravel with intermixed volcanic ash.

Palms Dami commercial DxP crosses.

Planted in April & May 1993 at 135 palms/ha.

Treatment applications commenced in June 1997.

DESIGN

The design of this trial has been changed on the advice of biometricians from the Pacific Regional Agricultural Programme and IACR - Rothamsted.

There are 15 fertiliser treatments in each replication and 4 control plots (Table 1.1). The 15 treatments will be replicated four times in a randomised complete block design. The four control plots are plots on the edge of the trial from which yield is recorded but the data will not be used in the analysis of variance. The mean yield from the control plots will be reported in the table of means as a comparison with the fertiliser treatments. 36 palm plots (6x6 palms) are used, the central 16 palms are recorded and the outer 20 palms are regarded as guard row palms.

Table 1.1 Treatments used in Trial 125.

| Fertiliser | Level (kg/palm/year) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| *g N/palm/year* | *520* | *1040* | *2080* |
| Ammonium Chloride | 2.0 | 4.0 | 8.0 |
| Sulphate of Ammonia | 2.6 | 5.2 | 10.3 |
| Urea | 1.2 | 2.4 | 4.7 |
| Ammonium Nitrate | 1.5 | 2.9 | 5.8 |
| Di-ammonium Phosphate | 3.0 | 6.0 | 12.0 |

Each rate of fertiliser at the same level contains the same amount of nitrogen. Experimental fertiliser treatments were first applied in June 1997 after pre-treatment yield data had been collected. Plot isolation trenches were completed prior to the first application of treatments. Until this time the palms had received a standard immature palm fertiliser input. Frond 17 leaflet and rachis cross-section sampling were carried out prior to treatments being applied.

## RESULTS

FFB yield and yield components for 1999, which is the second full year of yield recording since fertiliser treatments commenced, are presented in Table1.2. The results show that type of fertiliser had no significant effect on FFB yield, single bunch weight and bunch number. The yield on the control plot was slightly higher than the rest of the fertiliser types with a yield of 24.8 t/ha. This however, was not statistically significant. The increase in yield was due mainly to increase in the number of bunches per hectare. Fertiliser rate had no significant effect on yield, single bunch weight and bunch number.

Table 1.2 FFB Yield and yield components in 1999 (Trial 125).

| Fertiliser Type | Yield (t/ha) | Single Bunch Wt (kg) | Number of Bunches/ha |
|---|---|---|---|
| Control | 24.8 | 14.4 | 1738 |
| Ammonium Chloride | 24.4 | 14.8 | 1692 |
| Sulphate of Ammonia | 24.1 | 15.2 | 1648 |
| Urea | 23.9 | 15.1 | 1630 |
| Ammonium Nitrate | 23.6 | 15.4 | 1588 |
| Di-Ammonium Phosphate | 23.7 | 15.3 | 1602 |
| sig. Eff. | ns | ns | ns |
| Sed | 0.76 | 0.44 | 80.4 |
| cv (%) | 11.6 | 6.5 | 4.9 |
| **Fertiliser Rate (gN/palm/year)** | **Yield (t/ha)** | **Single Bunch Wt (kg)** | **Number of Bunches/ha** |
| 520 | 24.1 | 15.3 | 1617 |
| 1040 | 23.9 | 14.9 | 1656 |
| 2080 | 23.7 | 15.3 | 1623 |
| sig. Eff. | ns | ns | ns |
| Sed | 0.76 | 0.44 | 80.4 |
| cv (%) | 11.6 | 6.5 | 4.9 |

There was no significant Type x Rate interaction for yield, number of bunches and single bunch weight. These interactions are presented in Tables 1.3, 1.4 and 1.5.

Table 1.3 Effect of Type of Fertiliser and Rate of Application on FFB yield (t/ha) in 1999 (Trial 125).

| Type of Fertiliser | Rate (gN/palm/year) | | |
|---|---|---|---|
| | 520 | 1040 | 2080 |
| Ammonium Chloride | 24.23 | 25.94 | 22.96 |
| Sulphate of Ammonia | 23.76 | 22.73 | 25.89 |
| Urea | 24.56 | 24.53 | 22.54 |
| Ammonium Nitrate | 23.51 | 22.98 | 24.26 |
| Di-Ammonium Phosphate | 24.66 | 23.38 | 23.05 |

s.e 0.76, cv% 3.2

Table 1.4 Effect of Type of Fertiliser and Rate of Application on bunch number in 1999 (Trial 125).

| Type of Fertiliser | Rate (gN/palm/year) | | |
|---|---|---|---|
| | 520 | 1040 | 2080 |
| Ammonium Chloride | 1598 | 1804 | 1674 |
| Sulphate of Ammonia | 1626 | 1612 | 1706 |
| Urea | 1645 | 1712 | 1531 |
| Ammonium Nitrate | 1555 | 1563 | 1645 |
| Di-Ammonium Phosphate | 1662 | 1590 | 1555 |

S.e. 80.4, cv% 4.9

Table 1.5 Effect of Type of Fertiliser and Rate of Application on bunch weight (kg) in 1999 (Trial 125).

| Type of Fertiliser | Rate (gN/palm/year) | | |
|---|---|---|---|
| | 520 | 1040 | 2080 |
| Ammonium Chloride | 15.45 | 14.97 | 14.19 |
| Sulphate of Ammonia | 14.88 | 14.71 | 15.89 |
| Urea | 15.33 | 14.54 | 15.56 |
| Ammonium Nitrate | 15.77 | 15.27 | 15.23 |
| Di-Ammonium Phosphate | 15.21 | 15.22 | 1557 |

S.e. 0.44, cv% 2.9

The yield and components of yield in 1998 and 1999 for each type of nitrogen fertiliser are shown in Table 1.6.

Table 1.6 Effects of Type of fertiliser on Yield and Yield components in 1998 and 1999 (Trial 125).

| Type of Fertiliser | 1998 | | | 1999 | | |
|---|---|---|---|---|---|---|
| | Yield (t/ha) | SBW (kg) | NB/ha | Yield (t/ha) | SBW (kg) | NB/ha |
| **Control** | **27.6** | **10.3** | **2664** | **24.78** | **14.40** | **1738** |
| Ammonium Chloride | 28.3 | 11.0 | 2609 | 24.37 | 14.87 | 1692 |
| Sulphate of Ammonia | 27.5 | 10.8 | 2571 | 24.13 | 15.16 | 1648 |
| Urea | 27.6 | 10.6 | 2623 | 23.88 | 15.14 | 1630 |
| Ammonium Nitrate | 27.8 | 10.9 | 2608 | 23.58 | 15.42 | 1588 |
| Di-Ammonium Phosphate | 26.5 | 10.6 | 2532 | 23.70 | 15.33 | 1602 |

No tissue analysis was carried out in 1999.

**Trial 126 FACTORIAL FERTILISER TRIAL AT MALILIMI PLANTATION.**

[*Reanalysed & reported by James Kraip*]

PURPOSE

To provide fertiliser response information that will be useful in developing strategies for fertiliser usage. This trial was also designed to investigate further the yield responses seen in Trial 119, i.e. was the response due to potassium or chlorine?

SITE and PALMS

Malilimi Plantation

Soil: Young coarse textured freely draining soils formed on alluvially redeposited andesitic pumiceous sand and volcanic ash. Palaeosols are common.

Palms: Dami commercial DxP crosses. Planted in 1985 at 135 palms/ha.

DESIGN

There are 72 treatments comprising all factorial combinations of ammonium sulphate (SOA), potassium sulphate (SOP), each at three levels, and triple superphosphate (TSP), kieserite (KIE) and sodium chloride (NaCl), each at two levels (Table 1.7). The 72 treatments are replicated only once and are divided among two blocks. The 3 factor interaction '2x2x2' is confounded with blocks. Third and higher order interactions provide the error term in the statistical analysis. Each of the 72 plots consists of 36 palms (6x6) of which the central 16 palms are recorded and the outer 20 palms are regarded as guard row palms.

Table 1.7 Fertiliser rates in Trial 126.

| Fertiliser | Level (kg/palm.year) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| Ammonium sulphate (SOA) | 0 | 3 | 6 |
| Potassium sulphate (SOP) | 0 | 3 | 6 |
| Triple superphosphate (TSP) | 0 | 4 | - |
| Kieserite (KIE) | 0 | 4 | - |
| Sodium chloride (NaCl) | 0 | 4 | - |

*Note: Treatments are factorial combinations of levels of these fertilisers.*

The ammonium sulphate and potassium sulphate are split into two applications per year, while the other fertilisers are applied once per year.

This trial was approved in the PNGOPRA Scientific Advisory Board meeting in November 1993. Site selection, a detailed site survey and site mapping was carried out in May and June 1994. Plot selection was carried out in June 1994. Pre-treatment yield recording commenced in 1995. Experimental fertiliser treatments started in July 1996. Plot isolation trenches were dug prior to commencement of treatments.

RESULTS

The effects of SOA, SOP, TSP, KIE and NaCl on yield and its components in 1999 and during the 1997-1999 period are shown in tables 1.8 and 1.9. TSP and kieserite, applied at the rate of 4kg per palm per year, increased yields significantly in 1999, mainly through significant increase in individual bunch weights. Application of SOA, SOP and NaCl had no significant effect on yields in 1999. The

SOA application significantly increased individual bunch weight in 1999 but that did not necessarily increased yield.

Effects of interaction between fertilisers are shown in tables 1.10, 1.11 and 1.12. The interactional effects of SOP.TSP and TSP.KIE on yield in 1999 were significant. Significant SOP.TSP interactional effect was mainly through significant increase in the number of bunches per ha while TSP.KIE effect was through both significant increase in the number of bunches per ha and individual bunch weights. Highest yield was obtained at an application rate of 6 kg SOP and 4 kg of TSP per palm per year. SOP.KIE.NaCl interaction effect on yield was significant in 1999 (Table 2). The highest yield of 27.4 tonnes was obtained from an application rate of 4 kg of KIE and 4 kg of NaCl with no SOP added.

The main effects of fertiliser on frond 17 nutrient concentrations in 1999 are shown in table 1.13. Application of SOA had a significant effect on Leaflet N, P, Ca and B concentrations. SOP had a significant effect on rachis K concentration but not any other nutrient. Similarly, TSP had a significant effect on Leaflet P concentration. NaCl had a significant effect on leaflet K, Ca and Cl, and rachis K concentrations. The significant effects of SOA, SOP and NaCl on leaflet and rachis nutrient concentrations did not correspond to any significant yield increase.

The main effects of SOA, MOP, TSP, KIE and NaCl on yield and tissue nutrient concentrations over the course of the trial are shown in Fig. 1.1. SOA and NaCl applied at the rate of 6 kg and 4 kg per palm per year respectively had no significant effect on yields. During the first two years of the trial, TSP and KIE applied at the rate of 4 kg per palm per year had no significant effect on yields but yields increased significantly in the third year of the trial. The application of SOP at the rate 6 kg per palm per year had no significant effect on yield in the first and third year of the trial but yield increased significantly in the second year of the trial. All fertilisers applied at their maximum rates had significant effects on tissue nutrient concentrations over the course of the trial.

Table 1.8 Effects (p values) of treatments on FFB yield and its components in 1997-1999 and 1999 (Trial 126). p values less than 0.1 are indicated in bold.

| | 1997-1999 | | | 1999 | | |
|---|---|---|---|---|---|---|
| Source | Yield | Bun./ha | kg/bun. | Yield | Bun./ha | kg/bun. |
| SOA | 0.254 | 0.829 | **0.053** | 0.696 | 0.751 | **0.005** |
| SOP | 0.601 | 0.580 | **0.073** | 0.714 | 0.754 | 0.171 |
| TSP | 0.347 | 0.476 | **0.033** | **0.002** | 0.131 | **0.004** |
| KIE | 0.328 | 0.904 | 0.135 | **0.007** | 0.137 | **0.010** |
| NaCl | **0.009** | 0.199 | 0.154 | 0.129 | 0.416 | 0.215 |
| SOA.SOP | 0.593 | 0.718 | 0.682 | 0.880 | 0.786 | 0.550 |
| SOA.TSP | 0.252 | 0.577 | 0.986 | 0.762 | 0.870 | 0.985 |
| SOP.TSP | 0.551 | 0.649 | 0.365 | **0.051** | **0.096** | 0.739 |
| SOA.KIE | 0.480 | 0.347 | 0.319 | 0.534 | 0.346 | 0.289 |
| SOP.KIE | 0.988 | 0.570 | 0.369 | 0.906 | 0.332 | 0.201 |
| TSP.KIE | **<0.001** | 0.120 | **0.025** | **<0.001** | **0.007** | **0.015** |
| SOA.NaCl | 0.853 | 0.503 | 0.447 | 0.482 | 0.995 | **0.053** |
| SOP.NaCl | 0.406 | 0.531 | 0.921 | 0.256 | 0.226 | 0.374 |
| TSP.NaCl | 0.350 | 0.562 | 0.952 | 0.761 | 0.972 | 0.989 |
| KIE.NaCl | 0.660 | 0.720 | 0.877 | 0.772 | 0.881 | 0.813 |
| SOA.SOP.TSP | 0.646 | 0.331 | 0.506 | 0.747 | 0.721 | 0.578 |
| SOA.SOP.KIE | 0.961 | 0.667 | 0.631 | 0.937 | 0.586 | 0.408 |
| SOA.TSP.KIE | 0.184 | **0.018** | **0.051** | 0.502 | 0.192 | 0.260 |
| SOP.TSP.KIE | 0.226 | 0.473 | 0.990 | 0.194 | 0.276 | 0.814 |
| SOA.SOP.NaCl | 0.549 | 0.903 | 0.698 | 0.637 | 0.786 | 0.604 |
| SOA.TSP.NaCl | 0.757 | 0.559 | 0.683 | 0.819 | 0.968 | 0.389 |
| SOP.TSP.NaCl | 0.823 | 0.286 | 0.217 | 0.926 | 0.515 | **0.073** |
| SOA.KIE.NaCl | 0.584 | 0.536 | 0.884 | 0.624 | 0.862 | 0.496 |
| SOP.KIE.NaCl | 0.732 | 0.886 | 0.553 | **0.059** | 0.329 | 0.381 |
| TSP.KIE.NaCl | **0.067** | 0.988 | **0.042** | 0.707 | 0.257 | **0.020** |
| *CV %* | *7.0* | *9.7* | *6.3* | *11.5* | *14* | *6.3* |

Table 1.9 Main effects of treatments on FFB yield and its components (Trial 126). Significant effects ($p<0.1$) are shown in bold.

| | 1997-1999 Yield (t/ha) | Bun./ha | kg/bun. | 1999 Yield (t/ha) | Bun./ha | kg/bun. |
|---|---|---|---|---|---|---|
| SOA 1 | 28.4 | 1238 | **23.5** | 24.2 | 970 | **25.5** |
| SOA 2 | 28.9 | 1243 | **23.7** | 24.6 | 956 | **26.4** |
| SOA 3 | 29.4 | 1222 | **24.5** | 24.9 | 941 | **27.3** |
| *sed* | *0.6* | *35* | *0.43* | *0.8* | *38* | *0.5* |
| SOP 1 | 28.6 | 1247 | **23.4** | 24.6 | 971 | 25.9 |
| SOP 2 | 28.9 | 1242 | **23.9** | 24.2 | 944 | 26.4 |
| SOP 3 | 29.2 | 1213 | **24.4** | 24.9 | 951 | 26.9 |
| *sed* | *0.6* | *35* | *0.43* | *0.8* | *38* | *0.5* |
| TSP 1 | 28.7 | 1244 | **23.5** | **23.4** | 931 | **25.8** |
| TSP 2 | 29.1 | 1224 | **24.3** | **25.7** | 980 | **27.1** |
| *sed* | *0.5* | *28* | *0.35* | *0.7* | *31* | *0.4* |
| KIE 1 | 28.7 | 1236 | 23.6 | **23.6** | 931 | **25.9** |
| KIE 2 | 29.1 | 1232 | 24.2 | **25.6** | 979 | **27.0** |
| *sed* | *0.5* | *28* | *0.35* | *0.7* | *31* | *0.4* |
| NaCl 1 | **28.2** | 1215 | 23.6 | 24.0 | 942 | 26.2 |
| NaCl 2 | **29.6** | 1253 | 24.2 | 25.1 | 968 | 26.7 |
| *sed* | *0.5* | *28* | *0.35* | *0.7* | *31* | *0.4* |
| *GM* | *28.9* | *1234* | *23.9* | *24.6* | *955* | *26.4* |

Table 1.10 Effect of SOP.TSP interaction on FFB yield (t/ha) in 1999 (Trial 126). P= 0.051, $lsd_{0.05}$ = 2.4. Yields >35 t/ha are highlighted.

| | SOP1 | SOP2 | SOP3 |
|---|---|---|---|
| TSP1 | 22.3 | 23.4 | 24.6 |
| TSP2 | 27.0 | 25.0 | 25.2 |
| *sed 1.2* | | | |

Table 1.11 Effect of TSP.KIE interaction on FFB yield (t/ha) in 1999 (Trial 126). *p= <0.001*, $lsd_{0.05}$ = 2.0. Yields >35 t/ha are highlighted.

| | TSP1 | TSP2 |
|---|---|---|
| KIE1 | 20.7 | 26.5 |
| KIE2 | 26.1 | 25.0 |
| *sed 1.0* | | |

Table 1.12 Effect of TSP.KIE interaction on FFB yield (t/ha), 1997- 1999 (Trial 126). *p= <0.001*, $lsd_{0.05}$ = 1.4. Yields >35 t/ha are highlighted.

| | TSP1 | TSP2 |
|---|---|---|
| KIE1 | 27.3 | 28.0 |
| KIE2 | 28.0 | 28.3 |
| *sed 0.7* | | |

Table 1.13 Main effects of treatments on frond 17 nutrient concentrations in 1999, in units of % dry matter, except for B (ppm) (Trial 126). Significant effects (p<0.1) are shown in bold.

| | Leaflet | | | | | | | | Rachis | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Ash | N | P | K | Mg | Ca | B | Cl | Ash | K |
| SOA0 | | **2.21** | **0.133** | 0.77 | 0.14 | **0.87** | **9.69** | 0.46 | | 1.19 |
| SOA1 | | **2.26** | **0.138** | 0.78 | 0.14 | **0.85** | **10.38** | 0.42 | | 1.12 |
| SOA2 | | **2.29** | **0.138** | 0.74 | 0.13 | **0.81** | **9.75** | 0.44 | | 1.18 |
| *sig.* | | * | * | *ns* | *ns* | * | * | *ns* | | *ns* |
| *sed* | | *0.04* | *0.002* | *0.016* | *0.006* | *0.021* | *0.27* | *0.031* | | *0.05* |
| SOP0 | | 2.29 | 0.137 | 0.77 | 0.14 | 0.84 | 10.07 | 0.45 | | **1.02** |
| SOP1 | | 2.17 | 0.136 | 0.77 | 0.14 | 0.84 | 9.99 | 0.44 | | **1.21** |
| SOP2 | | 2.23 | 0.137 | 0.78 | 0.13 | 0.86 | 9.75 | 0.43 | | **1.27** |
| *sig.* | | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | *ns* | | *** |
| *sed* | | *0.04* | *0.002* | *0.016* | *0.006* | *0.021* | *0.27* | *0.031* | | *0.05* |
| TSP0 | | 2.26 | **0.134** | 0.78 | 0.14 | 0.85 | 10.12 | 0.43 | | 1.17 |
| TSP1 | | 2.25 | **0.138** | 0.77 | 0.14 | 0.84 | 9.75 | 0.46 | | 1.16 |
| *sig.* | | *ns* | ** | *ns* | *ns* | *ns* | *ns* | *ns* | | *ns* |
| *sed* | | *0.03* | *0.0015* | *0.014* | *0.005* | *17* | *0.22* | *0.025* | | *0.04* |
| KIE0 | | 2.26 | 0.136 | 0.77 | **0.13** | **0.87** | 10.02 | 0.45 | | 1.19 |
| KIE1 | | 2.25 | 0.136 | 0.77 | **0.14** | **0.82** | 9.86 | 0.43 | | 1.15 |
| *sig.* | | *ns* | *ns* | *ns* | * | ** | *ns* | *ns* | | *ns* |
| *sed* | | *0.03* | *0.0015* | *0.014* | *0.005* | *0.017* | *0.22* | *0.025* | | *0.04* |
| NaCl0 | | 2.23 | 0.137 | **0.78** | 0.14 | **0.83** | 9.92 | **0.39** | | **1.11** |
| NaCl1 | | 2.27 | 0.136 | **0.76** | 0.14 | **0.86** | 9.95 | **0.49** | | **1.23** |
| *sig.* | | *ns* | *ns* | * | *ns* | * | *ns* | *** | | ** |
| *sed* | | *0.03* | *0.0015* | *0.014* | *0.005* | *0.017* | *0.22* | *0.025* | | *0.04* |
| CV % | | 5.7 | 4.9 | 7.6 | 14.9 | 8.5 | 6.5 | 24.2 | | 13.9 |

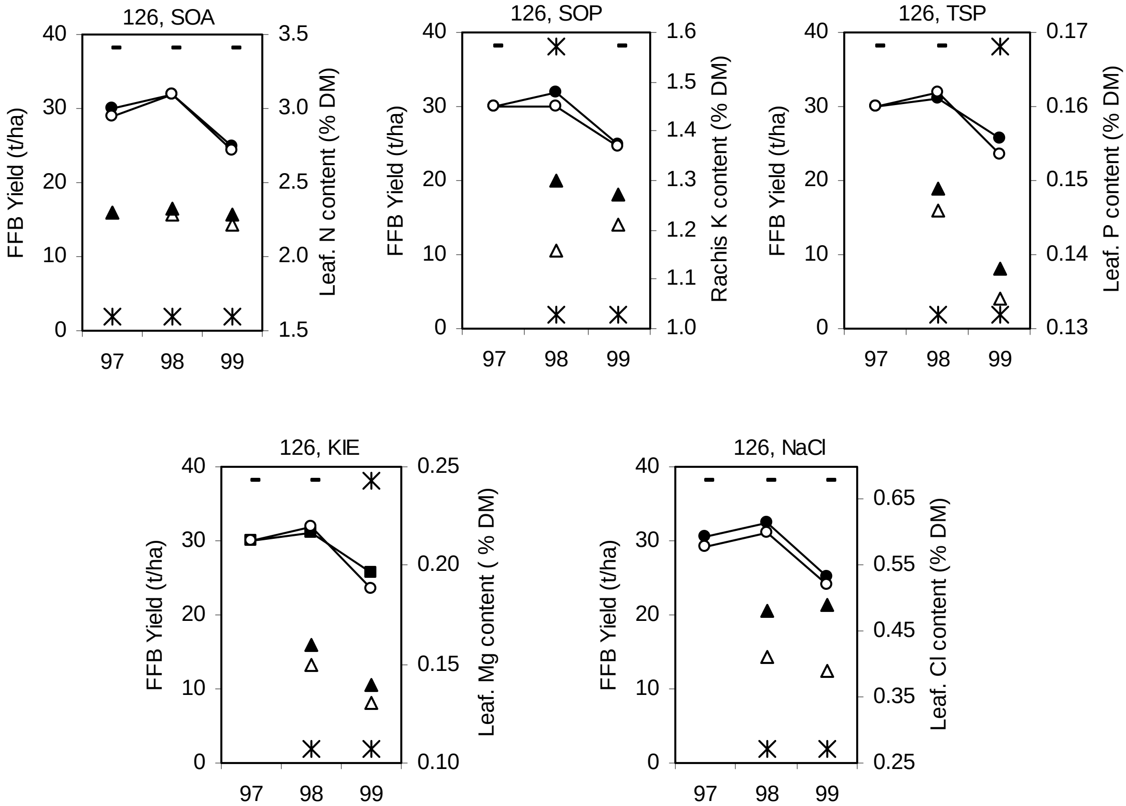



Figure 1.1 Main effects of SOA, SOP, TSP, KIE and NaCl over the course of Trial 126. Lines with circles are FFB yields and triangles are tissue concentrations. Full symbols represent the maximum level of application, and empty symbols zero application. Symbols along the top of the graph indicate significance 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.

## Trial 129 CROP RESIDUE AND FERTILISER PLACEMENT TRIAL.

### PURPOSE

To provide information on the effect of fertiliser placement in the presence or absence of EFB.

### DESCRIPTION

Site Kumbango Plantation, Division 1

Soil **Y**oung coarse textured freely draining soils formed on alluvially re-deposited andesitic pumiceous sands and gravel with intermixed volcanic ash.

Palms Dami commercial DxP crosses.

Planted in October 1994 at 135 palms/ha.

Treatments applications will start 36 months after planting.

### DESIGN

The trial was designed by biometricians from IACR - Rothamsted and the Pacific Regional Agricultural Program as a replacement for Trial 122 in 1998 re-plantings. There will in fact be two separate trials side by side but the results will be reported together.

In Trial 129a there are two EFB treatments (nil & 50 t/ha). The EFB will be applied on either side of the harvest path as per normal plantation practice. A standard fertiliser treatment of ammonium chloride and Kieserite will be applied to all plots receiving fertiliser. The fertiliser will be applied on either the weeded circle or on the frond pile. The six treatments (Table 1.14) are arranged in a randomised complete block design with 4 replications.

Trial 1.14 Treatment to be used in Trial 129a.

| Treatment Number | Crop Residue | Fertiliser Applied (kg/palm/yr) | Fertiliser Placement |
|---|---|---|---|
| 1 | EFB | 3.0kg AC & 3.0kg Kies | Weeded Circle |
| 2 | EFB | 3.0kg AC & 3.0kg Kies | Frond Pile |
| 3 | EFB | Nil | - |
| 4 | Nil | 3.0kg AC & 3.0kg Kies | Weeded Circle |
| 5 | Nil | 3.0kg AC & 3.0kg Kies | Frond Pile |
| 6 | Nil | Nil | - |

In Trial 129b all plots will receive EFB at a rate of 50 t/ha. A standard fertiliser treatment of ammonium chloride and Kieserite will be applied to all plots receiving fertiliser. The fertiliser will be applied on the weeded circle, the frond pile or the EFB (Table 1.15). The four treatments will be arranged in a randomised complete block design with 8 replications.

Table 1.15 Treatments to be used in Trial 129b.

| Treatment Number | Crop Residue | Fertiliser Applied (kg/palm/yr) | Fertiliser Placement |
|---|---|---|---|
| 1 | EFB | 3.0kg AC & 3.0kg Kies | Weeded Circle |
| 2 | EFB | 3.0kg AC & 3.0kg Kies | Frond Pile |
| 3 | EFB | 3.0kg AC & 3.0kg Kies | EFB |
| 4 | EFB | Nil | - |

## RESULTS

Yield recording of these trials commenced in January 1999. These results represent the first full year of recording.

Mean FFB yield in 1999 was 27.3 t/ha in Trial 129a and 26.7 t/ha in Trial 129b. Overall there were no statistically significant differences between the treatments on FFB yield and the yield components in 1999. The results in trial 129a show that the highest yield of 28.2 t/ha is achieved by applying fertiliser on the weeded circle in the absence of empty fruit bunch. This yield is higher than the recommended practice of applying fertiliser to frond piles that yielded 26.7 t/ha.

The FFB yield from the control plots was high at 27 t/ha.

In trial 129b, there were no significant differences between the four fertiliser placement treatments in the presence of empty fruit bunch. The application of fertiliser on empty fruit bunch produced the highest yield of 27.6 t/ha.

Table 1.16 Main effects of fertiliser placement with and without EFB on FFB yield and yield components in 1999 (Trial 129a).

| Treatment (+/- EFB) | Placement Types | 1999 | | |
|---|---|---|---|---|
| | | Yield (t/ha/yr) | Bunches (no/ha) | Bunch wt (kg) |
| 4 (-EFB) | Fert on weeded circle | 28.2 | 2134 | 13.3 |
| 1 (+EFB) | Fert on weeded circle | 27.4 | 2105 | 13.3 |
| 2 (+EFB) | Fert on frond pile | 27.2 | 2153 | 12.8 |
| 6 (-EFB) | Nil | 27.1 | 2052 | 13.3 |
| 3 (+EFB) | Nil | 27.0 | 2263 | 12.0 |
| 5 (-EFB) | Fert on frond pile | 26.7 | 2216 | 12.1 |
| | Mean | 27.3 | 2154 | 12.8 |
| | Sig | ns | ns | ns |
| | Cv% | 5.3 | 11.2 | 10.0 |
| | Sed | 1.43 | 240 | 1.27 |

Table 1.17 Main effects of fertiliser placement types in the presence of EFB on yield and yield components in 1999 (Trial 129b).

| Treatment Number (+EFB) | Fertiliser Placement Types | 1999 | | |
|---|---|---|---|---|
| | | Yield (t/ha/yr) | Bunches (no/ha) | Bunch wt (kg) |
| 3 | EFB | 27.62 | 2201 | 12.66 |
| 1 | Weeded Circle | 26.40 | 2190 | 12.18 |
| 4 | Frond Pile | 26.37 | 2084 | 12.78 |
| 2 | Nil | 26.27 | 2167 | 12.23 |
| | Mean | 26.66 | 2161 | 12.46 |
| | Sig | ns | ns | ns |
| | Cv% | 6.9 | 9.5 | 6.2 |
| | Sed | 1.84 | 204 | 0.78 |

**Figure 1.2. Fertiliser Placement With & Without EFB in Trial 129a**

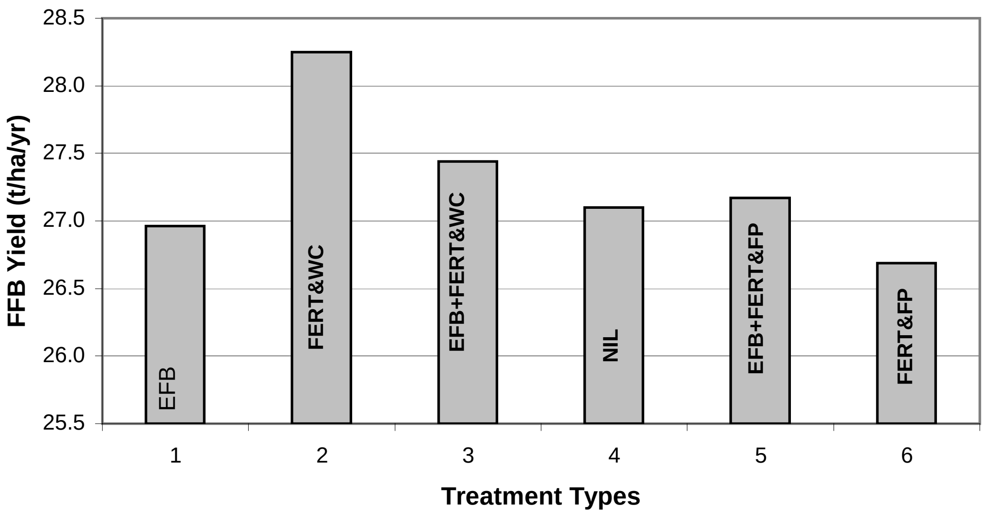
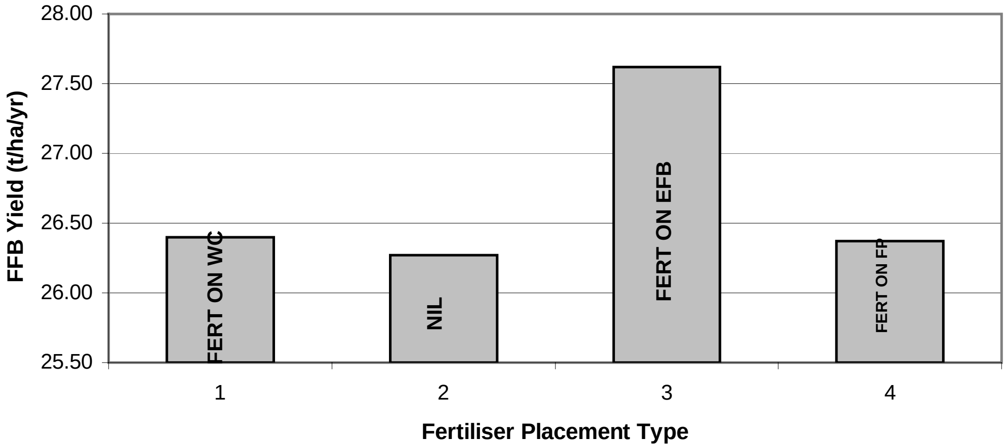


**Figure 1.3. Fertiliser Placement in the presence of EFB in Trial 129b**




Leaf sampling was carried out in 1999. The data is presented in Tables 1.18 and 1.19. In Trial 129a (Table 1.18) there was no significant differences in leaflet N, P, K, Ca, Mg and B caused by the different fertiliser placements, whether applied with or without EFB. There was however a significant difference between the treatments with regard to leaflet Cl.

In Trial 129b, there were no significant differences between the fertiliser placements for N, P, K, Ca, Mg, Cl and B.

Table 1.18 Effects of fertiliser placement with and without EFB on the concentrations of nutrients (Trial 129a).

| Treatment Number | Fertiliser Placement | Leaf concentrations (% dry matter) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Ash | N | P | K | Ca | Mg | Cl | B |
| 1 (+EFB) | Fert on weeded circle | 13.9 | 2.53 | 0.155 | 0.78 | 0.92 | 0.18 | 0.64 | 13.0 |
| 2 (+EFB) | Fert on frond pile | 14.2 | 2.55 | 0.157 | 0.76 | 0.94 | 0.19 | 0.69 | 13.4 |
| 3 (+EFB) | Nil | 14.3 | 2.52 | 0.157 | 0.75 | 0.94 | 0.20 | 0.68 | 14.8 |
| 4 (-EFB) | Fert on weeded circle | 14.1 | 2.52 | 0.156 | 0.82 | 0.95 | 0.19 | 0.64 | 14.6 |
| 5 (-EFB) | Fert on frond pile | 13.7 | 2.51 | 0.153 | 0.79 | 0.89 | 0.17 | 0.65 | 14.0 |
| 6 (-EFB) | Nil | 14.2 | 2.52 | 0.157 | 0.82 | 0.94 | 0.19 | 0.66 | 12.8 |
| | Mean | 14.1 | 2.52 | 0.156 | 0.78 | 0.93 | 0.19 | 0.66 | 13.8 |
| | Sig | ns | ns | ns | ns | ns | ns | * | ns |
| | Cv% | 4.4 | 2.3 | 1.9 | 6.9 | 5.1 | 11.1 | 3.8 | 9.6 |
| | Sed | 0.62 | 0.059 | 0.003 | 0.054 | 0.048 | 0.021 | 0.025 | 1.32 |

Table 1.19 Effects of fertiliser placement in the presence of EFB on nutrient concentration in 1999 (Trial 129b).

| Treatment | Fertiliser | Leaf nutrient concentrations (% dry matter) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. +EFB | Placement | Ash | N | P | K | Ca | Mg | Cl | B |
| 1 | Weeded circle | 14.2 | 2.61 | 0.156 | 0.78 | 0.97 | 0.19 | 0.68 | 13.1 |
| 2 | Nil | 14.1 | 2.56 | 0.156 | 0.73 | 0.94 | 0.18 | 0.66 | 12.6 |
| 3 | EFB | 14.3 | 2.56 | 0.157 | 0.77 | 1.00 | 0.18 | 0.66 | 13.1 |
| 4 | Frond Pile | 14.2 | 2.54 | 0.156 | 0.79 | 0.98 | 0.18 | 0.66 | 11.9 |
| | Mean | 14.2 | 2.57 | 0.156 | 0.77 | 0.97 | 0.18 | 0.66 | 12.7 |
| | Sig | ns | ns | ns | ns | ns | ns | ns | ns |
| | Cv% | 3.7 | 3.0 | 1.8 | 8.7 | 5.8 | 9.0 | 5.7 | 11.1 |
| | Sed | 0.53 | 0.076 | 0.003 | 0.067 | 0.056 | 0.016 | 0.038 | 1.41 |

**Trial 132 FACTORIAL FERTILISER TRIAL AT HAELLA PLANTATION.**

PURPOSE

To provide fertiliser response information that will be useful in developing strategies for fertiliser usage.

DESCRIPTION

Site Haella Plantation, Road 6-7, Avenues 10-12

Soil Freely draining andosols formed on intermediate to basic volcanic ash.

Palms Dami commercial DxP crosses.

Planted in 1995 at 128 palms/ha.

Treatments to commence 1999.

DESIGN

There will be 81 treatments, comprising all factorial combinations of N, P, K and Mg each at three levels (Table 1.20).

Table 1.20 Rates of fertiliser to be used in Trial 132.

| | Level (kg /palm/year) | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| Ammonium chloride | 2.0 | 4.0 | 6.0 |
| Triple superphosphate | 0.0 | 2.0 | 4.0 |
| Muriate of potash | 0.0 | 2.0 | 4.0 |
| Kieserite | 0.0 | 2.0 | 4.0 |

*Note: Treatments are factorial combinations of levels of these fertilisers.*

There are 81 plots each consisting of 36 palms (6x6) of which the central 16 palms are recorded and the outer 20 are guard row palms. The 81 treatments are replicated only once and are divided among nine blocks each of nine plots.

PROGRESS

The PNGOPRA Scientific Advisory Committee approved the trial in 1997 and the plots were marked out in December 1997. Pre-treatment yield recording has continued since 1998. Fertiliser treatments which would have commenced in 1999 was postponed due to the trenching not being completed and the impending changes being considered towards the redesigning of this trial. At the Scientific Advisory Committee Meeting held in 1999 it was agreed that this trial be simplified and the design change to a 2x2x2x2 ($2^4$) factorial trial. Fertiliser treatment will include the factorial combination of P, K, Mg and B.

In 1999 the result of pre-treatment yield recorded is shown in Table 1.21. The mean FFB yield was 31t/ha. Average number of bunch per hectare was 253 and the average bunch weight was about 10.3 kg.

Table 1.21 Pre-treatment Yield and yield component in 1999 (Trial 132).

| Month | Mean SBW | B/Ha | Yield (t/Ha |
|---|---|---|---|
| January | 9.2 | 302 | 2.8 |
| February | 10.4 | 256 | 2.7 |
| March | 10.4 | 220 | 2.3 |
| April | 9.6 | 207 | 2.0 |
| May | 9.7 | 223 | 2.2 |
| June | 8.8 | 172 | 1.5 |
| July | 9.0 | 230 | 2.1 |
| August | 9.6 | 193 | 1.9 |
| September | 11.2 | 255 | 2.9 |
| October | 12.0 | 275 | 3.3 |
| November | 12.0 | 298 | 3.6 |
| December | 11.5 | 404 | 4.7 |
| **Mean** | **10.3** | **253** | **2.6** |
| **Total** | | **3037** | **31.7** |

## Trial 135 EFFECT OF IMMATURE FERTILISER ON INCIDENCES AND SEVERITY OF CROWN DISEASE AT HAELLA AND KUMBANGO PLANTATION

### PURPOSE

To determine if high levels of fertiliser and boron have any effect on incidence and severity of Crown Disease.

### DESCRIPTION

Site Garu and Kumbango Plantation

Soil: Young free draining, formed on alluvially re-deposited pumiceous sands, gravel and volcanic ash. At Garu the site has recently been cleared from primary rainforest and sago swamp whilst on Kumbango the site has been under oil palm for 20 years.

Palms: Four selected Dami DxP progenies known to be susceptible to crown disease.

| Progeny No. | Lot No. | Pedigree |
|---|---|---|
| 1 | 9701129 | 711.808 x 742.207 |
| 2 | 9701608 | 711.619 x 742.307 |
| 3 | 9701815 | 714.604 x 742.307 |
| 4 | 9703205 | |

### BACKGROUND

This is a joint research project between Dami OPRS and PNGOPRA. There is evidence that Crown Disease is a genetic disorder but there are reports that boron and possibly high nitrogen levels during the immature phase may also be linked with expression of the disease. The trial has been planned as an agro-genetic trial.

### DESIGN

There were supposed to be three progenies planted in the trial with palms planted in plots of palms. There are 3 nitrogen fertiliser regimes and two levels of Boron (0, 40g/palm). The 18

treatments were supposed to be planted as three replicates of a 3x3x2 factorial at Garu and Kumbango Plantation with treatments arranged in blocks of 6. The actual field planting has consisted of 4 progenies, which makes the design unbalanced and therefore should not be regarded as a 3x3x2 factorial. Rothamsted will continue to be consulted to look into ways of further analysing the trial.

The plots receiving Boron will have 40g Borax/palm applied 3 months after planting.

The trials were planted in December 1998 and fertiliser application commenced in January 1999.

The nitrogen fertiliser schedules are as follows:

1. High Rates (NBPOL standard practice since November 1996)

| Timing | Fertiliser |
|---|---|
| At Planting | 200 g TSP |
| At Planting | 100 g AC or SoA |
| At Planting | 250 kg EFB mulched in 1 palm circle |
| 1 month | 200 g AC or SoA |
| 2 months | 200 g AC or SoA |
| 3 months | 200 g AC or SoA |
| 4 months | 200 g AC or SoA |
| 6 months | 200 g AC or SoA |
| 9 months | 200 g AC or SoA |
| 12 months | 250 g AC or SoA + 0.5 kg Kieserite |
| 18 months | 1.0 kg AC or SoA |

2. Medium Rate

| Timing | Fertiliser |
|---|---|
| At Planting | 200 g TSP |
| At planting | 100 g AC or SoA |
| At Planting | 250 kg EFB mulched in 1 palm circle |
| 1 month | 100 g AC or SoA |
| 2 months | 100 g AC or SoA |
| 3 months | 100 g AC or SoA |
| 4 months | 100 g AC or SoA |
| 6 months | 100 g AC or SoA |
| 9 months | 100 g AC or SoA |
| 12 months | 200 g AC or SoA + 0.5 kg Kieserite |
| 18 months | 500 g AC or SoA |

3. Low Rate

| Timing | Fertiliser |
|---|---|
| At Planting | 200 g TSP |
| At Planting | 100 g AC or SoA |
| At Planting | 250 kg EFB mulched in 1 palm circle |
| 1 month | |
| 2 months | |
| 3 months | 100 g AC or SoA |
| 4 months | |
| 6 months | 100 g AC or SoA |
| 9 months | 100 g AC or SoA |
| 12 months | 200 g AC or SoA + 0.5 kg Kieserite |
| 18 months | 300 g AC or SoA |

## RECORDING

Scoring for severity of crown disease in 1999 are done monthly by OPRS. Vegetative growth measurements were also completed. PNGOPRA was responsible for fertiliser applications and leaflet samples for nutrient analysis including micronutrients that were taken at 6 monthly intervals. Yield recording will be done by OPRS. One scoring run was conducted by PNGOPRA using the scoring guide designed for field census and used by the Numundo Group.

## RESULTS

There is a possibility that the data in this report may be unreliable due to the unbalanced replications of the progenies. Progeny 9701608 had 12 replications whilst progeny 9703205 had only 6 replications however there are some marked differences.

In both sites at Kumbango and Garu, the differences in the expression of crown disease scoring between the 4 progenies were statistically highly significant. This indicated that the expression variability is more so between the progenies. The severity of the expression is more so at Garu than at Kumbango with scores of 2.21 and 1.89 respectively.

In Kumbango progeny 9701608 provided the least expression of the disease, with the highest being progeny 9701815. Whilst in Garu progeny 9701608 did not express any crown disease, but the highest score of expression was progeny 9701129.

In Kumbango where the site is on replanted oil palm, nutrient concentrations of leaflet N, P, and Ca were much lower in progeny 9701608 as compared to the other progenies, whilst leaflet K, Mg, and Cl had the highest nutrient concentrations. Leaflet B concentrations of progeny 9701608 was 21.2 ppm, whilst 26.5 ppm was recorded on progeny 9701129 which had expressed highly on crown disease scoring.

There were statistically significant differences between the ash content (p=0.060), leaflet concentrations of N (p=0.021), P (p=0.050), K (p<0.001), Cl (p=0.011) and B (p=0.057). Differences between progenies on leaflet concentrations of Ca and Mg are approaching statistical significance (Table 1.22).

### KUMBANGO TRIAL

Table 1.22 Main effects between the different progenies on Crown Disease scoring and nutrient concentrations (Trial 135a).

| Progeny | Severity | Leaflet concentrations of nutrients (% of dry matter) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | Score(CD) | Ash% | N% | P% | K% | Ca% | Mg% | Cl% | B(ppm) |
| 9701129 | 2.40 | 11.2 | 2.87 | 0.168 | 1.06 | 0.87 | 0.20 | 0.84 | 26.5 |
| **9701608** | **0.33** | **10.2** | **2.69** | **0.160** | **1.19** | **0.81** | **0.20** | **0.97** | **21.2** |
| 9701815 | 2.50 | 11.0 | 2.89 | 0.169 | 0.99 | 0.90 | 0.19 | 0.80 | 19.8 |
| 9703205 | 2.35 | 11.2 | 2.85 | 0.169 | 0.94 | 0.88 | 0.19 | 0.80 | 19.5 |
| Mean | 1.90 | 10.9 | 2.82 | 0.166 | 1.04 | 0.87 | 0.20 | 0.85 | 21.8 |
| Sig | ** | * | * | * | *** | (ns) | (ns) | * | * |
| Cv% | 30.4 | 4.9 | 3.0 | 2.8 | 5.2 | 6.4 | 6.7 | 7.8 | 17.1 |
| Sed | 0.58 | 0.54 | 0.086 | 0.005 | 0.054 | 0.056 | 0.013 | 0.067 | 3.73 |

In Kumbango the application of nitrogen fertiliser had no statistically significant effects on severity scoring of crown disease. However a trend is developing, where increasing nitrogen rates reduces the severity of expression. The level of N concentration in the leaflets increased with increasing rates of N but was not significant. Increasing rates of N significantly reduced leaflet Boron levels (Table 1.23). The Kumbango situation illustrates a trend where high rates of N during the immature phase reduces the severity score of crown disease and also lowered the leaflet concentration of B to 21.4ppm (Table 1.23).

Leaflet K and Mg levels although significant was rather variable. There were no significant effects on leaflet P, Ca, Cl and ash content.

Application of Boron did not significantly reduce severity expression of crown disease, despite a significant increase in leaflet B. Boron application increased leaflet N, approaching significance. There were no significant effects on leaflet P, K, Ca, Mg and Cl (Table 1.24).

Table 1.23 Effect of Nitrogen application on Crown Disease scoring and nutrient concentrations (Trial 135a).

| Level | Severity | Leaf nutrient concentrations (% of dry matter) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Of N | Score (CD) | Ash% | N% | P% | K% | Ca% | Mg% | Cl% | B (ppm) |
| N1 | 2.04 | 10.9 | 2.77 | 0.167 | **1.12** | 0.86 | 0.21 | 0.86 | **22.3** |
| N2 | 1.90 | 10.7 | 2.84 | 0.167 | **0.99** | 0.84 | 0.19 | 0.85 | **21.6** |
| N3 | 1.75 | 11.2 | 2.87 | 0.166 | **1.02** | 0.89 | 0.20 | 0.84 | **21.4** |
| Mean | 1.90 | 10.9 | 2.82 | 0.166 | **1.04** | 0.87 | 0.20 | 0.85 | **21.8** |
| Sig | ns | Ns | Ns | ns | ***** | Ns | (ns) | ns | ***** |
| Cv% | 30.4 | 4.9 | 3.0 | 2.8 | **5.2** | 6.4 | 6.7 | 7.8 | **17.1** |
| Sed | 0.58 | 0.54 | 0.086 | 0.005 | **0.054** | 0.056 | 0.013 | 0.067 | **3.73** |

Table 1.24 Effects of Boron application on Crown Disease scoring and nutrient concentrations (Trial 135a).

| Level | Severity | Leaf nutrient concentrations ( as % of dry matter) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Of Boron | Score(CD) | Ash% | N% | P% | K% | Ca% | Mg% | Cl% | B (ppm) |
| B0 | 1.90 | 10.8 | 2.79 | 0.166 | 1.06 | 0.85 | 0.19 | 0.86 | **18.5** |
| B1 | 1.89 | 11.0 | 2.86 | 0.167 | 1.03 | 0.88 | 0.20 | 0.86 | **25.1** |
| Mean | 1.90 | 10.9 | 2.82 | 0.166 | 1.04 | 0.87 | 0.20 | 0.85 | **21.8** |
| Sig | ns | ns | (ns) | ns | ns | ns | ns | ns | ****** |
| Cv% | 30.4 | 4.9 | 3.0 | 2.8 | 5.2 | 6.4 | 6.7 | 7.8 | **17.1** |
| Sed | 0.58 | 0.54 | 0.086 | 0.005 | 0.054 | 0.056 | 0.013 | 0.067 | **3.73** |

Incidence severity scoring of crown disease at Garu was higher, than those scored at Kumbango. There were highly significant differences between the progenies. Progeny 9701608 had no expression of crown disease. The high severity scores were more so for progenies 9701129 and 9703205.

Progeny 9701608 had the lowest leaflet concentrations of N, P, and Ca, but high levels of Mg and Cl as compared to the other progenies. All nutrient concentrations except Mg were not significantly different between the progenies. There was a high Mg level in the leaflets of progeny 971608 (0.33%) that was statistically significant.

GARU TRIAL

Table 1.25 Main effects between different Progenies on Crown Disease scoring and nutrient concentration (Trial 135b).

| Progeny | **Severity** | Leaf nutrient concentrations (% dry matter) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| No. | **Score** | Ash% | N% | P% | K% | Ca% | **Mg%** | Cl% | B (ppm) |
| 9701129 | **3.02** | 10.4 | 2.84 | 0.159 | 0.94 | 0.85 | **0.31** | 0.90 | 20.2 |
| 9701608 | **0.00** | 9.9 | 2.76 | 0.155 | 0.96 | 0.83 | **0.33** | 0.98 | 17.6 |
| 9701815 | **2.67** | 10.2 | 2.76 | 0.162 | 0.89 | 0.85 | **0.30** | 0.89 | 15.9 |
| 9703205 | **3.17** | 9.9 | 2.78 | 0.156 | 1.01 | 0.86 | **0.30** | 0.89 | 17.7 |
| Mean | **2.21** | 10.12 | 2.79 | 0.158 | 0.95 | 0.85 | **0.31** | 0.92 | 17.9 |
| Sig | ******* | ns | ns | ns | ns | ns | ****** | ns | ns |
| Cv% | **14.5** | 8.5 | 3.7 | 3.1 | 10.9 | 7.2 | **3.5** | 7.0 | 21.3 |
| Sed | **0.32** | 0.86 | 0.104 | 0.005 | 0.103 | 0.061 | **0.011** | 0.064 | 3.81 |

Application of nitrogen with increasing rates did not affect severity scoring, but was variable. N leaflet levels was improved but was not significant. Leaflet Mg improved with increasing rates of N and was almost significant (Table 1.26).

Application of Boron reduced the severity of crown disease from B0 (2.3) to B1 (2.1), but was not significant. Leaflet B was significantly improved with applications of B from B0 (13.7ppm) to B1 (22.0ppm) Table 1.27.

Table 1.26 Effect of Nitrogen application on Crown Disease scoring and nutrient concentrations (Trial 135b).

| Level | Severity | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Of N | Score | Ash% | N% | P% | K% | Ca% | Mg% | Cl% | B (ppm) |
| N1 | 2.14 | 10.3 | 2.75 | 0.158 | 0.96 | 0.87 | **0.30** | 0.91 | 18.5 |
| N2 | 2.35 | 9.9 | 2.78 | 0.157 | 0.94 | 0.83 | **0.31** | 0.92 | 17.7 |
| N3 | 2.15 | 10.2 | 2.83 | 0.158 | 0.94 | 0.84 | **0.32** | 0.92 | 17.4 |
| Mean | 2.21 | 10.1 | 2.79 | 0.158 | 0.95 | 0.85 | **0.31** | 0.92 | 17.9 |
| Sig | ns | ns | ns | ns | ns | ns | **(ns)** | ns | ns |
| Cv% | 14.5 | 8.5 | 3.7 | 3.1 | 10.9 | 7.2 | **3.5** | 7.0 | 21.3 |
| Sed | 0.32 | 0.86 | 0.104 | 0.005 | 0.103 | 0.061 | **0.011** | 0.064 | 3.81 |

Table 1.27 Effects of Boron application on Crown Disease scoring and nutrient concentrations (Trial 135b)

| Level | Severity | Leaf nutrient concentrations (% dry matter) | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Of Boron | Score | Ash% | N% | P% | K% | Ca% | Mg% | Cl% | B (ppm) |
| B0 | 2.3 | 10.2 | 2.81 | 0.159 | 0.94 | 0.85 | 0.31 | 0.91 | **13.7** |
| B1 | 2.1 | 10.0 | 2.77 | 0.157 | 0.95 | 0.85 | 0.31 | 0.92 | **22.0** |
| Mean | 2.21 | 10.1 | 2.79 | 0.158 | 0.95 | 0.85 | 0.31 | 0.92 | **17.9** |
| Sig | ns | ns | ns | ns | ns | ns | ns | ns | ** |
| Cv% | 14.5 | 8.5 | 3.7 | 3.1 | 10.9 | 7.2 | 3.5 | 7.0 | **21.3** |
| Sed | 0.32 | 0.86 | 0.104 | 0.005 | 0.103 | 0.061 | 0.011 | 0.064 | **3.81** |

## Trial 136. MONTHLY LEAF SAMPLING INVESTIGATION

### PURPOSE

The Scientific Advisory Board Meeting in 1997 requested that monthly leaf sampling be conducted on New Britain Palm Oil Ltd plantations. This were to give information on annual variations in leaf nutrient levels which will be used to interpret the results of the annual plantation leaf sampling exercise. This trial commenced in early 1998 and will continue for a period of four years.

### DESCRIPTION

Sampling sites selected are listed in the Table 1.28.

Table 1.28 Sampling sites for Trial 136.

| Plantation | Year of planting | Location |
|---|---|---|
| HEALLA | 1995 | Between road 5 and 6 and Avenue 12 and 13 |
| KUMBANGO | 1993 (replanting) | Behind Kumbango office |
| MALILIMI | 1985 | Field 85B – Road 1 and 2 and Avenue 5 and 6. |
| BILOMI | 1987 | Field 86K- Road 2 and 3, and Avenue 9 and 10 |
| KAUTU | 1986 | Road 7 and 8, Avenue 14 – 15 |

### DESIGN

Leaf and rachis tissue are taken from frond 17 from approximately 40 palms from each field at the same time each month. Sampling intensity is 10 x 10 with different palms sampled on each date. Samples are collected and brought back to the station where they are dried according to standard procedure and method. Analyses are carried out for the major nutrients – N, P and K and the secondary nutrients; Ca, Mg and Cl. Boron is the only minor nutrient included in these analyses. Rachis samples were analysed for K nutrient only.

Fertiliser application at each sampling site is carried out under the management of each plantation. These could vary for each site and even each year. In Table 1.29 fertiliser applied in 1999 are given for some sites.

Table 1.29 Application of fertiliser at five sampling sites in 1999 (Trial 136).

| Plantation | Month | Fertiliser | Amount kg/palm |
|---|---|---|---|
| HEALLA | June/August | Ammonium Nitrate | 3.3 |
| | October | Kieserite | 1.0 |
| | September | Muriate of Potash | 1.6 |
| | November | Boron | 0.2 |
| KUMBANGO | | | |
| MALILIMI | March | Ammonium Nitrate | 3.7 |
| | May | Ammonium Nitrate | 3.7 |
| | June | Ammonium Nitrate | 3.7 |
| | September | Muriate of Potash | 2.0 |
| | August | Kieserite | 1.5 |
| BILOMI | June | Ammonium sulphate | 1.5 |
| KAUTU | June | Ammonium Nitrate | 1.5 |
| | October | Ammonium Nitrate | 1.0 |

## RESULTS

Analyses for leaflet nutrient concentration in the five sites were carried out for N, P, K, Ca, Mg, Cl and Boron. These are summarised for the twelve months period in 1999 in the tables below.

Table 1.30 Leaf Nutrient Level for 1995 Planting at Haella Plantation in 1999 (Trial 136).

| Nutrient | N% | P% | K% | Ca% | Mg% | Cl% | B ppm |
|---|---|---|---|---|---|---|---|
| Low | 2.28 | 0.149 | 0.69 | 0.75 | 0.19 | 0.61 | 9.8 |
| High | 2.61 | 0.167 | 0.95 | 1.0 | 0.26 | 0.71 | 17.0 |
| Mean | 2.42 | 0.158 | 0.81 | 0.88 | 0.23 | 0.71 | 13.4 |
| Std | 0.12 | 0.006 | 0.07 | 0.07 | 0.03 | 0.06 | 2.08 |

Table 1.31 Leaf Nutrient Level for 1993 replant at Kumbango Plantation in 1999 (Trial 136).

| Nutrient | N% | P% | K% | Ca% | Mg% | Cl% | B ppm |
|---|---|---|---|---|---|---|---|
| Low | 2.27 | 0.134 | 0.63 | 0.78 | 0.12 | 0.52 | 8.8 |
| High | 2.49 | 0.151 | 0.83 | 1.02 | 0.16 | 0.68 | 14.2 |
| Mean | 2.38 | 0.143 | 0.76 | 0.89 | 0.14 | 0.62 | 11.2 |
| Std | 0.12 | 0.006 | 0.06 | 0.07 | 0.01 | 0.05 | 1.48 |

Table 1.32 Leaf Nutrient Level for 1985 Planting at Malilimi Plantation in 1999 (Trial 136).

| Nutrient | N% | P% | K% | Ca% | Mg% | Cl% | B ppm |
|---|---|---|---|---|---|---|---|
| Low | 2.19 | 0.130 | 0.65 | 0.78 | 0.11 | 0.38 | 9.5 |
| High | 2.76 | 0.147 | 0.83 | 1.0 | 0.18 | 0.66 | 19.3 |
| Mean | 2.38 | 0.138 | 0.73 | 0.85 | 0.15 | 0.48 | 12.4 |
| Std | 0.19 | 0.005 | 0.05 | 0.06 | 0.02 | 0.07 | 3.06 |

Table 1.33 Leaf Nutrient Level for 1987 Planting at Bilomi Plantation in 1999 (Trial 136).

| Nutrient | N% | P% | K% | Ca% | Mg% | Cl% | B ppm |
|---|---|---|---|---|---|---|---|
| Low | 2.18 | 0.126 | 0.71 | 0.73 | 0.17 | 0.51 | 7.2 |
| High | 2.54 | 0.147 | 0.89 | 1.0 | 0.2 | 0.68 | 17.1 |
| Mean | 2.34 | 0.138 | 0.79 | 0.82 | 0.17 | 0.61 | 11.9 |
| Std | 0.12 | 0.006 | 0.07 | 0.1 | 0.2 | 0.06 | 2.88 |

Table 1.34 Leaf Nutrient Level for 1986 Planting at Kautu Plantation in 1999 (Trial 136).

| Nutrient | N% | P% | K% | Ca% | Mg% | Cl% | B ppm |
|---|---|---|---|---|---|---|---|
| Low | 2.27 | 0.145 | 0.61 | 0.59 | 0.19 | 0.42 | 9.3 |
| High | 2.62 | 0.163 | 0.98 | 0.84 | 0.29 | 0.57 | 18.4 |
| Mean | 2.38 | 0.153 | 0.74 | 0.7 | 0.23 | 0.50 | 12.9 |
| Std | 0.12 | 0.01 | 0.10 | 0.07 | 0.02 | 0.06 | 2.97 |

As each site is different from another in terms of the age of the palms and in its fertiliser and management regime, some indication of these factors can also be observed (Table 1.35). The commonly quoted optimum range for each nutrient is given along side the 1999 nutrient level for comparative purposes. The 1995 planting at Haella being the youngest planting among the sites had higher mean N, P, K, Mg, Cl and boron content compared to the other sites. The site at Kumbango had slightly higher mean leaflet Ca content whilst Chlorine content at Malilimi was comparatively lower than the other sites. In all the sites however, magnesium level seems to be very low.

Table 1.35 Mean Nutrient content at the five sampling sites in 1999 (Trial 136).

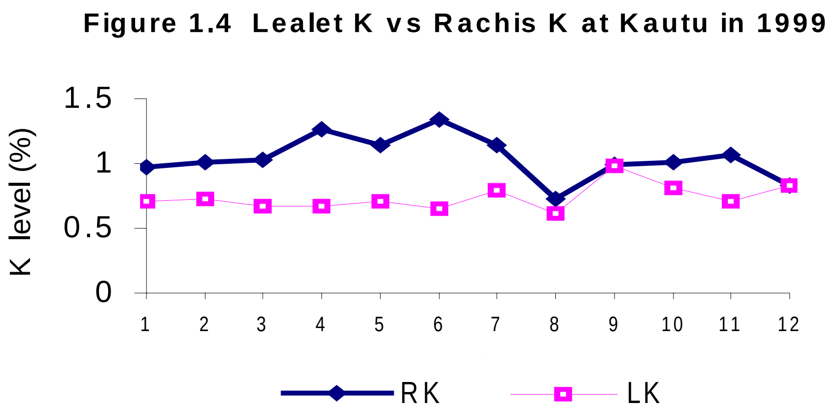
| Nutrient | Optimum range | Haella 1995 | Kumbango 1993 | Malilimi 1985 | Bilomi 1987 | Kautu 1986 |
|---|---|---|---|---|---|---|
| Nitrogen (%) | 2.4-2.8 | 2.42 | 2.38 | 2.38 | 2.34 | 2.38 |
| Phosphorous (%) | 0.15 - 0.18 | 0.158 | 0.143 | 0.138 | 0.138 | 0.153 |
| Potassium (%) | 0.9 – 1.2 | 0.81 | 0.76 | 0.73 | 0.79 | 0.74 |
| Calcium (%) | 0.5 – 0.75 | 0.88 | 0.89 | 0.85 | 0.82 | 0.70 |
| Magnesium (%) | 0.25 – 0.4 | 0.23 | 0.14 | 0.15 | 0.17 | 0.23 |
| Chlorine (%) | 0.5 – 0.7 | 0.71 | 0.62 | 0.48 | 0.61 | 0.50 |
| Boron (ppm) | 15 - 25 | 13.4 | 11.2 | 12.4 | 11.9 | 12.9 |

Mean leaflet nutrient content at each sampling site in 1998 and 1999 are presented in Table 1.36. The result show that the variation in the level of each nutrient within each site over the two year period did not seem to vary a great deal.

Table 1.36 Mean Leaflet Nutrient level for the five sites in 1998 and 1999 (Trial 136).

| Site | Planting year | Nutrient | 1998 | 1999 | Std |
|---|---|---|---|---|---|
| Haella | 1995 | Nitrogen (%) | 2.62 | 2.42 | 0.14 |
| Kumbango | 1993 | | 2.38 | 2.38 | 0.00 |
| Malilimi | 1985 | | 2.26 | 2.38 | 0.08 |
| Bilomi | 1987 | | 2.37 | 2.34 | 0.02 |
| Kautu | 1986 | | 2.46 | 2.38 | 0.06 |
| Haella | 1995 | Phosphorous (%) | 0.160 | 0.158 | 0.001 |
| Kumbango | 1993 | | 0.146 | 0.143 | 0.002 |
| Malilimi | 1985 | | 0.141 | 0.138 | 0.002 |
| Bilomi | 1987 | | 0.148 | 0.138 | 0.007 |
| Kautu | 1986 | | 0.157 | 0.153 | 0.003 |
| Haella | 1995 | Potassium (%) | 0.81 | 0.81 | 0.00 |
| Kumbango | 1993 | | 0.69 | 0.76 | 0.05 |
| Malilimi | 1985 | | 0.67 | 0.73 | 0.04 |
| Bilomi | 1987 | | 0.66 | 0.79 | 0.09 |
| Kautu | 1986 | | 0.72 | 0.74 | 0.01 |
| Haella | 1995 | Calcium (%) | 0.92 | 0.88 | 0.03 |
| Kumbango | 1993 | | 0.97 | 0.89 | 0.06 |
| Malilimi | 1985 | | 0.91 | 0.85 | 0.04 |
| Bilomi | 1987 | | 0.93 | 0.82 | 0.08 |
| Kautu | 1986 | | 0.79 | 0.70 | 0.06 |
| Haella | 1995 | Magnesium (%) | 0.26 | 0.23 | 0.021 |
| Kumbango | 1993 | | 0.17 | 0.14 | 0.021 |
| Malilimi | 1985 | | 0.16 | 0.15 | 0.007 |
| Bilomi | 1987 | | 0.18 | 0.17 | 0.007 |
| Kautu | 1986 | | 0.24 | 0.23 | 0.007 |
| Haella | 1995 | Chlorine (%) | 0.69 | 0.71 | 0.014 |
| Kumbango | 1993 | | 0.59 | 0.62 | 0.021 |
| Malilimi | 1985 | | 0.46 | 0.48 | 0.014 |
| Bilomi | 1987 | | 0.57 | 0.61 | 0.028 |
| Kautu | 1986 | | 0.49 | 0.50 | 0.007 |
| Haella | 1995 | Boron (ppm) | | 13.4 | |
| Kumbango | 1993 | | | 11.4 | |
| Malilimi | 1985 | | | 12.4 | |
| Bilomi | 1987 | | | 11.9 | |
| Kautu | 1986 | | | 12.9 | |

It has been observed elsewhere that rachis K was more sensitive to fertiliser input than leaflet K. With these findings, it was further claimed that rachis K is a more useful indicator of the K nutrient status of oil palm. Figure 1.4 shows the leaflet and rachis K level at Kautu over the twelve months period in 1999.




In August both the leaf and rachis K were lower than in the other months. The level however rose in about October and drop slightly again by December. No K fertiliser was applied in 1999. Only ammonium nitrate fertiliser was applied at the rate of 2.50 kg per palm per year as a split application. In June 1.50 kg of ammonium nitrate was applied and in October the remaining 1.0 kg was applied.

Table 1.37 presents the results for rachis K analysis at each sampling site from January to December 1999.

Table 1.37 Rachis K (%) results for the five sites from January to December 1999 (Trial 136).

| Month | Haella | Kumbango | Malilimi | Bilomi | Kautu |
|---|---|---|---|---|---|
| 1 | 1.26 | 1.54 | 1.14 | 1.22 | 0.97 |
| 2 | 1.22 | 1.50 | 1.01 | 1.74 | 1.01 |
| 3 | 1.26 | 1.58 | 0.91 | 1.58 | 1.03 |
| 4 | 1.42 | 1.66 | 1.22 | 1.22 | 1.26 |
| 5 | 1.30 | 1.30 | 1.26 | 1.78 | 1.14 |
| 6 | 1.50 | 1.50 | 1.46 | 1.46 | 1.34 |
| 7 | 1.38 | 1.62 | 1.10 | 1.22 | 1.14 |
| 8 | 1.38 | 1.42 | 1.22 | 1.42 | 0.73 |
| 9 | 1.78 | 1.58 | 0.99 | 1.83 | 0.99 |
| 10 | 1.38 | 1.46 | 1.07 | 1.38 | 1.01 |
| 11 | 1.76 | 1.05 | 1.46 | 1.66 | 1.07 |
| 12 | 1.46 | 1.38 | 0.99 | 1.38 | 0.88 |
| Range | 1.22-1.78 | 1.05-1.66 | 1.01-1.46 | 1.22-1.83 | 0.73-1.34 |
| Mean | 1.43 | 1.47 | 1.15 | 1.49 | 1.04 |
| Std | 0.19 | 0.03 | 0.18 | 0.22 | 0.17 |

In 1999 rachis K was particularly high in Bilomi Kumbango and Haella and was lower in Malilimi and Kautu. Mean rachis K results for 1998 and 1999 presented in Table 1.38 show that rachis K were lower in Malilimi and Kautu compared to other sites. It was severely reduced at

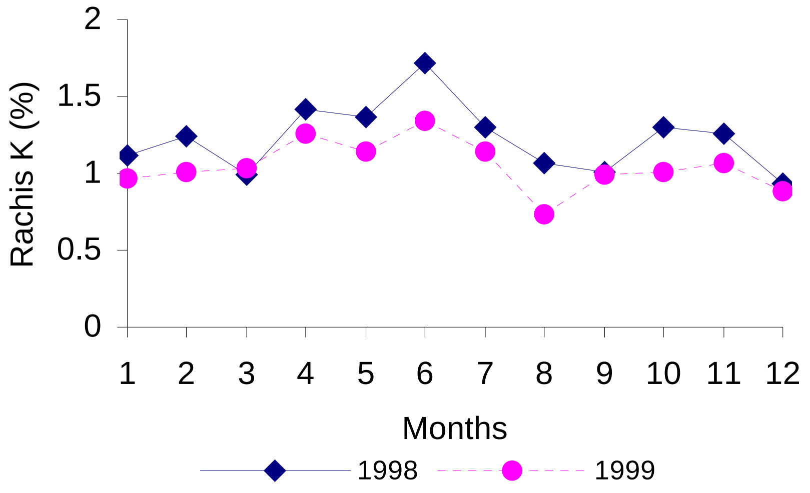
Kautu in 1999 but increased slightly at Malilimi. Rachis K level over the twelve month period in 1998 and 1999 at Kautu seem to have behaved similarly in spite of the 1999 level being lower than 1998 (figure 1.5). Mean rachis K at Haella in 1999 was much higher than in 1998. A slight increase was observed at Bilomi in 1999 while at Kumbango it was slightly lower than in 1998.

If rachis K is a more useful indicator of the K status of the palm; it is not known when rachis K content can be considered as limiting under the soils we have. Others have in fact reported that adequate to high rachis K levels range from 1.30 to 1.60% in certain soil type they were working with. Below about 1.30% it is considered as marginal. Using these figures as a guide, supply and maintenance of K nutrients is marginal at Malilimi and Kautu and may possibly need to be increased.

Table 1.38 Mean Rachis K (%) content in the five sites in 1998 and 1999 (Trial 136).

| Sites | Year of Planting | Nutrient | 1998 | 1999 | Std |
|---|---|---|---|---|---|
| Haella | 1995 | Rachis K | 1.34 | 1.43 | 0.06 |
| Kumbango | 1993 | | 1.50 | 1.47 | 0.02 |
| Malilimi | 1985 | | 1.05 | 1.15 | 0.07 |
| Bilomi | 1987 | | 1.48 | 1.49 | 0.01 |
| Kautu | 1986 | | 1.22 | 1.04 | 0.13 |

**Figure 1.5 Rachis K level at Kautu in 1998 and 1999**



**Trial 137 SYSTEMATIC FERTILISER TRIAL, KUMBANGO PLANTATION.**

PURPOSE

To provide fertiliser response information that will be necessary in developing strategies for fertiliser usage.

BACKGROUND

The fertiliser trials at NBPOL are currently designed with factorial treatment combinations laid out in a randomised block structure. The plots are large, consisting of an array of 6x6 palms, the central 4x4 being recorded. To date many of these trials have shown little response to increased doses of fertilisers. At other sites, Popondetta and Hargy this phenomenon has not occurred with distinct response curves being achieved. This non-response is now considered to be a product of the environment at NBPOL.

Examination of the data for Trials 401, 402 and 107 have indicated two problems:

a. There is a distinct possibility that N and possible K fertilisers are spreading from plot to plot despite trenching between the plot boundaries,
b. The scale of variation within the experimental area is such that groups of plots are located within patches of particular soil fertility, thus confounding the effects of applied fertilisers, particularly nitrogen, with soil fertility.

The implications are that continuation of the trials with this structure will not result in any changes to the patterns of response achieved so far. The trials are large and expensive and consideration of an alternative design structure appears now to be necessary.

DESIGN

The main factor for which estimation of a response is required is nitrogen with potassium as a secondary factor. Phosphorus and magnesium are unlikely to demonstrate yield increases but may need to be applied to maintain nutrient levels.

In the 1999 Scientific Advisory Committee meeting the trial design was revised. It was approved to have 4 rows per treatment instead of two as previously proposed and to have 9 levels of N treatments in a replication. The 9$^{th}$ treatment will not however be recorded.

Each plot will consist of 36 rows of 16 palms. Each of nine levels of N (N0, N1.....N8 kg/palm) should be applied to the consecutive four rows thus providing a systematic increase in N dosage. Thus in one rep the levels of N increase across each four rows of palm from left to right. In the neighbouring plot the plot is structured the same way, except that the increase in fertiliser runs from right to left. This is planned so that any unknown fertility trend is not confounded with the direction of increase of the N application.

If required two levels of K can be applied as well. To accommodate the systematic structure of the N applications, each level of K should be applied to one of the two plots. These treated plots should be replicated as many times as possible within the limits that space and labour permit. A minimum of two replicates is required to estimate the effect of K application at each of the N levels and to estimate the effect of increased doses of N at each of the K levels.

The experiment should be continued for at least 5 years

PROGRESS

A site has been identified at Kumbango Plantation for this trial. This field was replanted in October 1999. The systematic fertiliser trial will commence following 36 months of the standard immature fertiliser schedule.

**Trial 402 FACTORIAL FERTILISER TRIAL AT BILOMI PLANTATION.**

PURPOSE

To provide fertiliser response information that will be useful in developing strategies for fertiliser usage.

DESCRIPTION

Site Kapiura Estates, Bilomi Plantation, Division 2, Field 11C.

Soil Young coarse textured freely draining soils formed on alluvially re-deposited andesitic pumiceous sands and volcanic ash.

Palms Dami commercial DxP crosses.

Planted in early 1987 at 120 palms/ha.

Treatments started in May 1990.

DESIGN

There are 36 treatments, comprising all factorial combinations of N and P at three levels and K and Mg each at two levels (Table 1.39).

Table 1.39 Rates of fertiliser used in Trial 402.

| | Level (kg /palm/year) | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| Ammonium chloride | 0.0 | 3.0 | 6.0 |
| Triple superphosphate | 0.0 | 2.0 | 4.0 |
| Muriate of potash | 0.0 | 3.0 | --- |
| Kieserite | 0.0 | 3.0 | --- |
| | | (Tonnes/ha/yr) | |
| EFB | 0 | 50 | --- |

Note: Treatments are factorial combinations of levels of these fertilisers.

The ammonium chloride is split into two applications per year, while the other fertilisers are applied only once.

EFB applications started in mid 1993. EFB is applied with a Giltrap EFB applicator.

There are 72 plots, each plot consisting of 36 palms (6x6) of which the central 16 are recorded.

The 72 treatments are replicated once and are grouped into two blocks. The 3 factor interaction ‘2x2x2’ is confounded with blocks. High order interactions provide the error term in the statistical analysis.

RESULTS

The mean plot yield in 1999 was only 13.99 t/ha compared to a mean yield of 16.1t/ha in 1998. In 1999 application of N, P, K, Mg, and EFB did not have any significant influence on yield and yield component (Table 1.40). In comparison to 1998 the only significant response recorded was an increase in bunch weight as a result of application of ammonium chloride and EFB. It was further reported in 1998 that cumulative data from 1996 to 1998 showed a similar increase in bunch weight with the application of ammonium chloride. The cumulative data for 1997 to 1999 (Table 1.41) showed also increases in bunch weight with the application of ammonium chloride and EFB. It should be pointed out that P was accounted for as a term in the yield analysis in spite of it not being applied in 1999. Any influence on yield and yield components attributed to P fertiliser in 1999 will be considered as that due to residual P.

Table 1.40 Main effects of N, P, K and Mg on yield and yield components in 1999 (Trial 402).

| | Nutrient element and level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | sig | Sed | cv% |
| | N0 | N1 | N2 | | | |
| Yield (t/ha/yr) | 13.74 | 13.92 | 14.32 | ns | 0.61 | 15.0 |
| Bunches/ha | 672 | 669 | 688 | ns | 27 | 13.9 |
| Bunch weight (kg) | 20.62 | 20.90 | 20.96 | ns | 0.32 | 5.4 |
| | P0 | P1 | P2 | | | |
| Yield (t/ha/yr) | 14.02 | 14.23 | 13.73 | ns | 0.61 | 15.0 |
| Bunches/ha | 679 | 681 | 669 | ns | 27 | 13.9 |
| Bunch weight (kg) | 20.66 | 20.91 | 20.90 | ns | 0.32 | 5.4 |
| | K0 | K1 | | | | |
| Yield (t/ha/yr) | 14.29 | 13.69 | | ns | 0.49 | 15.0 |
| Bunches/ha | 689 | 663 | | ns | 22.1 | 13.9 |
| Bunch weight (kg) | 20.94 | 20.71 | | ns | 0.26 | 5.4 |
| | Mg0 | Mg1 | | | | |
| Yield (t/ha/yr) | 14.42 | 13.57 | | ns | 0.49 | 15.0 |
| Bunches/ha | 694 | 658 | | ns | 22.1 | 13.9 |
| Bunch weight (kg) | 20.96 | 20.70 | | ns | 0.26 | 5.4 |
| | EFB0 | EFB1 | | | | |
| Yield (t/ha/yr) | 14.18 | 13.80 | | ns | 0.49 | 15.0 |
| Bunches/ha | 693 | 659 | | ns | 22.1 | 13.9 |
| Bunch weight (kg) | 20.66 | 20.99 | | ns | 0.26 | 5.4 |

Table 1.41 Main effects of N, P, K and Mg on FFB yield and yield components from 1997 - 99 (Trial 402).

| | Nutrient element and level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | Sed | cv% |
| | N0 | N1 | N2 | | | |
| Yield (t/ha/yr) | 17.32 | 17.62 | 17.42 | ns | 0.48 | 9.7 |
| Bunches/ha | 866.1 | 865.1 | 849.4 | ns | 23.27 | 9.4 |
| Bunch weight (kg) | 20.03 | 20.38 | 20.52 | ** | 0.14 | 2.4 |
| | P0 | P1 | P2 | | | |
| Yield (t/ha/yr) | 17.37 | 17.74 | 17.26 | ns | 0.48 | 9.7 |
| Bunches/ha | 862.1 | 866.2 | 852.3 | ns | 23.27 | 9.4 |
| Bunch weight (kg) | 20.15 | 20.49 | 20.27 | * | 0.14 | 2.4 |
| | K0 | K1 | | | | |
| Yield (t/ha/yr) | 17.61 | 17.30 | | ns | 0.39 | 9.7 |
| Bunches/ha | 871 | 849.4 | | ns | 19 | 9.4 |
| Bunch weight (kg) | 20.24 | 20.37 | | ns | 0.11 | 2.4 |
| | Mg0 | Mg1 | | | | |
| Yield (t/ha/yr) | 17.47 | 17.44 | | ns | 0.39 | 9.7 |
| Bunches/ha | 863 | 857.4 | | ns | 19.0 | 2.4 |
| Bunch weight (kg) | 20.25 | 20.36 | | ns | 0.11 | 2.4 |
| | EFB0 | EFB1 | | | | |
| Yield (t/ha/yr) | 17.46 | 17.45 | | ns | 0.39 | 9.7 |
| Bunches/ha | 867.9 | 852.5 | | ns | 19.0 | 9.4 |
| Bunch weight (kg) | 20.14 | 20.48 | | ** | 0.11 | 2.4 |

Table 1.42 shows the FFB yield figures recorded from this trial since yield recording commenced in 1991.

Table 1.42 Effect of N and EFB on FFB yield from 1992 to 1999 (Trial 402).

| Year (age from planting) | Yield (t/ha) | | | | |
|---|---|---|---|---|---|
| | N0 | N1 | N2 | EFB0 | EFB1 |
| 1991 (4) | 22.4 | 23.4 | 22.2 | - | - |
| 1992 (5) | 30.0 | 31.6 | 31.5 | - | - |
| 1993 (6) | 27.2 | 28.6 | 28.9 | - | - |
| 1994 (7) | 25.2 | 26.0 | 25.8 | 25.7 | 25.6 |
| 1995 (8) | 23.2 | 22.6 | 23.5 | 22.8 | 23.4 |
| 1996 (9) | 25.6 | 26.6 | 27.6 | 25.8 | 27.4 |
| 1997 (10) | 21.3 | 21.7 | 20.9 | 20.9 | 21.7 |
| 1998 (11) | 15.9 | 16.2 | 16.3 | 16.3 | 16.0 |
| 1999 (12) | 13.99 | 13.92 | 14.32 | 14.18 | 13.80 |

The lack of response has not been clearly understood. Some suggestions mentioned the movement of nutrients especially N and K from plot to plot despite trenching between the plot boundaries. Varying fertility level within the plots could also be a factor. Other management aspect of this trial has been investigated. However we ca not say for certain how the changes in the harvesting schedule might have affected this trial. This trial is scheduled to be closed in December 2000.

**Trial 204 FACTORIAL FERTILISER TRIAL AT NAVO PLANTATION**.

PURPOSE

To provide fertiliser response information that is necessary for developing strategies for fertiliser management.

DESCRIPTION

Site Navo Plantation, Area 8, Blocks 10 and 11.

Soil Very young coarse textured freely draining soils formed on air fall volcanic scoria

Palms Dami commercial DxP crosses.

Planted in 1986 at 115 palms/ha.

Treatments started in May 1989.

DESIGN

There are 36 treatments, comprising all factorial combinations of N and P at three levels and K and Mg each at two levels (Table 1.43).

Table 1.43 Rates of fertiliser used in Trial 204.

| | Level (kg /palm/year) | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| Ammonium chloride | 0.0 | 3.0 | 6.0 |
| Triple superphosphate | 0.0 | 2.0 | 4.0 |
| Muriate of potash | 0.0 | 3.0 | --- |
| Kieserite | 0.0 | 3.0 | --- |

*Note: Treatments are factorial combinations of levels of these fertilisers.*

The ammonium chloride is split into two applications per year while the other fertilisers are applied once per year.

There are 72 plots, each plot consisting of 36 palms (6x6), of which the central 16 are recorded. The 36 treatments are replicated twice and are grouped into two blocks. The trial was designed as a 3x3x2x2x2 factorial trial, but one ‘x2’ factor has been left “vacant” and is regarded as replication for the time being. The “vacant” treatment will be used later. The 3 factor interaction ‘2x2x2’ is confounded with blocks. High order interactions provide the error term in the statistical analysis.

RESULTS

The mean yield in 1999 was 22.13 t/ha compared to 30.7 t/ha in 1998 and 25.7 t/ha in 1997. It is the lowest mean yield recorded in the last three years. As in previous years application of ammonium chloride lead to increase in yield due to increase in bunch weight and bunch number. Yield of FFB for the three levels of N was from 16.92t/ha (N0) to 23.46 t/ha (N1) and 25.46 t/ha (N2) (Table 1.44). No other fertiliser had a significant affect on yield or the components of yield. Significant interaction was observed between N and K as presented in Table 1.45.

Table 1.44 Main effects of N, P, K and Mg on yield and yield components in 1999 (Trial 204).

| | Nutrient element and level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | sed | Cv% |
| | N0 | N1 | N2 | | | |
| Yield (t/ha/yr) | 16.98 | 23.46 | 25.96 | *** | 0.88 | 13.8 |
| Bunches/ha | 758 | 818 | 884 | *** | 26.9 | 11.4 |
| Bunch weight (kg) | 22.8 | 29.14 | 29.70 | *** | 0.62 | 7.8 |
| | P0 | P1 | P2 | | | |
| Yield (t/ha/yr) | 22.15 | 21.51 | 22.73 | ns | 0.88 | 13.8 |
| Bunches/ha | 812 | 806 | 842 | ns | 26.9 | 11.4 |
| Bunch weight (kg) | 27.74 | 26.66 | 27.12 | ns | 0.62 | 7.8 |
| | K0 | K1 | | | | |
| Yield (t/ha/yr) | 22.11 | 22.15 | | ns | 0.72 | 13.8 |
| Bunches/ha | 812 | 828 | | ns | 22 | 11.4 |
| Bunch weight (kg) | 27.55 | 26.86 | | ns | 0.51 | 7.8 |
| | Mg0 | Mg1 | | | | |
| Yield (t/ha/yr) | 22.36 | 21.90 | | ns | 0.72 | 13.8 |
| Bunches/ha | 838 | 803 | | ns | 22 | 11.4 |
| Bunch weight (kg) | 26.96 | 27.46 | | ns | 0.51 | 7.8 |

Table 1.45 Effect of N and K on yield in 1999 (Trial 204).

| Rate of Fertiliser | K0 | K1 |
|---|---|---|
| N0 | 17.47 | 16.48 |
| N1 | 23.43 | 23.50 |
| N2 | 25.43 | 26.48 |
| Grand Mean 22.18 | s.e. 1.25 | |

Analysis of the three year cumulative yield data show that nitrogen through the application of ammonium chloride fertiliser accounted for the variation in FFB yield due to increase both in single bunch weight and the number of bunches (Table 1.46).

Table 1.46 Main effects of N, P, K and Mg on FFB yield and yield components for 1997 to 1999 (Trial 204).

| | Nutrient element and level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | sed | cv% |
| | N0 | N1 | N2 | | | |
| Yield (t/ha/yr) | 22.07 | 28.03 | 29.36 | *** | 0.82 | 10.7 |
| Bunches/ha | 1067 | 1143 | 1198 | *** | 34.5 | 10.5 |
| Bunch weight (kg) | 20.85 | 24.57 | 24.82 | ** | 0.43 | 6.4 |
| | P0 | P1 | P2 | | | |
| Yield (t/ha/yr) | 26.50 | 25.90 | 27.06 | ns | 0.82 | 10.7 |
| Bunches/ha | 1130 | 1118 | 1159 | ns | 34.5 | 10.5 |
| Bunch weight (kg) | 23.72 | 23.30 | 23.22 | ns | 0.43 | 6.4 |
| | K0 | K1 | | | | |
| Yield (t/ha/yr) | 25.51 | 26.46 | | ns | 0.66 | 10.7 |
| Bunches/ha | 1137 | 11.35 | | ns | 28.2 | 10.5 |
| Bunch weight (kg) | 23.64 | 23.18 | | ns | 0.35 | 6.4 |
| | Mg0 | Mg1 | | | | |
| Yield (t/ha/yr) | 27.15 | 25.82 | | * | 0.66 | 10.7 |
| Bunches/ha | 1163 | 1109 | | * | 28.2 | 10.5 |
| Bunch weight (kg) | 23.33 | 23.49 | | ns | 0.35 | 6.4 |

Nitrogen was also found to influence phosphorous (p=0.037) and potassium (p=0.089). These interactions are shown in Tables 1.47 and 1.48.

Application of Kieserite accounted for negative influence on yield (p=0.050) resulting from decrease in the number of bunches.

Table 1.47 Effect of N and P on yield in 1999 (Trial 204).

| Rate of Fertiliser | P0 | P1 | P2 |
|---|---|---|---|
| N0 | 23.67 | 19.71 | 22.85 |
| N1 | 26.40 | 29.06 | 28.61 |
| N2 | 29.42 | 28.93 | 29.73 |
| Grand Mean 26.49 | | s.e. 1.42 | |

Table 1.48 Effect of N and K on yield in 1999 (Trial 204).

| Rate of Fertiliser | K0 | K1 |
|---|---|---|
| N0 | 23.12 | 21.03 |
| N1 | 27.80 | 28.25 |
| N2 | 28.61 | 30.10 |
| Grand Mean 26.49 | s.e. 1.15 | |

FFB yield and components of yield from 1992 to 1999 is presented in Table 1.49.

Table 1.49 Yield and components of yield for each year from 1992 to 1999 (Trial 204).

| Year (Age from planting) | Yield (t/ha) | | | Bunches/ha | | | Bunch Weight (kg) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N0 | N1 | N2 | N0 | N1 | N2 | N0 | N1 | N2 |
| 1992 (6) | 18.6 | 21.0 | 22.3 | 1558 | 1617 | 1753 | 11.9 | 13.0 | 12.8 |
| 1993 (7) | 19.1 | 21.2 | 20.3 | 1405 | 1447 | 1411 | 13.7 | 14.8 | 14.5 |
| 1994 (8) | 20.5 | 24.4 | 25.0 | 1353 | 1452 | 1491 | 15.2 | 17.0 | 16.8 |
| 1995 (9) | 23.3 | 30.4 | 32.3 | 1298 | 1427 | 1506 | 18.1 | 21.4 | 21.5 |
| 1996 (10) | 26.2 | 34.0 | 35.2 | 1305 | 1439 | 1502 | 20.1 | 23.7 | 23.5 |
| 1997 (11) | 21.7 | 27.2 | 28.1 | 1071 | 1218 | 1256 | 20.6 | 22.7 | 22.7 |
| 1998 (12) | 26.0 | 32.4 | 33.9 | 1304 | 1393 | 1445 | 19.9 | 23.4 | 23.6 |
| 1999 (13) | 16.9 | 23.5 | 25.9 | 758 | 818 | 884 | 22.8 | 29.2 | 29.7 |

Results for leaf and rachis samples taken and analysed in1999 are given in Table 1.50. Full leaflet analysis was conducted while rachis was analysed only for K. Leaflet N increased from 1.92 at N0 to 2.16 at N1 and 2.29 at N2. Though response was significant, leaflet N was slightly lower in 1999 compared to leaflet N obtained in 1998. The results show also that application of ammonium chloride lead to a significant increase in leaflet N, P, and Cl but decrease leaflet Ca and Mg.

Applications of TSP lead to a significant increase in leaflet P and leaflet Ca.

Application of MoP lead to a significant increase in leaflet Ca and Cl but no increase was observed in leaflet K. Kieserite application led to a significant increase in leaflet Mg but decreases leaflet Ca. Rachis K decreased with the application of ammonium chloride but this response was not significant (Table 1.51). Application of MoP significantly increased Rachis K while application of TSP significantly reduces rachis K.

Table 1.50 Treatment main effects on leaflet nutrient concentrations in 1999 (Trial 204).

| Element as % of dry matter | Nutrient element and level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | Sed | Cv% |
| | N0 | N1 | N2 | | | |
| Nitrogen | 1.92 | 2.16 | 2.29 | *** | 0.027 | 4.4 |
| Phosphorus | 0.126 | 0.135 | 0.139 | *** | 0.0011 | 2.7 |
| Potassium | 0.68 | 0.65 | 0.67 | ns | 0.013 | 6.8 |
| Calcium | 0.94 | 0.93 | 0.86 | *** | 0.016 | 6.2 |
| Magnesium | 0.22 | 0.17 | 0.15 | *** | 0.005 | 9.4 |
| Chlorine | 0.37 | 0.54 | 0.55 | *** | 0.013 | 9.0 |
| | P0 | P1 | P2 | | | |
| Nitrogen | 2.15 | 2.10 | 2.12 | ns | 0.027 | 4.4 |
| Phosphorus | 0.131 | 0.134 | 0.136 | *** | 0.0011 | 2.7 |
| Potassium | 0.68 | 0.65 | 0.67 | ns | 0.013 | 6.8 |
| Calcium | 0.88 | 0.92 | 0.93 | * | 0.016 | 6.2 |
| Magnesium | 0.18 | 0.18 | 0.17 | ns | 0.005 | 9.4 |
| Chlorine | 0.48 | 0.49 | 0.48 | ns | 0.013 | 9.0 |
| | K0 | K1 | | | | |
| Nitrogen | 2.14 | 2.11 | | ns | 0.022 | 4.4 |
| Phosphorus | 0.134 | 0.133 | | ns | 0.0008 | 2.7 |
| Potassium | 0.68 | 0.66 | | * | 0.010 | 6.8 |
| Calcium | 0.88 | 0.93 | | ** | 0.013 | 6.2 |
| Magnesium | 0.18 | 0.17 | | * | 0.004 | 9.4 |
| Chlorine | 0.46 | 0.52 | | *** | 0.010 | 9.0 |
| | Mg0 | Mg1 | | | | |
| Nitrogen | 2.12 | 2.13 | | ns | 0.022 | 4.4 |
| Phosphorus | 0.133 | 0.134 | | ns | 0.0008 | 2.7 |
| Potassium | 0.66 | 0.67 | | ns | 0.010 | 6.8 |
| Calcium | 0.94 | 0.87 | | *** | 0.013 | 6.2 |
| Magnesium | 0.16 | 0.19 | | *** | 0.004 | 9.4 |
| Chlorine | 0.48 | 0.49 | | ns | 0.010 | 9.0 |

Table 1.51 Treatment main effects on rachis potassium concentrations (as %DM) in 1998 (Trial 204).

| Nutrient element and level | | | Statistics | | |
|---|---|---|---|---|---|
| | | | Sig | Sed | cv% |
| N0 | N1 | N2 | | | |
| 1.43 | 1.41 | 1.38 | ns | 0.037 | 9.1 |
| P0 | P1 | P2 | | | |
| 1.48 | 1.36 | 1.37 | ** | 0.037 | 9.1 |
| K0 | K1 | | | | |
| 1.28 | 1.54 | | *** | 0.031 | 9.1 |
| Mg0 | Mg1 | | | | |
| 1.41 | 1.41 | | ns | 0.031 | 9.1 |

There was a significant interaction between N and K in rachis K (Table 1.52). Rachis K was highest at N0K1 (p=004).

Table 1.52 Effect of N and K on rachis K concentration in 1999 (Trial 204).

| Rate of Fertiliser | K0 | K1 |
|---|---|---|
| N0 | 1.23 | 1.64 |
| N1 | 1.30 | 1.51 |
| N2 | 1.31 | 1.47 |

Sed 0.052 **

**Trial 205 EFB/FERTILISER TRIAL AT HARGY PLANTATION.**

PURPOSE

To investigate the response of oil palm to applications of Empty Fruit Bunches (EFB), and to investigate whether the uptake of phosphorus and magnesium from Triple Superphosphate and Kieserite can be improved by applying the fertiliser in conjunction with EFB.

DESCRIPTION

Site Blocks 7 and 8, Area 9, Hargy Plantation, Bialla, WNBP.

Soil Freely draining Andosol formed on intermediate to basic volcanic ash.

Palms Dami identified DxP crosses.

Planted in July and August 1993 at 135 palms/ha.

Treatments to start 36 months after planting.

DESIGN

There are eight treatments comprising all factorial combinations of EFB, Triple Superphosphate and Kieserite each at two levels (Table 1.53). The treatments are replicated six times, with each replicate comprising one block. 36 palm plots (6x6 palms) are used, the central 16 palms are recorded and the outer 20 palms are regarded as guard row palms. The recorded palms comprise 16 different identified Dami DxP progenies that have been arranged in a random spatial configuration in each plot. The 16 progenies are as follows:

| Code | Progeny Number |
|---|---|
| A | 9004093E |
| B | 9009030E |
| C | 9009149E |
| D | 9102109E |
| E | 9010040E |
| F | 4091 |
| G | 9008022E |
| H | 5148 |

| Code | Progeny Number |
|---|---|
| I | 9009127E |
| J | 9103073E |
| K | 9103136E |
| L | 9010217E |
| M | 9010190E |
| N | 9009110E |
| O | 9101100E |
| P | 9007130E |

Table 1.53 Fertiliser and EFB treatments used in Trial 205.

| Treatment | EFB (kg/palm/yr) | Triple superphosphate (kg/palm/yr) | Kieserite (kg/palm/yr) |
|---|---|---|---|
| 1 | Nil | Nil | Nil |
| 2 | Nil | Nil | 3.0 |
| 3 | Nil | 3.0 | Nil |
| 4 | Nil | 3.0 | 3.0 |
| 5 | 230 | Nil | Nil |
| 6 | 230 | Nil | 3.0 |
| 7 | 230 | 3.0 | Nil |
| 8 | 230 | 3.0 | 3.0 |

## RESULTS

1999 was the third full year of yield recording since fertiliser treatments started. The effect of fertiliser treatment on yield or the components of yield for the twelve months period Jan to Dec 1999 are given in Table 1.54. This show that there was a significant response of yield to application of Kieserite and triple super phosphate which was almost significant due to increase in single bunch weight. Although there was a significant increase in single bunch weight due to EFB application, this did not affect the overall yield. Over the three-year period 1997 to 1999 there were a statistical significant increase in yield and single bunch weight caused by empty fruit bunch and triple-superphosphate (Table 1.55). There was an almost significant response to Kieserite on single bunch weight but this did not affect the overall yield.

Table 1.54 FFB yield and components of yield in 1999 (Trial 205).

| Components of Yield | Treatment | | Statistics | | |
|---|---|---|---|---|---|
| | EFB0 | EFB1 | Sig | Cv% | Sed |
| FFB Yield (t/ha) | 30.3 | 31.6 | ns | 8.5 | 2.63 |
| Bunches/ha | 2088 | 2111 | ns | 9.0 | 189 |
| Single Bunch wt (kg) | 14.7 | 15.2 | * | 4.4 | 0.66 |
| | Mg0 | Mg1 | | | |
| Yield (t/ha) | 30.3 | 31.6 | * | 8.5 | 2.63 |
| Bunches/ha | 2087 | 2112 | ns | 9.0 | 189 |
| Single Bunch wt (kg) | 14.8 | 15.2 | * | 4.4 | 0.66 |
| | P0 | P1 | | | |
| FFB Yield (t/ha) | 30.1 | 31.8 | * | 8.5 | 2.63 |
| Bunches/ha | 2075 | 2124 | ns | 9.0 | 189 |
| Single Bunch wt (kg) | 14.8 | 15.2 | * | 4.4 | 0.66 |

There were no significant interactions between EFB and Mg or between EFB and TSP in 1999 or in the 97 – 99 data. The interactions between TSP and EFB on different progenies were not significant. However a number progenies produced yields of over 30 tons in the presence of EFB, Mg or TSP.

Table 1.55 FFB yield and the components of yield for 1997-1999 (Trial 205).

| Components of Yield | Treatment | | Statistics | | |
|---|---|---|---|---|---|
| | EFB0 | EFB1 | Sig | Cv% | Sed |
| Yield (t/ha | 19.5 | 20.6 | ** | 5.7 | 1.15 |
| Bunches/ha | 1692 | 1736 | ns | 20.7 | 354 |
| Single Bunch wt (kg) | 11.6 | 12.0 | ** | 15.7 | 1.85 |
| | Mg0 | Mg1 | | | |
| Yield (t/ha | 19.8 | 20.3 | ns | 5.7 | 1.15 |
| Bunches/ha | 1711 | 1718 | ns | 20.7 | 354 |
| Single Bunch wt (kg) | 11.7 | 11.9 | ns | 15.7 | 1.85 |
| | P0 | P1 | | | |
| Yield (t/ha | 19.6 | 20.6 | ** | 5.7 | 1.15 |
| Bunches/ha | 1699 | 1729 | Ns | 20.7 | 3.54 |
| Single Bunch wt (kg) | 11.6 | 12.0 | * | 15.7 | 1.85 |

There were large highly significant differences between progenies for yield and the components of yield in 1999 (Table 1.56).

Table 1.56 FFB yield and the components of yield for 16 selected progenies in 1999 (Trial 205).

| Progeny | Yield (t/ha) | No. of bunches/ha | Single Bunch Wt. (kg) |
|---|---|---|---|
| A | 33.9 | 2250 | 15.2 |
| B | 30.4 | 2121 | 14.4 |
| C | 30.0 | 2059 | 14.9 |
| D | 31.8 | 2171 | 14.8 |
| E | 30.8 | 2149 | 14.8 |
| F | 31.8 | 2191 | 14.8 |
| G | 30.8 | 2008 | 15.4 |
| H | 31.8 | 2199 | 14.7 |
| I | 31.9 | 2183 | 14.8 |
| J | 29.5 | 2064 | 14.8 |
| K | 28.3 | 1890 | 15.2 |
| L | 28.8 | 2000 | 14.6 |
| M | 32.5 | 2081 | 15.8 |
| N | 28.8 | 1915 | 15.2 |
| O | 31.5 | 2205 | 14.4 |
| P | 32.7 | 2104 | 15.6 |
| Mean | 31.0 | 2100 | 15.0 |
| Sig. | *** | *** | *** |
| Sed | 1.95 | 189.1 | 0.66 |
| Cv% | 8.5 | 9.0 | 4.4 |

There was a significant interaction between EFB, P and with EFB x P with Progeny A resulting in very large yield increases (36.6 and 37.7 t/ha respectively). Significant yield increase was also observed with progeny P that is attributed to EFB x Mg interaction (40.9t/ha) and even EFB x P interaction (35.3 t/ha). Further increases in yield were also observed in progenies F, G and M attributed to Mg x P interaction (36.5, 37.4 and 38.6 t/ha respectively).

There has been a continued response due to application of TSP with increasing differences in yield over the three-year period (Table 1.57). In 1998 EFB application produced a significant increase in yield of 2.1.tons but was lowered by 0.8 tons in 1999 (Table 1.58). Kieserite did not produce any significant response over the years. The differences in yield were gradually increasing. Responses to Kieserite are expected in coming years.

Table 1.57 FFB yield trends over the three years 1997-1999 (Trial 205).

| Treatment | Yield (t/ha) | | |
|---|---|---|---|
| | 1997 | 1998 | 1999 |
| EFB0 | 24.2 | **28.3** | 30.3 |
| EFB1 | 24.7 | **30.4** | 31.6 |
| Mg0 | 24.2 | 29.3 | 30.3 |
| Mg1 | 24.7 | 29.4 | 31.6 |
| Tsp0 | **24.0** | **28.7** | **30.1** |
| TSP1 | **24.9** | **29.9** | **31.8** |

Table 1.58 Treatment yield responses in 1997, 1998 and 1999 (Trial 205).

| Treatment | Yield Response (t/ha) | | |
|---|---|---|---|
| | 1997 | 1998 | 1999 |
| EFB | 0.5 | 2.1 | 1.3 |
| Mg | 0.5 | 0.1 | 1.3 |
| TSP | 0.9 | 1.2 | 1.7 |

## Trial 209 FACTORIAL FERTILISER TRIAL AT HARGY PLANTATION.

### PURPOSE

To provide fertiliser response information that is necessary in developing strategies for fertiliser management.

### DESCRIPTION

| | |
|---|---|
| Site | Blocks 4 and 6, Area 1, Hargy Plantation, Bialla, WNBP. |
| Soil | Freely draining Andosol formed on intermediate to basic volcanic ash. |
| Palms | Dami commercial DxP crosses. |
| | Planted in October and November 1994 at 135 palms/ha. |
| | Treatments commenced in June 1998 36 months after planting. |

### DESIGN

There are 81 treatments comprising all factorial combinations of sulphate of ammonia, Triple Superphosphate, muriate of potash and Kieserite each at three levels. There are 81 plots each consisting of 36 palms (6x6) of which the central 16 palms are recorded and the outer 20 are guard row palms. The 81 treatments are replicated only once and will be divided among nine blocks each of nine plots (Table 1.59).

Table 1.59 Fertiliser treatments used in Trial 209.

| | Level (kg /palm/year) | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| Ammonium sulphate | 2.0 | 4.0 | 8.0 |
| Triple superphosphate | 0.0 | 4.0 | 8.0 |
| Muriate of potash | 0.0 | 2.0 | 4.0 |
| Kieserite | 0.0 | 4.0 | 8.0 |

### PROGRESS

The trial was planted in October and November 1994. The site was surveyed and mapped, and plot and palm labelling was carried out in November 1996.

For the first 36 months, the palms received a standard immature palm fertiliser input. Pre-treatment yield recording commenced in January 1997 and treatments were first applied in June 1998.

### RESULTS

The mean plot yield in 1999 was 28.37 t/ha. The analysis results show that application of SoA lead to an increase in yield however this was not statistically significant. It was observed that application of 4 kg of SoA per palm resulted in a significant reduction in single bunch weight from 14.29 kg (N0) to 13.52 kg (N1). Application of 8 kg of SoA per palm led to a further increase in single bunch weight (Table 1.60). Application of 4 kg of TSP per palm led to an increase in yield as a result of an increase in bunch number. No further increase in yield was achieved with the application of 8 kg of TSP per palm. Application of MoP resulted in a significant increase in yield due to an increase in single bunch weight. The yield increase was from 27.24 t/ha (K0) to 28.74 t/ha (K1), and 29.13 t/ha with (K2). Application of Kieserite did not influence yield or other yield components.

Table 1.60 Main effects of N, P, K and Mg on yield and yield components for 1999 (Trial 209).

| | Nutrient element and level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | Sed | cv% |
| | N0 | N1 | N2 | | | |
| Yield (t/ha/yr) | 27.91 | 28.19 | 29.01 | ns | 0.75 | 9.8 |
| Bunches/ha | 2011 | 2114 | 2045 | ns | 59.9 | 10.7 |
| Bunch weight (kg) | 14.29 | 13.52 | 14.64 | *** | 0.27 | 7.1 |
| | P0 | P1 | P2 | | | |
| Yield (t/ha/yr) | 27.30 | 29.35 | 28.45 | * | 0.75 | 9.8 |
| Bunches/ha | 1998 | 2140 | 2033 | * | 59 | 10.7 |
| Bunch weight (kg) | 14.02 | 14.04 | 14.39 | ns | 0.27 | 7.1 |
| | K0 | K1 | K2 | | | |
| Yield (t/ha/yr) | 27.24 | 28.74 | 29.13 | * | 0.75 | 9.8 |
| Bunches/ha | 2018 | 2081 | 2071 | ns | 59.9 | 10.7 |
| Bunch weight (kg) | 13.81 | 14.17 | 14.46 | * | 0.27 | 7.1 |
| | Mg0 | Mg1 | Mg2 | | | |
| Yield (t/ha/yr) | 28.78 | 27.99 | 28.34 | ns | 0.75 | 9.8 |
| Bunches/ha | 2066 | 2064 | 2041 | ns | 59.9 | 10.7 |
| Bunch weight (kg) | 14.27 | 13.92 | 14.26 | ns | 0.27 | 7.1 |

There was a significant interaction between N and K that influenced both FFB yield (p=0.005) and the number of bunch per hectare (p= 0.006) as shown in Table 1.61. K application was observed to affect Mg (p=0.020) (Table 1.62).

Table 1.61 Effect of N and K on Yield in 1999 (Trial 209).

| | K0 | K1 | K2 |
|---|---|---|---|
| N0 | 28.30 | 28.01 | 27.43 |
| N1 | 24.56 | 29.53 | 30.49 |
| N2 | 28.86 | 28.68 | 29.49 |
| Mean = 28.37 | Sed = 1.31 | | |

Table 1.62 Effect of N and Mg on Yield in Trial 209 in 1999 (Trial 209).

| | Mg0 | Mg1 | Mg2 |
|---|---|---|---|
| K0 | 28.05 | 27.77 | 25.90 |
| K1 | 28.26 | 27.04 | 30.91 |
| K2 | 30.04 | 29.16 | 28.20 |
| Mean 28.37 | Sed = 1.31 | | |

**Trials 251 and 252 FACTORIAL FERTILISER TRIALS AT MARAMAKAS AND LUBURUA PLANTATIONS.**

PURPOSE

To provide fertiliser response information that is necessary in developing strategies for fertiliser management.

DESCRIPTION

Sites Trial 251: Fields 2B, 2C, 2D and 3A, Maramakas Plantation.

Trial 252: Block 4, Luburua Plantation.

Soils Reddish brown clay soil overlying raised coral and showing great variability in depth. The soils are shallow on terrace margins and low ridges and moderately deep in depressions. The soil is freely draining.

Palms Dami commercial DxP crosses.

Planted in March 1989 (251) and September 1989 (252) at 128 palms/ha.

Treatments started in April 1991.

DESIGN

There are 36 treatments at both sites, comprising all factorial combinations of N and K at three levels and P and Mg each at two levels (Table 1.63).

Table 1.63. Rates of fertiliser used in Trials 251 and 252.

| | Level (kg /palm/year) | | |
|---|---|---|---|
| | 0 | 1 | 2 |
| Ammonium sulphate | 0.0 | 2.5 | 5.0 |
| Muriate of potash | 0.0 | 2.5 | 5.0 |
| Triple superphosphate | 0.0 | 2.0 | --- |
| Kieserite | 0.0 | 2.0 | --- |

*Note: Treatments are factorial combinations of levels of these fertiliser*

Annual fertiliser application rates are split into three applications.

These two trials were originally planned as a single 3x3x2x2 factorial trial with two replicates, but because of restricted availability of land, the two replicates were located on two separate sites and regarded as two trials. The 1995 and 1996 data was analysed with a site factor included in the single analysis for these two trials. However, as the two trials are performing quite differently the data for the two trial sites were analysed separately since 1997.

There are 36 plots at each site, each plot consisting of 36 palms (6x6), of which the central 16 are recorded.

High order interactions provide the error term in the statistical analysis.

Soil depth was used as a concomitant variable in an analysis of covariance of the yield data in 1997 and 1998 as well as the pooled 1995-1997 data. The analysis of yield data in 1999 excluded soil depth as a concomitant variable.

RESULTS

Mean FFB yield in 1999 was 21.56 t/ha at Maramakas and 21.08 t/ha at Luburua. At Maramakas there was a dramatic increase of almost 6 t/ha over the 1998 mean yield while at Luburua the increase in yield was 0.78 t/ha over the 1998 mean yield. At Maramakas application of 2.5 kg of MoP per palm per year lead to a significant increase in yield as a result of increase in both bunch number and bunch weight. No further increases were observed with the application of 5 kg of MoP (Table 1.64). Similar responses were recorded in the previous years.

Table 1.64 Main effects of N, P, K and Mg on FFB yield and yield components for 1999 at Maramakas (Trial 251).

| | Nutrient Element and Level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | sed | cv % |
| | N0 | N1 | N2 | | | |
| Yield (t/ha) | 21.77 | 20.38 | 22.53 | Ns | 1.91 | 21.7 |
| Bunches/ha | 1243 | 1139 | 1265 | Ns | 105.9 | 21.3 |
| Bunch weight (kg) | 17.76 | 17.78 | 17.82 | Ns | 0.53 | 7.2 |
| | K0 | K1 | K2 | | | |
| Yield (t/ha) | 14.01 | 25.03 | 25.64 | *** | 1.91 | 21.7 |
| Bunches/ha | 1039 | 1282 | 1327 | * | 105.9 | 21.3 |
| Bunch weight (kg) | 13.27 | 20.24 | 19.86 | *** | 0.53 | 7.2 |
| | P0 | P1 | | | | |
| Yield (t/ha) | 21.35 | 21.77 | | Ns | 1.55 | 21.7 |
| Bunches/ha | 1196 | 1236 | | Ns | 86.5 | 21.3 |
| Bunch weight (kg) | 17.93 | 17.64 | | Ns | 0.43 | 7.2 |
| | Mg0 | Mg1 | | | | |
| Yield (t/ha) | 21.59 | 21.54 | | Ns | 1.55 | 21.7 |
| Bunches/ha | 1190 | 1242 | | Ns | 85.5 | 21.3 |
| Bunch weight (kg) | 18.18 | 17.39 | | * | 0.43 | 7.2 |

Analysis of the cumulative data for 1997 to 1999 at Maramakas shows that K accounted for variation in FFB yield and yield components. There was a significant increase in yield as a result of an increase in single bunch weight and bunch number. This result was the same as seen in the 1999 data (Table 1.65).

Table 1.65 Main Effects of N, P, K and Mg on yield and yield components for January 1997 to December 1999 at Maramakas (Trial 251).

| | Nutrient Element and Level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | sed | cv % |
| | N0 | N1 | N2 | | | |
| Yield (t/ha) | 20.66 | 19.89 | 21.38 | Ns | 1.74 | 20.6 |
| Bunches/ha | 1332 | 1275 | 1346 | Ns | 87.7 | 16.3 |
| Bunch weight (kg) | 15.43 | 15.37 | 15.71 | Ns | 0.58 | 9.2 |
| | K0 | K1 | K2 | | | |
| Yield (t/ha) | 14.05 | 23.76 | 24.12 | *** | 1.74 | 20.6 |
| Bunches/ha | 1110 | 1414 | 1430 | ** | 87.7 | 16.3 |
| Bunch weight (kg) | 12.38 | 17.09 | 17.04 | *** | 0.58 | 9.2 |
| | P0 | P1 | | | | |
| Yield (t/ha) | 20.29 | 21.00 | | Ns | 1.42 | 20.6 |
| Bunches/ha | 1274 | 1362 | | Ns | 71.6 | 16.3 |
| Bunch weight (kg) | 15.69 | 15.32 | | Ns | 0.47 | 9.2 |
| | Mg0 | Mg1 | | | | |
| Yield (t/ha) | 20.39 | 20.90 | | Ns | 1.42 | 20.6 |
| Bunches/ha | 1277 | 1358 | | Ns | 71.6 | 16.3 |
| Bunch weight (kg) | 15.79 | 15.22 | | Ns | 0.47 | 9.2 |

At Luburua the results for 1999 show that there was a significant response to potassium and nitrogen. Application of 2.5 kg of MoP led to a significant increase in FFB yield due to an increase both in bunch number and bunch weight. Application of 2.5 kg of SoA led to an increase in yield from 19.62 t/ha to 23.37 t/ha due to a significant increase in bunch number. There was no further increase in FFB yield with application of 5.0 kg SoA per palm (Table 1.66).

Table 1.66 Main effects of N , P , K and Mg on FFB yield and yield components for 1999 at Luburua (Trial 252).

| | Nutrient Element and Level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | Sed | Cv % |
| | N0 | N1 | N2 | | | |
| Yield (t/ha) | 19.62 | 23.37 | 20.25 | * | 1.16 | 13.5 |
| Bunches/ha | 1162 | 1351 | 1193 | * | 59.5 | 11.8 |
| Bunch weight (kg) | 16.21 | 17.59 | 16.98 | Ns | 0.92 | 13.3 |
| | K0 | K1 | K2 | | | |
| Yield (t/ha) | 14.95 | 23.82 | 24.46 | *** | 1.16 | 13.5 |
| Bunches/ha | 1020 | 1320 | 1366 | *** | 59.5 | 11.8 |
| Bunch weight (kg) | 14.27 | 18.40 | 18.11 | *** | 0.92 | 13.3 |
| | P0 | P1 | | | | |
| Yield (t/ha) | 20.33 | 21.83 | | Ns | 0.95 | 13.5 |
| Bunches/ha | 1205 | 1266 | | Ns | 48.5 | 11.8 |
| Bunch weight (kg) | 16.43 | 17.43 | | Ns | 0.75 | 13.3 |
| | Mg0 | Mg1 | | | | |
| Yield (t/ha) | 21.50 | 20.66 | | Ns | 0.95 | 13.5 |
| Bunches/ha | 1262 | 1209 | | Ns | 48.5 | 11.8 |
| Bunch weight (kg) | 16.99 | 16.86 | | Ns | 0.75 | 13.3 |

Analysis of the 1999 yield data further showed that there was a significant N x P interaction for FFB yield at Luburua ($p<0.001$) (Table 1.67). There are also significant NxK ($p=0.054$) and PxK interactions ($p=0.019$) (Table1.68 and 1.69).

Table 1.67 Effects of N x P on yield at Luburua in 1999 (Trial 252).

| Treatment | P0 | P1 |
|---|---|---|
| N1 | 15.92 | 23.31 |
| N2 | 23.11 | 23.64 |
| N3 | 21.97 | 18.54 |
| Mean 21.08 | Sed 1.64 | |

Table 1.68 Effects of N x K on yield at Luburua in 1999 (Trial 252).

| Treatment | K1 | K2 | K3 |
|---|---|---|---|
| N1 | 12.56 | 24.11 | 22.18 |
| N2 | 19.76 | 25.23 | 25.13 |
| N3 | 12.55 | 22.13 | 26.09 |
| Mean = 21.08 | | Sed 2.01 | |

Table 1.69 Effects of P x K on yield at Luburua in 1999 (Trial 252).

| Treatment | K1 | K2 | K3 |
|---|---|---|---|
| P1 | 12.07 | 24.08 | 24.84 |
| P2 | 17.84 | 23.56 | 24.08 |
| Mean = 21.08 | | Sed 1.64 | |

Analysis of the cumulative data from 1997 to 1999 (Table 1.70) at Luburua shows that K application also accounted for variation in FFB yield ($P<0.001$). A significant increase in yield was due to an increase in single bunch weight and bunch number ($p <0.001$). The three year cumulative data from 1997 to 1999 showed a similar response to that of 1999.

Table 1.70 Main Effects of N, P, K and Mg on yield and yield components for January 1997 to December 1999 at Luburua (Trial 252).

| | Nutrient Element and Level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | sed | cv % |
| | N0 | N1 | N2 | | | |
| Yield (t/ha) | 20.93 | 24.60 | 22.62 | * | 1.51 | 16.2 |
| Bunches/ha | 15.38 | 17.04 | 16.14 | * | | |
| Bunch weight (kg) | 13.19 | 14.36 | 13.68 | Ns | 0.69 | 12.4 |
| | K0 | K1 | K2 | | | |
| Yield (t/ha) | 17.29 | 24.51 | 26.36 | *** | 1.51 | 16.2 |
| Bunches/ha | 14.12 | 1669 | 1774 | *** | | |
| Bunch weight (kg) | 11.80 | 14.73 | 14.69 | *** | 0.69 | 12.4 |
| | P0 | P1 | | | | |
| Yield (t/ha) | 21.87 | 23.56 | | Ns | 1.23 | 16.2 |
| Bunches/ha | 15.90 | 16.47 | | Ns | | |
| Bunch weight (kg) | 13.30 | 14.19 | | Ns | 0.57 | 12.4 |
| | Mg0 | Mg1 | | | | |
| Yield (t/ha) | 23.17 | 22.27 | | Ns | 1.23 | 16.2 |
| Bunches/ha | 1664 | 1591 | | Ns | | |
| Bunch weight (kg) | 13.81 | 13.67 | | Ns | 0.57 | 12.4 |

Results for leaf and rachis analysis for 1999 are presented in Tables 1.71 and 1.72 for Maramakas and Luburua respectively.

Table 1.71 Treatment main effects on leaflet nutrient concentrations in 1999 (Trial 251).

| Element as % of dry matter | Nutrient Element and Level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | sig | Sed | Cv % |
| | N0 | N1 | N2 | | | |
| Nitrogen | 2.41 | 2.41 | 2.44 | ns | 0.037 | 3.8 |
| Phosphorous | 0.159 | 0.153 | 0.157 | ** | 0.0014 | 2.3 |
| Potassium | 0.62 | 0.60 | 0.61 | ns | 0.016 | 6.5 |
| Calcium | 1.21 | 1.16 | 1.15 | ns | 0.035 | 7.5 |
| Magnesium | 0.32 | 0.33 | 0.31 | ns | 0.013 | 10.2 |
| Chlorine | 0.73 | 0.73 | 0.74 | ns | 0.017 | 5.7 |
| Boron | 12.21 | 13.73 | 13.33 | ns | 0.71 | 13.3 |
| | K0 | K1 | K2 | | | |
| Nitrogen | 2.21 | 2.52 | 2.54 | *** | 0.037 | 3.8 |
| Phosphorous | 0.145 | 0.162 | 0.163 | *** | 0.0014 | 2.3 |
| Potassium | 0.33 | 0.73 | 0.77 | *** | 0.016 | 6.5 |
| Calcium | 1.25 | 1.11 | 1.17 | ** | 0.035 | 7.5 |
| Magnesium | 0.47 | 0.25 | 0.22 | *** | 0.013 | 10.2 |
| Chlorine | 0.77 | 0.72 | 0.72 | ** | 0.017 | 5.7 |
| Boron | 15.61 | 11.91 | 11.76 | *** | 0.71 | 13.3 |
| | P0 | P1 | | | | |
| Nitrogen | 2.43 | 2.41 | | ns | 0.037 | 3.8 |
| Phosphorous | 0.155 | 0.159 | | ** | 0.0014 | 2.3 |
| Potassium | 0.61 | 0.61 | | ns | 0.016 | 6.5 |
| Calcium | 1.17 | 1.17 | | ns | 0.075 | 7.5 |
| Magnesium | 0.31 | 0.31 | | ns | 0.013 | 10.2 |
| Chlorine | 0.73 | 0.75 | | * | 0.017 | 5.7 |
| Boron | 13.14 | 13.04 | | ns | 0.57 | 13.3 |
| | Mg0 | Mg1 | | | | |
| Nitrogen | 2.43 | 2.41 | | ns | 0.037 | 3.8 |
| Phosphorous | 0.158 | 0.156 | | * | 0.0014 | 2.3 |
| Potassium | 0.63 | 0.58 | | ** | 0.016 | 6.5 |
| Calcium | 1.20 | 1.15 | | ns | 0.075 | 7.5 |
| Magnesium | 0.29 | 0.34 | | *** | 0.013 | 10.2 |
| Chlorine | 0.73 | 0.73 | | ns | 0.017 | 5.7 |
| Boron | 13.14 | 13.04 | | ns | 0.57 | 13.3 |

At Maramakas application of MoP lead to a significant increase in leaflet N, P, K whilst Ca, Mg, Cl and Boron were depressed. Application of TSP caused an increase in leaflet P and Cl. Application of Kieserite caused an increase in leaflet Mg but decreased leaflet K and P.

Applications of SoA reduced the leaflet P concentration. It is possible that available P could have been taken up by legume cover crop. A healthy active nodule is reported to contain 2 to 3 times more P than the root on which it is formed, so the need for available P from the surrounding soil is great.

In 1998 the effect of ground cover was investigated and reported (PNGOPRA Annual Research Report 1998). It was found that % ground cover and vigour increases whilst deficiency symptoms decrease with application of MoP. In terms of ground cover score Maramakas had less ground cover than Luburua. This was assumed to have had some influence on the low yield obtained at Maramakas in 1998. The highest yield was recorded at Maramakas in 1999; this can be attributed to improved uptake and utilisation of NPK fertilisers.

Table 1.72 Treatment main effects on leaflet nutrient concentrations in 1999 (Trial 252).

| Element as % of dry matter | Nutrient Element and Level | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | Sed | cv % |
| | N0 | N1 | N2 | | | |
| Nitrogen | 2.41 | 2.41 | 2.44 | ns | 0.037 | 3.8 |
| Phosphorous | 0.159 | 0.153 | 0.157 | ** | 0.0014 | 2.3 |
| Potassium | 0.62 | 0.59 | 0.62 | ns | 0.016 | 6.5 |
| Calcium | 1.21 | 1.16 | 1.15 | ns | 0.035 | 7.5 |
| Magnesium | 0.31 | 0.32 | 0.31 | ns | 0.013 | 10.2 |
| Chlorine | 0.73 | 0.73 | 0.74 | ns | 0.017 | 5.7 |
| Boron | 12.21 | 13.73 | 13.33 | ns | 0.71 | 13.3 |
| | K0 | K1 | K2 | | | |
| Nitrogen | 2.21 | 2.52 | 2.54 | *** | 0.037 | 3.8 |
| Phosphorous | 0.145 | 0.162 | 0.163 | *** | 0.0014 | 2.3 |
| Potassium | 0.33 | 0.73 | 0.77 | *** | 0.016 | 6.5 |
| Calcium | 1.25 | 1.11 | 1.17 | ** | 0.035 | 7.5 |
| Magnesium | 0.47 | 0.25 | 0.22 | *** | 0.013 | 10.2 |
| Chlorine | 0.77 | 0.72 | 0.72 | ** | 0.017 | 5.7 |
| Boron | 15.61 | 11.91 | 11.76 | *** | 0.71 | 13.3 |
| | P0 | P1 | | | | |
| Nitrogen | 2.43 | 2.42 | | ns | 0.037 | 3.8 |
| Phosphorous | 0.155 | 0.159 | | ** | 0.0014 | 2.3 |
| Potassium | 0.61 | 0.61 | | ns | 0.016 | 6.5 |
| Calcium | 1.17 | 1.17 | | ns | 0.035 | 7.5 |
| Magnesium | 0.31 | 0.31 | | ns | 0.013 | 10.2 |
| Chlorine | 0.72 | 0.75 | | * | 0.017 | 5.7 |
| Boron | 13.14 | 13.04 | | ns | 0.57 | 13.3 |
| | Mg0 | Mg1 | | | | |
| Nitrogen | 2.43 | 2.41 | | ns | 0.037 | 3.8 |
| Phosphorous | 0.158 | 0.155 | | ns | 0.0014 | 2.3 |
| Potassium | 0.63 | 0.58 | | ** | 0.016 | 6.5 |
| Calcium | 1.2 | 1.15 | | ns | 0.035 | 7.5 |
| Magnesium | 0.29 | 0.34 | | *** | 0.013 | 10.2 |
| Chlorine | 0.73 | 0.73 | | ns | 0.017 | 5.7 |
| Boron | 13.14 | 13.04 | | ns | 0.57 | 13.3 |

At Luburua application of MoP caused a significant increase in leaflet N, P, K and reduced leaflet Ca, Mg, Cl and Boron concentrations. Application of SoA reduced leaflet P and application of TSP increased leaflet P and leaflet Cl. Application of Kieserite increased leaflet Mg and reduced leaflet K concentrations.

Analysis of nutrient content of rachis tissue was carried out only for. The results are presented in Tables 1.73 and 1.74 for Maramakas and Luburua respectively. At both locations application of MoP caused a significant increase in rachis K whilst application of SoA reduced rachis K concentrations.

Table 1.73 Treatment main effects on rachis K concentrations (as % DM) in 1999 at Maramakas (Trial 251).

| Nutrient Element and Level | | | Statistics | | |
|---|---|---|---|---|---|
| | | | Sig | Sed | Cv % |
| N0 | N1 | N2 | | | |
| 0.89 | 0.85 | 0.76 | * | 0.048 | 14.2 |
| K0 | K1 | K2 | | | |
| 0.14 | 0.98 | 1.38 | *** | 0.048 | 14.2 |
| P0 | P1 | | | | |
| 0.85 | 0.82 | | ns | 0.039 | 14.2 |
| Mg0 | Mg1 | | | | |
| 0.85 | 0.82 | | ns | 0.039 | 14.2 |

Table 1.74 Treatment main effects on rachis K concentrations (as %DM) in 1999 at Luburua (Trial 252).

| Nutrient Element and Level | | | Statistics | | |
|---|---|---|---|---|---|
| | | | Sig | Sed | cv % |
| N0 | N1 | N2 | | | |
| 0.89 | 0.85 | 0.76 | * | 0.048 | 14.2 |
| K0 | K1 | K2 | | | |
| 0.14 | 0.98 | 1.38 | *** | 0.048 | 14.2 |
| P0 | P1 | | | | |
| 0.85 | 0.82 | | ns | 0.039 | 14.2 |
| Mg0 | Mg1 | | | | |
| 0.85 | 0.82 | | ns | 0.039 | 14.2 |

Bunch analysis showed an average oil/bunch ratio of 25.05%. The K0 plot in Trial 252 produced only one bunch while a sample size of 30 bunches was obtained from other plots. This discrepancy has affected the mean value for the measured parameters (Table 1.75).

Table 1.75 Bunch Analysis results from 6 selected plots at Maramakas and Luburua (Trials 251 & 252).

| Trial | Plot | K Level | No of Bunches analysed | Fruit/Bunch | Kernel/Bunch (%) | Oil/Bunch (%) |
|---|---|---|---|---|---|---|
| 251 | 35 | K0 | 30 | 76.1 | 6.36 | 29.71 |
| 251 | 14 | K1 | 30 | 64.2 | 5.90 | 25.73 |
| 251 | 24 | K2 | 30 | 65.5 | 6.76 | 24.43 |
| 252 | 26 | K0 | 1 | 46.0 | 4.48 | 17.63 |
| 252 | 5 | K1 | 30 | 65.5 | 5.69 | 25.92 |
| 252 | 32 | K2 | 30 | 66.6 | 6.39 | 26.87 |
| | | | Mean | 63.9 | 5.93 | 25.05 |

# 2. PNG MAINLAND REGION AGRONOMY

(M. Banabas)

## INTRODUCTION

In 1999 all work programmed for the year was completed. There were some changes in staffing at Popondetta. No new trials were initiated, nor old trials closed.

## STAFF

Dr. Rob Caudwell, Senior Officer (Popondetta) and Senior Entomologist was transferred to Dami and was replaced by Mr. Graham King (Senior Agronomist - Smallholders). Murom Banabas remained as Agronomist-in-Charge of mainland trials while Mrs. Jojo Papah, Assistant Agronomist, continued working on GIS and took charge of smallholder demonstration trials. Mr. Winston Eremu remained at Milne Bay as Assistant Agronomist while Paul Simin remained as supervisor for agronomy trials at Popondetta.

Mr. Takis Solulu (Entomologist) left for PhD studies in Australia and was replaced by Mr. Ross Safitoa (Assistant Entomologist) who was transferred from Bialla.

## TRIALS

Routine work on all trials was completed as scheduled. Trials at both Popondetta and Milne Bay remained unchanged.

Short studies on soil compaction and “Wettasoil” were conducted during the year.

Leaf sampling on trials, demonstration blocks and estates were all completed as scheduled both at Popondetta and Milne Bay.

## SMALLHOLDERS

Farmer field days were organised with OPIC officers and smallholders in Popondetta. PNGOPRA staff attended OPIC LPC meetings both at Popondetta and Milne Bay. All smallholder demonstration sites at both Popondetta and Milne Bay were closed at the end of 1999.

## PUBLICATIONS

Progress is made with analysing and writing up Trials 305 and 306. Two papers from Murom Banabas’s MSc Thesis were written and sent to Dr. Max Turner at Massey University (NZ) for review.

## VEHICLES

Numerous breakdowns due to the age of the vehicle fleet meant that some transport difficulties were experienced.

**Trial 309 POTASSIUM, CHLORINE AND SULPHUR TRIAL AT AMBOGO ESTATE**

PURPOSE

To investigate the response to potassium, chlorine and sulphur fertiliser applications.

DESCRIPTION

Site Ambogo Estate Block 80H

Soil Penderetta family. Thin dark sandy loam topsoil over sandy loam subsoil derived from alluvially deposited volcanic ash. Mottling due to seasonally high water tables.

Palms Dami commercial DxP crosses planted in 1980 at 143 palms per hectare. Trial started in June 1990.

DESIGN

There are 25 plots each containing 16 core palms. The numbers and weight of bunches for each individual core palms are recorded at intervals of 14 days. In each plot, at least one guard row and a plot isolation trench surround the core palms.

The 25 plots are divided into five replicate blocks each containing five treatments (Table 2.1). The trial is laid down on the site of an earlier trial that was started in 1984 to test effects of EFB. Each treatment used in the present trial has a Latin Square design.

The treatments are combinations of fertilisers, one of which is bunch ash (BA). The right hand part of table 2.1 shows the amount of each element that is applied to each treatment. The effects of an element are found by comparing the yields from two treatments; for example the effect of chlorine is found by comparing the yields from treatments 4 and 5.

The treatments that were used from January 1988 to June 1990 were similar, but there are some important differences. Treatment 3 now receives N and S, but used to receive only K. Treatment 2 now receives N and Cl, but used to receive K and Cl. Thus in comparison of a treatment with either 2 or 3 in order to test the effect of K.

Table 2.1 Types and amounts of fertiliser given in each treatment, and the corresponding amounts of nutrient element in Trial 309.

| Treatment No | Amount of fertiliser (kg/plm/yr) | | | | Amount of Element (kg/plm/yr) | | | |
|---|---|---|---|---|---|---|---|---|
| | MoP | BA | SoA | AmC | N | K | Cl | S |
| 1 | - | - | - | - | - | - | - | - |
| 2 | - | - | | 3.2 | 0.80 | - | 2.1 | - |
| 3 | - | - | 4.0 | - | 0.84 | - | - | 0.96 |
| 4 | 4.4 | - | 4.0 | - | 0.84 | 2.3 | 2.1 | 0.96 |
| 5 | - | 8.8 | 4.0 | - | 0.84 | 2.2 | - | 0.96 |

## RESULTS

Yield comparisons of the effects of N, S, K and Cl for 1999 and 1997-1999 data are summarised in Table 2.2. In 1999 and 1997-1999 fertiliser treatments significantly ($p<0.001$) affected FFB yield, number of bunches per hectare and single bunch weight. Mean FFB yield in 1999 has improved from 13.1 t/ha in 1998 to 19.8 t/ha/yr in 1999.

Separation of effects on yield from different fertiliser treatments for 1999 and 1997–1999 are also shown in Table 2.2. In 1999, treatments 4 and 3 were significantly different from treatments 5, 2 and 1, however treatments 5, 2 and 1 are also significantly different from each other. For the 1997–1999 data similar effects to 1999 are seen, however here treatment 5 is no different to treatment 2.

Sulphate of ammonia (N and S) applied at 4 kg/palm/yr produced high yields (> 20 t/ha/yr) however addition of K and Cl either together or separately does not appear to further enhance yield (comparison of treatments 3, 4 and 5) (Table 2.2). K and Cl added to the N and S enhanced yield from 1991 to 1994 but this ceased in 1995 (Table 2.4). The difference in results seen from 1991-1994 and 1995 onwards may be due to the residual effects of earlier treatments or to a new factor other than the treatments becoming limiting.

Sulphate of ammonia (effect of N and S) produced a yield increase of 12.4 tonnes/ha/yr while ammonium chloride (effect of N and Cl) produced a yield increase of 8.0 tonnes. It appears N is very important for high FFB yields in this particular soil type but only when applied with S. The effect of K and Cl either applied together or separately (excluding N and S) produced low yield increases of less than 3.0 tonnes FFB.

A comparison of N source indicates ammonium sulphate (N and S) is better than ammonium chloride (N and Cl) by a difference of 3 tonnes though statistically this was not significant (Table 2.2 and 2.4).

Table 2.2 Effects of N, S, K, and Cl in different combinations on yield and yield components in 1999 and 1997-99 (Trial 309).

| Treatments | 1999 | | | 1997 – 1999 | | |
|---|---|---|---|---|---|---|
| | THA | BHA | SBW | THA | BHA | SBW |
| 4 N S K Cl | 25.4a | 1047 | 24.3 | 20.8a | 949 | 21.8 |
| 5 N S K | 21.3b | 907 | 23.5 | 17.9b | 839 | 21.3 |
| 3 N S | 24.4a | 1024 | 23.8 | 20.3a | 938 | 21.5 |
| 2 N Cl | 18.9c | 885 | 21.3 | 15.9b | 815 | 19.4 |
| 1 Nil | 9.1d | 626 | 14.8 | 7.9c | 552 | 14.1 |
| GM | 19.8 | 898 | 21.5 | 16.6 | 819 | 19.6 |
| Sig | *** | *** | *** | *** | *** | *** |
| SE | 2.38 | 87 | 1.799 | 2.04 | 81 | 1.277 |
| CV% | 12 | 9.7 | 8.4 | 12.3 | 9.9 | 6.5 |

Table 2.3 Mean Yield for 1997-99, and difference in yield for selected comparisons (Trial 309).

| Treatments | THA | Comparison | % Difference | Sig |
|---|---|---|---|---|
| 4 N S K Cl | 20.8 | 4 – 2 (effect of K and S) | 6.5 | * |
| 5 N S K | 17.9 | 3 – 2 (substituting S for Cl) | 5.5 | * |
| 3 N S | 20.3 | 4 – 3 (effect of K and Cl) | 0.04 | NS |
| 2 N Cl | 15.9 | 4 – 5 (effect of Cl) | 4.06 | * |
| 1 Nil | 7.9 | 5 – 3 (effect of K) | -3.02 | NS |
| | | 3 – 1 (effect of N and S) | 15.25 | * |
| | | 2 – 1 (effect of N and Cl) | 9.76 | * |
| Mean | 16.6 | | | |
| Sig | *** | | | |
| SE | 2.04 | | | |
| CV% | 12.3 | | | |

Table 2.4 Effects of N, S, K, and Cl, in different combinations on FFB yield trends in 1991-1999 (Trial 309).

| Treatments | FFB Yield (t/ha/yr) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
| | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 4 N S K Cl | 31.3 | 32.5 | 28.4 | 27.7 | 18.6 | 18.7 | 21.1 | 15.4 | 25.4 |
| 5 N S K | 28.6 | 30.9 | 28.7 | 26.4 | 19.7 | 14.7 | 19.4 | 12.2 | 21.3 |
| 3 N S | 28.5 | 27.8 | 25.2 | 24.2 | 28.6 | 15.1 | 18.7 | 17.3 | 24.4 |
| 2 N Cl | 24.5 | 21.7 | 19.4 | 18.7 | 14.4 | 13.8 | 14.5 | 14.3 | 18.9 |
| 1 Nil | 16.4 | 13.6 | 9.8 | 7.1 | 6.4 | 7.6 | 8.3 | 6.3 | 9.1 |
| GM | | | | | | | | | 19.8 |
| Sig | ** | *** | *** | *** | *** | Ns | *** | ** | *** |
| SE | | | | | | | | | 2.38 |
| CV% | 17.1 | 20.1 | 19.1 | 9.4 | 26.3 | 30.4 | 11.1 | 27.4 | 12.0 |

Leaflets and rachis analysis results for 1999 are presented in tables 2.5 and 2.6 respectively. The fertiliser treatments had significant effects on all nutrient concentrations except for K and S in the leaflets.

In the leaflets, treatment 2 (N Cl) improved N and P levels while the Cl component in treatments 2 and 4 maintained high Cl and Ca concentrations.

In the rachis, the K component in the fertilisers (treatments 4 and 5) maintained high K concentrations while Cl (2 and 5) maintained both Ca and Cl at high levels.

Table 2.5 Effect of N, S, K and Cl in different combinations, on the concentration of elements in leaf tissue of frond 17 in 1999 (Trial 309).

| Treatments | Leaf Nutrient Concentrations (% DM) | | | | | | |
|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | Cl | S |
| 4 N S K Cl | 1.99 | 0.136 | 0.60 | 0.63 | 0.16 | 0.44 | 0.14 |
| 5 N S K | 2.07 | 0.138 | 0.60 | 0.55 | 0.17 | 0.32 | 0.15 |
| 3 N S | 2.07 | 0.137 | 0.67 | 0.55 | 0.17 | 0.28 | 0.15 |
| 2 N Cl | 2.19 | 0.142 | 0.59 | 0.61 | 0.17 | 0.43 | 0.14 |
| 1 Nil | 1.78 | 0.131 | 0.57 | 0.56 | 0.24 | 0.26 | 0.14 |
| GM | 2.02 | 0.137 | 0.61 | 0.58 | 0.18 | 0.35 | 0.14 |
| Sig | *** | ** | ns | * | ** | *** | ns |
| SE | 0.093 | 0.004 | 0.081 | 0.046 | 0.030 | 0.063 | 0.015 |
| CV% | 4.6 | 3 | 13.4 | 7.9 | 17.0 | 18.4 | 10.3 |

Table 2.6 Effect of N, S, K, and Cl in different combinations on the concentration of elements in the rachis of frond 17 in 1999 (Trial 309).

| Treatments | Rachis Nutrient Concentrations (% DM) | | | | | | |
|---|---|---|---|---|---|---|---|
| | N | P | K | Ca | Mg | Cl | S |
| 4 N S K Cl | 0.26 | 0.148 | 1.78 | 0.35 | 0.06 | 0.94 | 0.06 |
| 5 N S K | 0.27 | 0.164 | 1.54 | 0.27 | 0.06 | 0.34 | 0.05 |
| 3 N S | 0.27 | 0.082 | 1.06 | 0.27 | 0.05 | 0.16 | 0.06 |
| 2 N Cl | 0.44 | 0.173 | 1.13 | 0.33 | 0.10 | 0.99 | 0.04 |
| 1 Nil | 0.25 | 0.181 | 1.26 | 0.23 | 0.08 | 0.31 | 0.04 |
| GM | 0.30 | 0.149 | 1.36 | 0.29 | 0.07 | 0.55 | 0.05 |
| Sig | *** | *** | *** | *** | *** | *** | * |
| SE | 0.048 | 0.026 | 0.140 | 0.027 | 0.0076 | 0097 | 0.009 |
| CV% | 16.1 | 17.7 | 10.3 | 9.5 | 10.8 | 17.6 | 17.5 |

## Trial 310 POTASSIUM, CHLORINE AND SULPHUR TRIAL AT AMBOGO ESTATE

### PURPOSE

To investigate the response to potassium, chlorine and sulphur fertiliser applications.

### DESCRIPTION

Site: Ambogo Estate block 80D5

Soil: Ambogo and Penderetta families. Silt loam over sandy loam, with mottling due to seasonally high water tables, derived from alluvially deposited volcanic ash.

Palms: Dami commercial DxP crosses planted in 1980 at 143 palms per hectare. Trial started January 1986, but present treatments started in November 1990.

### DESIGN

There are 35 plots each containing 16 core palms. The numbers and weight of bunches for each individual core palms are recorded at intervals of 14 days. In each plot at least one guard row and a plot isolation trench surround the core palms. The 35 plots are divided into five replicate blocks each containing seven treatments that are randomised (Table 2.7). The treatments represent combinations of fertilisers. The lower half of Table 2.7 shows the amount of each element that is applied in each treatment. The effect of an element is found by comparing the yields from two treatments; for example, the effect of chlorine in the absence of K and S is found by comparing treatments 3 and 1.

Table 2.7 Amount of each type of fertiliser, and each element, used for each treatment in Trial 310.

| Type of Fertiliser | Treatment number (kg of fertiliser/palm/year) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Urea | 1.8 | - | - | - | - | - | - |
| Sulphate of Ammonia | - | 4.0 | - | 4.0 | - | 4.0 | 2.0 |
| Ammonium Chloride | - | - | 3.2 | - | 3.2 | - | 1.6 |
| Bunch Ash | - | - | - | 4.4 | 4.4 | - | - |
| Muriate of Potash | - | - | - | - | - | 2.2 | - |

| Element | Treatment number (kg of element/palm/year) | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| N | 0.81 | 0.84 | 0.80 | 0.84 | 0.80 | 0.84 | 0.82 |
| K | - | - | - | 1.1 | 1.1 | 1.04 | - |
| S | - | 0.96 | - | 0.96 | - | 0.96 | 0.48 |
| Cl | - | - | 2.1 | - | 2.1 | 1.1 | 1.1 |

### RESULTS

FFB yield results for 1999 and 1997–1999 are presented in Tables 2.8 and 2.11 respectively. The effect of an element is found by comparing the yields from two treatments. However, in 1999 there were no significant differences between the treatment means and therefore comparisons are not meaningful. In addition, effects have generally been insignificant since 1991 (Tables 2.8 and 2.11).

There were no significant differences between treatments for mean bunch numbers (Table2.9) but there were differences in single bunch weight ($p<0.001$) (Table 2.10). Although there are differences in single bunch weights, FFB yield was not affected because of declining bunch numbers.

The addition of Cl increased FFB yield by 2.3 t/ha/yr on this soil type on the outwash plains on Ex-forest soils (Table 2.12). A general comparison of results suggest ammonium chloride is a better N source than ammonium sulphate on ex-forest soils where soil organic matter levels are generally high.

Table 2.8 The effects of K, Cl and S on yield in 1999 (Trial 310)

| Treatment No | Elements Supplied | Element Missing | Yield (t/ha/yr) | Difference from treatment 6 | |
|---|---|---|---|---|---|
| | | | | Yield (t/ha/yr) | % Difference |
| 6 | N S K Cl | None | 22.7 | 0.0 | 0 |
| 4 | N K S | Cl | 23.4 | -0.7 | -3 |
| 7 | N Cl S | K | 25.0 | -2.3 | -10 |
| 5 | N K Cl | S | 23.4 | -0.7 | -3 |
| 2 | N S | K, Cl | 21.6 | 1.1 | 5 |
| 3 | N Cl | K, S | 25 | -2.3 | -10 |
| 1 | N (Urea) | K, Cl, S | 21.3 | 1.4 | 5 |
| | | GM | 23.2 | | |
| | | Sig | Ns | | |
| | | SE | 2.79 | | |
| | | CV% | 12.1 | | |

Table 2.9 The effects of K, Cl and S on bunch numbers in 1999 (Trial 310).

| Treatment No | Elements Supplied | Element Missing | Bunches (No/ha/yr) | Difference from treatment 6 | |
|---|---|---|---|---|---|
| | | | | Bunches (No/ha/yr) | % Difference |
| 6 | N S K Cl | None | 854 | 0 | 0 |
| 4 | N K S | Cl | 932 | -78 | -9 |
| 7 | N Cl S | K | 972 | -118 | -14 |
| 5 | N K Cl | S | 876 | -22 | -3 |
| 2 | N S | K, Cl | 917 | -63 | -7 |
| 3 | N Cl | K, S | 942 | -88 | -10 |
| 1 | N (Urea) | K, Cl, S | 998 | -144 | -17 |
| | | GM | 927 | | |
| | | Sig | Ns | | |
| | | SE | 119.5 | | |
| | | CV% | 12.9 | | |

Table 2.10 The effects of K, Cl, and S on single bunch weight in 1999 (Trial 310).

| Treatment No | Elements Supplied | Element Missing | Single bunch weight (kg) | Difference from treatment 6 | |
|---|---|---|---|---|---|
| | | | | Single bunch weight (kg) | % Difference |
| 6 | N S K Cl | None | 26.7 | 0 | 0 |
| 4 | N K S | Cl | 25.3 | 1.4 | 5 |
| 7 | N Cl S | K | 25.7 | 1.0 | 4 |
| 5 | N K Cl | S | 26.8 | -0.1 | 0 |
| 2 | N S | K, Cl | 23.6 | 3.15 | 12 |
| 3 | N Cl | K, S | 26.6 | 0.10 | 0 |
| 1 | N (Urea) | K, Cl, S | 21.4 | 5.34 | 20 |
| | | GM | 25.2 | | |
| | | Sig | *** | | |
| | | SE | 1.389 | | |
| | | CV% | 5.5 | | |

Table 2.11 The effects of K, Cl and S on FFB yield in 1997-1999 (Trial 310).

| Treatment No | Elements Supplied | Element Missing | Yield (t/ha/yr) | Difference from treatment 6 | |
|---|---|---|---|---|---|
| | | | | Yield (t/ha/yr) | % Difference |
| 6 | N S K Cl | None | 26.9 | 0.0 | 0 |
| 4 | N K S | Cl | 25.7 | 1.2 | 4 |
| 7 | N Cl S | K | 28.4 | -1.5 | -6 |
| 5 | N K Cl | S | 26.7 | 0.2 | 1 |
| 2 | N S | K, Cl | 24.3 | 2.6 | 10 |
| 3 | N Cl | K, S | 27.5 | -0.6 | -2 |
| 1 | N (Urea) | K, Cl, S | 25.3 | 1.6 | 6 |
| | | GM | 26.4 | | |
| | | Sig | Ns | | |
| | | SE | 2.42 | | |
| | | CV% | 9.2 | | |

Table 2.12 Effect of Elements on 1997 – 1999 Yield Data (Trial 310).

| Nutrient Elements | Mean Yields | Differences |
|---|---|---|
| | (t/ha/yr) | |
| N only (Urea) | 25.3 | 0 |
| + Cl | 27.4 | |
| - Cl | 25.1 | 2.3 |
| + K | 26.4 | |
| - K | 26.4 | 0 |
| + S | 26.3 | |
| - S | 26.4 | 0 |

Table 2.13 The effects of N, S, K, and Cl in different combinations on FFB yield from 1991 to 1999 (Trial 310).

| Treatment No | Elements Supplied | Element Missing | Yields (t/ha/yr) 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
| 6 | N S K Cl | None | 26.7 | 34.0 | 29.9 | 26.9 | 25.7 | 25.6 | 27.5 | 29.6 | 22.7 |
| 4 | N K S | Cl | 26.2 | 31.0 | 26.8 | 27.4 | 26.2 | 24.6 | 25.7 | 27.4 | 23.4 |
| 7 | N Cl S | K | 27.6 | 28.9 | 28.7 | 28.3 | 25.7 | 27.0 | 28.9 | 29.5 | 25.0 |
| 5 | N K Cl | S | 27.4 | 28.6 | 28.9 | 28.0 | 26.0 | 28.2 | 30.1 | 26.3 | 23.4 |
| 2 | N S | K, Cl | 26.5 | 29.6 | 29.9 | 30.4 | 22.8 | 23.7 | 24.4 | 26.0 | 21.6 |
| 3 | N Cl | K, S | 29.1 | 30.3 | 31.5 | 28.9 | 26.3 | 28.8 | 30.1 | 26.8 | 25 |
| 1 | N (Urea) | K, Cl, S | 25.3 | 25.6 | 28.1 | 27.1 | 22.7 | 24.5 | 26.9 | 27.0 | 21.3 |
| | | GM | 27.0 | 29.7 | 29.1 | 28.1 | 25.1 | 26.1 | 27.7 | 27.5 | 23.2 |
| | | Sig | ns | ** | Ns | Ns | Ns | Ns | * | Ns | Ns |
| | | SED | | | | | 1.82 | 3.54 | 3.06 | 2.19 | |
| | | SE | | | | | | | | | 2.79 |
| | | lsd | | 3.4 | | | | | | | |
| | | CV% | | 8.8 | 12.0 | 10.5 | 11.5 | 13.6 | 11.1 | 12.6 | 12.1 |

Leaf and rachis analysis results for 1999 are presented in Tables 2.14 and 2.15 respectively. The fertiliser treatments produced significant effects on Cl concentrations ($p<0.001$) in the leaflets and on K ($p=0.004$), Mg ($p=0.014$) and Cl ($p=0.022$) in the rachis tissue. The Cl anion in the fertiliser treatments significantly increased Cl in the leaflets and the cations, Ca and Mg, in the rachis.

Table 2.14 The effects of N, S, K, and Cl in different combinations, on the concentrations of elements in leaf tissue of frond 17 in 1999 (Trial 310).

| Treatment No | Elements Supplied | Element Missing | Element % DM Leaflets | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | Ca | Mg | Cl | S |
| 6 | N S K Cl | None | 2.25 | 0.144 | 0.66 | 0.68 | 0.15 | 0.47 | 0.15 |
| 4 | N K S | Cl | 2.26 | 0.148 | 0.69 | 0.62 | 0.14 | 0.28 | 0.14 |
| 7 | N Cl S | K | 2.24 | 0.143 | 0.66 | 0.64 | 0.16 | 0.48 | 0.13 |
| 5 | N K Cl | S | 2.15 | 0.147 | 0.64 | 0.66 | 0.13 | 0.44 | 0.14 |
| 2 | N S | K, Cl | 2.18 | 0.143 | 0.72 | 0.64 | 0.16 | 0.11 | 0.15 |
| 3 | N Cl | K, S | 2.16 | 0.148 | 0.64 | 0.70 | 0.16 | 0.49 | 0.14 |
| 1 | N (Urea) | K, Cl, S | 2.21 | 0.149 | 0.74 | 0.65 | 0.16 | 0.12 | 0.14 |
| | | GM | 2.21 | 0.146 | 0.66 | 0.66 | 0.15 | 0.34 | 0.14 |
| | | Sig | ns | ns | * | Ns | * | *** | ns |
| | | SE | 0.106 | 0.004 | 0.055 | 0.06 | 0.016 | 0.069 | 0.010 |
| | | CV% | 4.8 | 2.8 | 8.1 | 9.2 | 11 | 20.4 | 7 |

Table 2.15 Effects of N, S, K and Cl in different combinations, on the concentrations of elements in rachis of frond 17 in 1999 (Trial 310).

| Treatment No | Elements Supplied | Element Missing | Element % DM Rachis | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | N | P | K | Ca | Mg | Cl | S |
| 6 | N S K Cl | None | 0.31 | 0.185 | 1.50 | 0.43 | 0.07 | 0.97 | 0.06 |
| 4 | N K S | Cl | 0.31 | 0.156 | 1.33 | 0.34 | 0.04 | 0.16 | 0.07 |
| 7 | N Cl S | K | 0.31 | 0.127 | 1.26 | 0.45 | 0.08 | 1.02 | 0.07 |
| 5 | N K Cl | S | 0.35 | 0.192 | 1.39 | 0.45 | 0.07 | 1.06 | 0.06 |
| 2 | N S | K, Cl | 0.31 | 0.107 | 0.94 | 0.31 | 0.05 | 0.07 | 0.07 |
| 3 | N Cl | K, S | 0.38 | 0.181 | 1.13 | 0.44 | 0.10 | 1.06 | 0.05 |
| 1 | N (Urea) | K, Cl, S | 0.31 | 0.144 | 1.05 | 0.31 | 0.05 | 0.06 | 0.06 |
| | | GM | 0.33 | 0.156 | 1.23 | 0.39 | 0.06 | 0.63 | 0.06 |
| | | Sig | * | *** | *** | *** | *** | *** | * |
| | | SE | 0.035 | 0.024 | 0.160 | 0.042 | 0.008 | 0.084 | 0.012 |
| | | CV% | 10.7 | 15.5 | 13.0 | 10.7 | 13.2 | 13.3 | 19.6 |

## Trial 311 NITROGEN, POTASSIUM, AND EMPTY FRUIT BUNCH TRIAL AT ISAVENE ESTATE

### PURPOSE

To test the response to N and K fertilisers, with and without EFB, with a view to using EFB to replace or supplement chemical fertiliser.

### DESCRIPTION

| | |
|---|---|
| Site | Isavene Estate Block 78A |
| Soil | Higaturu family; deep sandy clay loam with good drainage, derived from volcanic ash. |
| Palms | Dami commercial DxP crosses. Planted in 1978 at 128 palms/ha. |

### DESIGN

There are 32 plots each with a core of 16 recorded palms. The number and weights of bunches from each individual core palm are recorded at intervals of 14 days. In each plot the core palms are surrounded by at least one guard row and a trench. The 32 plots are a single replicate containing 32 treatments made up of all combinations of four levels each of N and K, and two levels of EFB (Table 2.16). Sulphate of ammonia (SoA) is the source of nitrogen, and muriate of potash (MoP) is the source of potassium. The EFB is applied by hand as mulch between the palm circles. The weights of EFB presented in Table 2.16 are fresh weights ex-mill. When EFB was applied for the first time in November 1988 the amount was 333 kg/palm. In September 1990 this was increased to 500 kg/palm and it is intended to apply this amount every two years.

Table 2.16 Amounts of fertiliser and EFB used in Trial 311.

| Fertiliser | Amount (kg/palm/year) | | | |
|---|---|---|---|---|
| | Level 0 | Level 1 | Level 2 | Level 3 |
| SoA | 0.0 | 2.0 | 4.0 | 6.0 |
| MoP | 0.0 | 2.0 | 4.0 | 6.0 |
| | kg/palm/2 years | | | |
| EFB | 0.0 | 500 | | |

Note: SoA and MoP have been applied twice a year since April 1988, and three times a year since 1995. The trial was trenched in 1995.

### RESULTS

FFB yield data for 1999 is presented in Table 2.17. Ammonium sulphate significantly (p=0.003) increased FFB yield and this was due to a significant increase in both bunch numbers (p<0.009) and single bunch weight (p=0.002). Empty fruit bunch also improved FFB yield and yield components but there were no responses to muriate of potash. Similar responses are seen in the mean cumulative FFB yield and yield components data for 1997–1999 (Table 2.20).

Although interactions between the 3 fertiliser treatments were not statistically significant, 1999 and 1997– 999 FFB yield results are presented in two-way Tables 2.18, 2.19 and 2.21. In 1999 a maximum yield of 33.1 t FFB/ha/yr was obtained with a combination of 6 kg SoA and 2 kg MoP averaged over all levels of EFB (Table 2.18). However a more realistic yield of 30 t/ha/yr is obtained with 4 kg SoA/palm/yr and 2 kg MoP/palm/yr based on the 1997–1999 data. It appears that full benefit from high N rates (N2 and N3) is only seen in the presence of MoP. N is the major limiting nutrient. SoA and EFB combinations (2 kg SoA in the presence of EFB) produced a high FFB yield of 26 t in 1999 and 30 t FFB/ha/yr in 1997–1999. These combinations (N2 & K1 and N1 & EFB1) (Tables 2.18 and 2.21) produced more realistic yields even in the presence and absence of either K or EFB (Tables 2.19 and 2.22).

Table 2.17 Main effects of N, K, EFB on yield and yield components in 1999 (Trial 311).

| | Nutrient & Levels | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | Sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| Yield t/ha | 18.5 | 22.6 | 25.1 | 29.2 | ** | 3.919 | 16.5 |
| BNO /ha | 722 | 774 | 849 | 954 | ** | 107 | 13.0 |
| SBW kg | 25.2 | 28.9 | 29.6 | 30.6 | ** | 1.93 | 6.8 |
| | K0 | K1 | K2 | K3 | | | |
| Yield t/ha | 23.0 | 23.4 | 24.6 | 24.2 | Ns | 3.919 | 16.5 |
| BNO /ha | 806 | 809 | 853 | 830 | Ns | 107 | 13.0 |
| SBW kg | 28.1 | 28.4 | 28.8 | 29.1 | Ns | 1.93 | 6.8 |
| | EFB0 | EFB1 | | | | | |
| Yield t/ha | 21.8 | 25.6 | | | * | 3.919 | 16.5 |
| BNO /ha | 787 | 863 | | | (*) | 107 | 13.0 |
| SBW kg | 27.3 | 29.9 | | | ** | 1.93 | 6.8 |

Table 2.18 Effect of combinations of N and K, N and EFB, and K and EFB in 1999 on FFB Yield (t/ha/yr) (Trial 311).

| | Level of N | | | |
|---|---|---|---|---|
| Level of K | N0 | N1 | N2 | N3 |
| K0 | 17.1 | 22.5 | 25.7 | 26.8 |
| K1 | 17.5 | 18.1 | 25.0 | 33.1 |
| K2 | 19.6 | 26.6 | 23.1 | 29.3 |
| K3 | 19.6 | 23.1 | 26.5 | 27.5 |

| | Level of N | | | |
|---|---|---|---|---|
| Level of EFB | N0 | N1 | N2 | N3 |
| EFB 0 | 15.3 | 19.3 | 23.7 | 29.1 |
| EFB 1 | 21.6 | 25.9 | 26.5 | 29.2 |

GM = 23.8 s.e.d N x K = 3.92 and N x EFB = 2.77

Table 2.19 Effect of combinations of N and K (absence of EFB) and N and EFB (absence of K) in 1999 (Trial 311).

| | Level of N (Absence of EFB) | | | |
|---|---|---|---|---|
| Level of K | N0 | N1 | N2 | N3 |
| K0 | 10.1 | 17.1 | 24.7 | 29.3 |
| K1 | 11.6 | 11.7 | 25.3 | 31.7 |
| K2 | 19.2 | 26.0 | 19.8 | 29.8 |
| K3 | 20.1 | 22.2 | 24.9 | 25.7 |
| | **Level of N (Absence of K)** | | | |
| Level of EFB | N0 | N1 | N2 | N3 |
| EFB 0 | 10.1 | 17.1 | 24.7 | 29.3 |
| EFB 1 | 24.1 | 27.9 | 26.7 | 24.4 |

Table 2.20 Main effects of N, K and EFB on FFB yield and yield components for 1997–1999 (Trial 311).

| | Nutrient & Levels | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | Sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| Yield t/ha | 17.8 | 26.2 | 29.7 | 32.0 | *** | 3.155 | 11.9 |
| BNO /ha | 694 | 920 | 985 | 1040 | *** | 71 | 7.8 |
| SBW kg | 25.3 | 28.3 | 30.1 | 30.8 | *** | 1.809 | 6.3 |
| | K0 | K1 | K2 | K3 | | | |
| Yield t/ha | 25.9 | 26.0 | 26.5 | 27.3 | Ns | 3.155 | 11.9 |
| BNO /ha | 907 | 884 | 902 | 946 | Ns | 71 | 7.8 |
| SBW kg | 28.0 | 28.7 | 29.1 | 28.7 | Ns | 1.809 | 6.3 |
| | EFB0 | EFB1 | | | | | |
| Yield t/ha | 23.9 | 29.0 | | | *** | 3.155 | 11.9 |
| BNO /ha | 851 | 968 | | | *** | 71 | 7.8 |
| SBW kg | 27.4 | 29.9 | | | ** | 1.809 | 6.3 |

Table 2.21 Effect of combinations of N and K, N and EFB, and K and EFB in 1997-1999 on Yield (t/ha/yr) (Trial 311).

| | Level of N | | | |
|---|---|---|---|---|
| Level of K | N0 | N1 | N2 | N3 |
| K0 | 17.5 | 25.2 | 29.6 | 31.1 |
| K1 | 18.4 | 21.3 | 30.1 | 34.1 |
| K2 | 16.6 | 29.7 | 27.1 | 32.7 |
| K3 | 18.6 | 28.7 | 31.8 | 30.2 |

| | Level of N | | | |
|---|---|---|---|---|
| Level of EFB | N0 | N1 | N2 | N3 |
| EFB 0 | 13.8 | 22.6 | 27.9 | 31.1 |
| EFB 1 | 21.7 | 29.9 | 31.4 | 32.9 |

GM = 26.4 s.e.d N x K = 3.16 and N x EFB = 2.23

Table 2.22 Effect of combinations of N and K (absence of EFB) and N and EFB (absence of K) in 1997-1999 (Trial 311).

| | Level of N (Absence of EFB) | | | |
|---|---|---|---|---|
| Level of K | N0 | N1 | N2 | N3 |
| K0 | 11.3 | 19.3 | 28.8 | 31.2 |
| K1 | 12.5 | 14.3 | 30.0 | 31.8 |
| K2 | 14.8 | 29.1 | 24.2 | 32.6 |
| K3 | 16.8 | 27.7 | 28.7 | 28.7 |

| | Level of N (Absence of K) | | | |
|---|---|---|---|---|
| Level of EFB | N0 | N1 | N2 | N3 |
| EFB 0 | 11.3 | 19.3 | 28.8 | 31.2 |
| EFB 1 | 23.7 | 31.2 | 30.5 | 31.0 |

Leaflet and rachis tissue analysis results are presented in Tables 2.23 and 2.24 respectively. Ammonium sulphate significantly increased N concentrations (p=0.026) while MoP and EFB significantly increased Cl contents at p<0.001 and p=0.004 respectively.

In the rachis (Table 2.24), SoA significantly increased N (p<0.001) whilst lowering Mg (p=0.008) concentrations. Muriate of potash increased K (p=0.023) and Cl (p=0.002) concentrations while EFB significantly increased N (p=0.003) and P (p=0.011) concentrations.

Table 2.23 Main effects of N, K, and EFB on concentrations of elements in frond 17 leaflet tissue in 1999 (Trial 311).

| | Nutrient & Levels | | | | Statistics | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | GM | Sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | | |
| N | 2.18 | 2.18 | 2.25 | 2.26 | 2.22 | ns | 0.168 | 7.5 |
| P | 0.134 | 0.139 | 0.142 | 0.146 | 0.141 | * | 0.0064 | 4.6 |
| K | 0.66 | 0.69 | 0.66 | 0.68 | 0.67 | ns | 0.041 | 6.1 |
| Ca | 0.69 | 0.68 | 0.68 | 0.66 | 0.68 | ns | 0.075 | 11.1 |
| Mg | 0.16 | 0.15 | 0.13 | 0.13 | 0.14 | ns | 0.025 | 17.6 |
| Cl | 0.42 | 0.45 | 0.45 | 0.48 | 0.45 | ns | 0.044 | 9.9 |
| S | 0.15 | 0.14 | 0.15 | 0.15 | 0.15 | ns | 0.013 | 9.0 |
| | K0 | K1 | K2 | K3 | | | | |
| N | 2.22 | 2.13 | 2.24 | 2.28 | | ns | 0.168 | 7.5 |
| P | 0.142 | 0.139 | 0.140 | 0.141 | | ns | 0.0064 | 4.6 |
| K | 0.69 | 0.66 | 0.64 | 0.69 | | ns | 0.041 | 6.1 |
| Ca | 0.66 | 0.68 | 0.68 | 0.69 | | ns | 0.075 | 11.1 |
| Mg | 0.15 | 0.14 | 0.14 | 0.14 | | ns | 0.025 | 17.6 |
| Cl | 0.31 | 0.47 | 0.49 | 0.52 | | *** | 0.044 | 9.9 |
| S | 0.15 | 0.15 | 0.15 | 0.14 | | ns | 0.013 | 9.0 |
| | EFB0 | EFB1 | | | | | | |
| N | 2.19 | 2.25 | | | | ns | 0.168 | 7.5 |
| P | 0.137 | 0.144 | | | | ns | 0.0064 | 4.6 |
| K | 0.68 | 0.66 | | | | ns | 0.041 | 6.1 |
| Ca | 0.67 | 0.68 | | | | ns | 0.075 | 11.1 |
| Mg | 0.15 | 0.14 | | | | ns | 0.025 | 17.6 |
| Cl | 0.42 | 0.48 | | | | ** | 0.044 | 9.9 |
| S | 0.15 | 0.15 | | | | ns | 0.013 | 9.0 |

Table 2.24 Main effects of N, K, and EFB on concentrations of elements in frond 17 rachis tissue in 1999 (Trial 311).

| | Nutrient & Levels | | | | Statistics | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | GM | sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | | |
| N | 0.24 | 0.27 | 0.32 | 0.32 | 0.29 | *** | 0.018 | 6.3 |
| P | 0.115 | 0.098 | 0.087 | 0.087 | 0.097 | ns | 0.0199 | 20.6 |
| K | 1.50 | 1.63 | 1.69 | 1.40 | 1.56 | ns | 0.24 | 15.4 |
| Ca | 0.38 | 0.41 | 0.42 | 0.38 | 0.40 | ns | 0.038 | 9.5 |
| Mg | 0.07 | 0.06 | 0.05 | 0.05 | 0.06 | ** | 0.0069 | 12.2 |
| Cl | 0.81 | 0.88 | 1.00 | 0.78 | 0.87 | ns | 0.251 | 28.9 |
| S | 0.06 | 0.06 | 0.06 | 0.06 | 0.06 | ns | 0.010 | 16.5 |
| | K0 | K1 | K2 | K3 | | | | |
| N | 0.30 | 0.28 | 0.28 | 0.29 | | ns | 0.018 | 6.3 |
| P | 0.085 | 0.095 | 0.102 | 0.105 | | ns | 0.0199 | 20.6 |
| K | 1.27 | 1.62 | 1.69 | 1.65 | | * | 0.24 | 15.4 |
| Ca | 0.36 | 0.42 | 0.48 | 0.41 | | ns | 0.038 | 9.5 |
| Mg | 0.05 | 0.06 | 0.06 | 0.06 | | ns | 0.0069 | 12.2 |
| Cl | 0.43 | 1.00 | 1.03 | 1.00 | | ** | 0.251 | 28.9 |
| S | 0.06 | 0.06 | 0.06 | 0.06 | | ns | 0.010 | 16.5 |
| | EFB0 | EFB1 | | | | | | |
| N | 0.27 | 0.30 | | | | ** | 0.018 | 6.3 |
| P | 0.085 | 0.108 | | | | * | 0.0199 | 20.6 |
| K | 1.54 | 1.58 | | | | ns | 0.24 | 15.4 |
| Ca | 0.39 | 0.40 | | | | ns | 0.038 | 9.5 |
| Mg | 0.06 | 0.06 | | | | ns | 0.0069 | 12.2 |
| Cl | 0.87 | 0.86 | | | | ns | 0.251 | 28.9 |
| S | 0.06 | 0.06 | | | | ns | 0.010 | 16.5 |

**Trial 312 NITROGEN, POTASSIUM, AND EMPTY FRUIT BUNCH TRIAL AT AMBOGO ESTATE.**

PURPOSE

To test the response to N and K fertilisers, with and without EFB, with a view to using EFB to replace or supplement chemical fertiliser.

DESCRIPTION

Site Ambogo Estate block 80E2

Soil Ambogo family, which is of recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam subsoil, with seasonally high water tables.

Palms Dami commercial DxP crosses. Planted 1980 at 143 palms/ha.

DESIGN

There are 32 plots each with a core of 16 palms. The number and weight of bunches from each individual core palm are recorded at intervals of 14 days. In each plot at least one guard row and a plot isolation trench surround the core palms.

The 32 plots are a single replicate containing 32 treatments made up from all combinations of four levels each of N and K, and two levels each of EFB (Table 2.25). Sulphate of ammonia (SoA) is the source of N, and muriate of potash (MoP) is the source of K. EFB is applied by hand as a mulch between palm circles. The weights of EFB given in Table 34 are the fresh weights ex-mill. When EFB was given for the first time in November 1988 the amount was 333 kg/palm every two years. In September 1990 it was increased to 500 kg/palm, and it is intended to give this amount every two years.

Table 2.25 Amounts of fertiliser and EFB used in 1999 in Trial 312.

| Type of Fertiliser or EFB | Amount (kg/palm/year) | | | |
|---|---|---|---|---|
| | Level 0 | Level 1 | Level 2 | Level 3 |
| SoA | 0.0 | 2.0 | 4.0 | 6.0 |
| MoP | 0.0 | 2.0 | 4.0 | 6.0 |
| | kg/palm/2 years | | | |
| EFB | 0.0 | 500 | | |

Notes: SoA and MoP have been applied twice a year since 1988, and three times a year since 1995. EFB has been applied once every two years.

RESULTS

Yield data for 1999 is presented in Table 2.26. Ammonium sulphate significantly increased yields ($p=0.004$) in 1999. The increase in yield was due to significant increases in bunch numbers ($p=0.013$) and single bunch weight ($p<0.001$). Muriate of potash did not have any significant effect on yield and or yield components. Empty fruit bunch applications significantly increased yield and it’s components. The significant responses to ammonium sulphate and EFB seen in 1999 were similar to responses for 1997-1999 (Table 2.31).

There were no significant interactions for FFB yield and bunch numbers between sulphate of ammonia and EFB treatments however there was a significant interaction ($p<0.001$) for SBW. There is a strong N effect on SBW but only in the presence of EFB. The interaction was also reflected in the FFB yields however statistically these were not significant. Though there were no significant interactions, two–way tables for 1999 are presented in Tables 2.27, 2.28, 2.29 and 2.30 while for 1997-1999 in Tables 2.32, 2.33, 2.34 and 2.35.

A maximum FFB yield of 30.0 t/ha/yr was obtained with 6 kg SoA and 4 kg MoP averaged over all levels of EFB, though a realistic yield of 28.6 t/ha/yr was obtained with 4 kg SoA and 2kg MoP. With SoA and EFB, a maximum yield of 29.8 t/ha/yr was obtained with 4 kg SoA and 500 kg EFB.

Table 2.26 Main effects of N, K and EFB on FFB yield and yield components in 1999 (Trial 312)

| | Nutrient & Levels | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| Yield t/ha | 18.7 | 22.2 | 27.0 | 28.3 | ** | 3.94 | 16.3 |
| BNO /ha | 963 | 926 | 1108 | 1191 | * | 132 | 12.7 |
| SBW kg | 19.4 | 23.9 | 24.4 | 23.9 | *** | 1.087 | 4.8 |
| | K0 | K1 | K2 | K3 | | | |
| Yield t/ha | 22.6 | 25.0 | 25.4 | 23.2 | ns | 3.94 | 16.3 |
| BNO /ha | 978 | 1093 | 1125 | 993 | Ns | 132 | 12.7 |
| SBW kg | 23.0 | 22.6 | 22.7 | 23.2 | Ns | 1.087 | 4.8 |
| | EFB0 | EFB1 | | | | | |
| Yield t/ha | 21.8 | 26.4 | | | * | 3.94 | 16.3 |
| BNO /ha | 976 | 1118 | | | * | 132 | 12.7 |
| SBW kg | 22.2 | 23.5 | | | ** | 1.087 | 4.8 |

Table 2.27 Effect of combinations of N and K, N and EFB on yield in 1999 (Trial 312).

| | Level of N | | | |
|---|---|---|---|---|
| Level of K | N0 | N1 | N2 | N3 |
| K0 | 16.0 | 21.1 | 26.2 | 27.3 |
| K1 | 17.6 | 25.7 | 28.6 | 28.3 |
| K2 | 22.3 | 24.0 | 25.7 | 29.8 |
| K3 | 19.2 | 18.2 | 27.6 | 28.0 |

| | Level of N | | | |
|---|---|---|---|---|
| Level of EFB | N0 | N1 | N2 | N3 |
| EFB 0 | 15.5 | 19.5 | 24.2 | 28.0 |
| EFB 1 | 22.0 | 25.0 | 29.8 | 28.6 |

GM = 24.1, s.e.d N x K = 3.94 and N x EFB = 2.78

Table 2.28 Effect of combinations of N and K, N and EFB on FFB yield in the present/absence of K and EFB in 1999 (Trial 312).

| | Level of N (Absence of EFB) | | | |
|---|---|---|---|---|
| Level of K | N0 | N1 | N2 | N3 |
| K0 | 16.2 | 20.4 | 20.8 | 23.9 |
| K1 | 13.2 | 20.7 | 28.1 | 31.8 |
| K2 | 18.1 | 21.6 | 24.8 | 30.3 |
| K3 | 14.5 | 14.9 | 23.3 | 26.1 |

| | Level of N (Absence of K) | | | |
|---|---|---|---|---|
| Level of EFB | N0 | N1 | N2 | N3 |
| EFB 0 | 16.2 | 20.4 | 20.8 | 23.9 |
| EFB 1 | 15.7 | 21.8 | 31.7 | 30.5 |

Table 2.31 Main effects of N, K, and EFB on FFB yield and yield components in 1997–1999 (Trial 312).

| Nutrient & Levels | | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | Sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| Yield t/ha | 20.2 | 26.2 | 29.9 | 30.9 | *** | 2.35 | 8.8 |
| BNO /ha | 1022 | 1122 | 1238 | 1287 | *** | 84 | 7.2 |
| SBW kg | 19.5 | 23.3 | 24.2 | 24.0 | *** | 0.685 | 3.0 |
| | K0 | K1 | K2 | K3 | | | |
| Yield t/ha | 25.6 | 27.7 | 27.9 | 25.9 | Ns | 2.35 | 8.8 |
| BNO /ha | 1109 | 1224 | 1224 | 1112 | * | 84 | 7.2 |
| SBW kg | 22.8 | 22.4 | 22.7 | 23.1 | Ns | 0.685 | 3.0 |
| | EFB0 | EFB1 | | | | | |
| Yield t/ha | 24.6 | 29.1 | | | *** | 2.35 | 8.8 |
| BNO /ha | 1102 | 1232 | | | ** | 84 | 7.2 |
| SBW kg | 22.0 | 23.6 | | | *** | 0.685 | 3.0 |

Table 2.32 Effects of combinations of N and K, N and EFB and K and EFB on FFB yield in 1997–1999 (Trial 312).

| Level of K | Level of N | | | |
|---|---|---|---|---|
| | N0 | N1 | N2 | N3 |
| K0 | 18.1 | 24.6 | 29.0 | 31.0 |
| K1 | 21.1 | 28.2 | 31.2 | 30.4 |
| K2 | 21.8 | 29.0 | 29.0 | 31.9 |
| K3 | 20.0 | 23.0 | 30.6 | 30.2 |

| Level of EFB | Level of N | | | |
|---|---|---|---|---|
| | N0 | N1 | N2 | N3 |
| EFB 0 | 15.7 | 23.5 | 27.9 | 31.2 |
| EFB 1 | 24.8 | 28.9 | 32.0 | 30.6 |

GM = 26.8, s.e.d N x K = 2.35 and N x EFB = 1.66

Table 2.33 Effect of combinations of N and K and N and EFB on FFB yield in present/absence of K and EFB from 1997 to 1999 (Trial 312).

| Level of K | Level of N (Absence of EFB) | | | |
|---|---|---|---|---|
| | N0 | N1 | N2 | N3 |
| K0 | 14.1 | 21.9 | 26.7 | 29.8 |
| K1 | 14.5 | 24.4 | 31.4 | 32.0 |
| K2 | 19.6 | 27.7 | 25.9 | 32.3 |
| K3 | 14.4 | 20.0 | 27.3 | 30.7 |

| Level of EFB | Level of N (Absence of K) | | | |
|---|---|---|---|---|
| | N0 | N1 | N2 | N3 |
| EFB 0 | 14.1 | 21.9 | 26.7 | 29.8 |
| EFB 1 | 22.0 | 27.2 | 31.2 | 32.1 |

Leaflet and rachis tissue analysis results are presented in Tables 2.36 and 2.37 respectively. In the leaflet tissue, sulphate of ammonia significantly increased N ($p<0.001$), P ($p=0.025$) and Ca ($p=0.014$) whilst lowering Mg concentrations ($p=0.009$). Muriate of potash increased only Ca contents ($p=0.027$). EFB significantly increased N ($p=0.008$), P ($p=0.002$), K ($p=0.004$) and Mg ($p=0.048$).

In the rachis SoA significantly increased N ($p=0.003$) and Cl (0.011) concentrations whilst lowering P ($p<0.001$) levels. Muriate of potash significantly increased P ($p=0.023$), K ($p<0.001$), Ca ($p=0.011$) and Cl ($p<0.001$) levels. EFB also significantly increased the N ($p=0.044$), P ($p<0.001$), K ($p<0.001$), Ca ($p=0.026$) and Cl ($p=0.025$) concentrations.

Table 2.36 Main effects of N, K, and EFB on concentrations of elements in leaflet tissue of frond 17 in 1999 (% of dry matter) (Trial 312).

| | Nutrient & Levels | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| N | 2.14 | 2.19 | 2.11 | 2.17 | ns | 0.041 | 1.9 |
| P | 0.137 | 0.143 | 0.141 | 0.143 | * | 0.0039 | 2.8 |
| K | 0.66 | 0.72 | 0.69 | 0.68 | ns | 0.0063 | 9.2 |
| Ca | 0.77 | 0.69 | 0.62 | 0.61 | ** | 0.061 | 9.1 |
| Mg | 0.19 | 0.15 | 0.13 | 0.13 | ** | 0.022 | 14.7 |
| Cl | 0.44 | 0.45 | 0.48 | 0.47 | ns | 0.032 | 6.9 |
| S | 0.14 | 0.13 | 0.13 | 0.14 | ns | 0.007 | 5.6 |
| | K0 | K1 | K2 | K3 | | | |
| N | 2.11 | 2.19 | 2.20 | 2.12 | ns | 0.041 | 1.9 |
| P | 0.140 | 0.141 | 0.140 | 0.143 | ns | 0.0039 | 2.8 |
| K | 0.71 | 0.69 | 0.66 | 0.70 | ns | 0.0063 | 9.2 |
| Ca | 0.63 | 0.69 | 0.69 | 0.68 | ns | 0.061 | 9.1 |
| Mg | 0.15 | 0.16 | 0.15 | 0.14 | ns | 0.022 | 14.7 |
| Cl | 0.36 | 0.50 | 0.49 | 0.49 | *** | 0.032 | 6.9 |
| S | 0.14 | 0.13 | 0.13 | 0.14 | ns | 0.007 | 5.6 |
| | EFB0 | EFB1 | | | | | |
| N | 2.10 | 2.21 | | | * | 0.041 | 1.9 |
| P | 0.138 | 0.143 | | | ** | 0.0039 | 2.8 |
| K | 0.67 | 0.70 | | | ns | 0.0063 | 9.2 |
| Ca | 0.68 | 0.66 | | | ns | 0.061 | 9.1 |
| Mg | 0.15 | 0.15 | | | ns | 0.022 | 14.7 |
| Cl | 0.44 | 0.48 | | | * | 0.032 | 6.9 |
| S | 0.14 | 0.13 | | | ns | 0.007 | 5.6 |

Table 2.37 Main effects of N, K, and EFB on concentrations of elements in the rachis in 1999 (% of dry matter) (Trial 312).

| Nutrient & Levels | | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| N | 0.27 | 0.29 | 0.30 | 0.33 | *** | 0.012 | 4.0 |
| P | 0.217 | 0.178 | 0.134 | 0.121 | *** | 0.0156 | 9.6 |
| K | 1.67 | 1.66 | 1.73 | 1.63 | ns | 0.164 | 9.8 |
| Ca | 0.40 | 0.39 | 0.36 | 0.37 | ns | 0.041 | 10.8 |
| Mg | 0.06 | 0.06 | 0.05 | 0.05 | * | 0.0061 | 11.4 |
| Cl | 0.78 | 0.86 | 0.92 | 0.98 | ** | 0.073 | 8.3 |
| S | 0.05 | 0.05 | 0.05 | 0.06 | ns | 0.009 | 18.0 |
| | K0 | K1 | K2 | K3 | | | |
| N | 0.30 | 0.30 | 0.29 | 0.29 | ns | 0.012 | 4.0 |
| P | 0.153 | 0.161 | 0.172 | 0.165 | ns | 0.0156 | 9.6 |
| K | 1.50 | 1.71 | 1.72 | 1.76 | ns | 0.164 | 9.8 |
| Ca | 0.34 | 0.40 | 0.40 | 0.39 | * | 0.041 | 10.8 |
| Mg | 0.05 | 0.05 | 0.05 | 0.05 | ns | 0.0061 | 11.4 |
| Cl | 0.47 | 0.96 | 1.05 | 1.05 | *** | 0.073 | 8.3 |
| S | 0.05 | 0.06 | 0.05 | 0.05 | ns | 0.009 | 18.0 |
| | EFB0 | EFB1 | | | | | |
| N | 0.28 | 0.31 | | | *** | 0.012 | 4.0 |
| P | 0.17 | 0.15 | | | ** | 0.0156 | 9.6 |
| K | 1.56 | 1.79 | | | ** | 0.164 | 9.8 |
| Ca | 0.40 | 0.36 | | | * | 0.041 | 10.8 |
| Mg | 0.06 | 0.05 | | | ** | 0.0061 | 11.4 |
| Cl | 0.82 | 0.95 | | | ** | 0.073 | 8.3 |
| S | 0.05 | 0.06 | | | ns | 0.009 | 18.0 |

**Trial 324 SOURCES OF NITROGEN TRIAL ON HIGATURU SOILS – SANGARA ESTATE.**

PURPOSE

To investigate the relative effectiveness of different nitrogen fertilisers on Higaturu Soils.

DESCRIPTION

Site Sangara Estate Blocks 2 and 3.

Soil Higaturu family; Deep sandy clay loam with good drainage, derived from volcanic ash.

Palms Dami commercial DxP crosses planted in 1996 (as replants) at 135 palms per hectare.

Trial to begin in January 2001.

DESIGN

The N sources to be tested are Sulphate of Ammonia, Ammonium Chloride, Ammonium Nitrate, Urea and Diammonium Phosphate.
The design is similar to Trial 125 at Kumbango (WNBP). Five N sources will be tested at 3 different rates of equivalent N contents and in 4 replicates. There will therefore be 15 treatments per replicate. A total of 60 plots will be used in this experiment. There will also be 4 zero fertiliser plots at the edge of the trial but data collected from these plots will not be used for ANOVA. Each of the plots will consist of 36 palms; 20 of which will be guard rows and central 16 will be the palms from which data recording will be collected. Fertiliser treatments are shown in Table 2.38.

Table 2.38 Sources of Nitrogen Trial - Treatments and Levels (Trial 324).

| N Source | Level (kg/palm/yr) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| SoA (21% N) | 2.0 | 4.0 | 8.0 |
| AmC (26 % N) | 1.6 | 3.2 | 6.4 |
| Urea (46% N) | 0.9 | 1.8 | 3.6 |
| Amm. Nitrate (35% N) | 1.2 | 2.4 | 4.8 |
| DAP (18 % N) | 2.3 | 4.6 | 9.2 |
| g N /palm/yr | 420 | 840 | 1680 |

RESULTS

Trial to begin in January 2001.

**Trial 325 SOURCES OF NITROGEN TRIAL ON AMBOGO / PENDERETTA SOILS (OUTWASH PLAINS) – AMBOGO ESTATE.**

## PURPOSE

To investigate the relative effectiveness of different nitrogen fertilisers on Ambogo / Penderetta soils.

## DESCRIPTION

Site Ambogo Estate

Soil Ambogo family, which is of recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam subsoil, with seasonally high water tables.

Penderetta family. Thin dark sandy loam topsoil over sandy loam subsoil derived from alluvially deposited volcanic ash. Mottling due to seasonally high water tables.

Palms Dami commercial DxP crosses to be planted (as replants) in 2001/2002 at 135 palms per hectare.

Trial to begin 36–48 months after planting.

## DESIGN

Nitrogen fertilisers to be tested are Sulphate of Ammonia, Ammonium Chloride, Ammonium Nitrate, Urea and Diammonium Phosphate.

The design is similar to Trial 125 at Kumbango (WNBP). Five N sources will be tested at 3 different rates of equivalent N contents and in 4 replicates. There will therefore be 15 treatments per replicate. A total of 60 plots will be used in this experiment. There will be 4 zero fertiliser plots at the edge of the trial, but data collected from these plots will not be used for ANOVA. Each of the plots will consist of 36 palms; 20 of which will be guard rows and central 16 will be the palms from which data recording will be collected. Fertiliser treatments are shown in Table 2.39.

Table 2.39 Sources of Nitrogen Trial - Treatments and Levels (Trial 325).

| N Source | Level (kg/plm/yr) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| SoA (21% N) | 2.0 | 4.0 | 8.0 |
| AmC (26 % N) | 1.6 | 3.2 | 6.4 |
| Urea (46% N) | 0.9 | 1.8 | 3.6 |
| Amm. Nitrate (35% N) | 1.2 | 2.4 | 4.8 |
| DAP (18 % N) | 2.3 | 4.6 | 9.2 |
| g N /plm/yr | 420 | 840 | 1680 |

## RESULTS

Trial to begin in 2004.

**Trial 326 FERTILISER NITROGEN X EMPTY FRUIT BUNCH TRIAL ON HIGATURU SOILS – SANGARA ESTATE.**

## PURPOSE

To develop recommendations for a minimum EFB application rate as part of a general fertiliser input regime.

## DESCRIPTION

Site Sangara Estate

Soil Higaturu family; Deep sandy clay loam with good drainage, derived from volcanic ash.

Palms Dami commercial DxP crosses planted in 1998/1999 (as replants) at 135 palms per hectare.

Trial to begin in 2002.

## DESIGN

It is proposed to have 4 levels of N (SoA) and 3 of EFB in factorial combinations in 5 Blocks (RCBD) (Table 2.40). The trial will consist of 60 plots. Each plot will have 36 palms; 20 of the palms will provide the guard row while recordings will be conducted in the 16 core palms. The plots will also be surrounded by a trench to prevent inter plot poaching of nutrients. EFB treatments will be applied once a year.

Table 2.40 NxEFB Trial - Treatments and Levels (Trial 326).

| Treatment | Levels (kg/plm/yr) | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| SoA | 0 | 2.5 | 5.0 | 7.5 |
| EFB | 0 | 130 | 390 | - |

## RESULTS

Trial to begin in 2002.

## Trial 327 NITROGEN FERTILISER X EMPTY FRUIT BUNCH TRIAL ON AMBOGO / PENDERETTA SOILS (OUTWASH PLAINS) – AMBOGO ESTATE

### PURPOSE

To develop recommendations for a minimum EFB application rate as part of a general fertiliser input regime.

### DESCRIPTION

Site: Ambogo Estate

Soil: Ambogo family, which is of recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam subsoil, with seasonally high water tables.

Penderetta family. Thin dark sandy loam topsoil over sandy loam subsoil derived from alluvially deposited volcanic ash. Mottling due to seasonally high water tables.

Palms: Dami commercial DxP crosses to be planted in 2001/2002 (as replants) at 135 palms per hectare.

Trial to begin 36 – 48 months after planting.

### DESIGN

It is proposed to have 4 levels of N (SoA) and 3 of EFB in factorial combinations in 5 Blocks (RCBD) (Table 2.41). The trial will consist of 60 plots. Each plot will have 36 palms; 20 of the palms will provide the guard row while recordings will be conducted in the 16 core palms. The plots will also be surrounded by a trench to prevent inter plot poaching of nutrients. EFB treatments will be applied once a year.

Table 2.41 NxEFB Trial - Treatments and Levels (Trial 327).

| Treatment | Levels (kg/plm/yr) | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| SoA | 0 | 2.5 | 5.0 | 7.5 |
| EFB | 0 | 130 | 390 | - |

### RESULTS

Trial to begin in 2004.

**Trial 328 NITROGEN, PHOSPHORUS AND MAGNESIUM FERTILISER TRIAL ON OHITA SOILS – SUMBIRIPA ESTATE.**

PURPOSE

To provide information for fertiliser recommendations to both estate and smallholders on the Ohita Soil Family.

DESCRIPTION

Site Sumbiripa Estate

Soil Ohita family; Soils are formed from several shallow recently deposited volcanic ash falls overlying older alluvial surface and are found on the lower terraces. Many of the lower terraces are also mixed with alluvial materials from the Higaturu Soils Family. The topsoil is moderately to strongly developed structure and has high permeability and excellent physical properties.

Palms Dami commercial DxP crosses to be planted (as replants) at 135 palms per hectare.

Trial to begin 36 – 48 months after planting.

DESIGN

It is proposed to use a 3 x 3 x 3 (N, P & Mg) factorial Randomised Complete Block Design. MoP will be applied as a basal application. There will be 3 replicate blocks of 27 plots each, totalling 81 plots. Each plot will have 36 palms; 20 of the palms will provide the guard row while recording will be conducted in the 16 core palms. A trench to prevent inter-plot poaching of nutrients will also surround the plots.

Table 2.42 Trial 328 - Fertiliser Treatments and Levels.

| Fertiliser | Levels (kg/palm/yr) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| SoA (N) | 2.0 | 4.0 | 6.0 |
| TSP (P) | 0 | 2.0 | 4.0 |
| Kieserite (Mg) | 0 | 2.0 | 4.0 |

RESULTS

Trial to be initiated.

**Trial 329 NITROGEN, PHOSPHORUS, POTASSIUM AND MAGNESIUM FACTORIAL FERTILISER TRIAL ON MAMBA SOILS – MAMBA ESTATE.**

PURPOSE

To provide information for fertiliser recommendations to both estate and smallholders in the Kokoda Valley and Ilimo/Papaki Areas.

DESCRIPTION

Site Mamba Estate Blocks 97 G1 and 97 G2.

Soil Dark sandy loam airfall ash overlying coarse to medium textured alluvial materials from the Owen Stanley mountain range.

Palms Dami commercial DxP crosses were planted from old cocoa plantations at 135 palms per hectare in 1997.

Trial to begin in 2001.

DESIGN

It is proposed to use a 2x3x3x3 (N, P, K and Mg) confounded factorial design of a single replicate with 3 blocks of 18 plots each. There will be a total of 54 plots. Each plot will have 36 palms; 20 of the palms will provide the guard row while recordings will be conducted in the 16 core palms. A trench to prevent inter-plot poaching of nutrients will surround the plots.

Table 2.43 Trial 329 - Fertiliser Treatments and Levels.

| Fertiliser | Levels (kg/palm/yr) | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| SoA (N) | 2.0 | 4.0 | - |
| TSP (P) | 0.0 | 2.0 | 4.0 |
| MoP (K) | 0.0 | 2.0 | 4.0 |
| Kieserite (Mg) | 0.0 | 2.0 | 4.0 |

RESULTS

Trial to begin in 2001.

## Trial 330 GRASSLAND SULPHUR TRIAL ON OUTWASH PLAINS AT PARAHE MINI-ESTATE.

### PURPOSE

To provide information for fertiliser recommendations to the estate, mini estates and smallholder growers in the grassland areas of Popondetta.

### DESCRIPTION

Site Parahe Mini-Estate

Soil Soils at the grassland area are formed from alluvial volcanic materials. The black top soils are loamy sand to sandy loam and over lay more sandier materials at the subsurface.

Palms Dami commercial DxP crosses were planted at 135 palms per hectare in 2000.

Trial to begin in 2002.

### DESIGN

It is proposed to have a 4x3 (Urea x Sulphur) factorial fertiliser trial using randomised complete blocks. Each plot will have 64 palms; 48 of the palms will provide double guard rows while recordings will be conducted in the 16 core palms. It is thought there will be no need for trenches to prevent inter-plot poaching of nutrients

There is no zero N treatment because it was felt landowners may not want very low cropping palms in the mini estates. Also it is already known that in Popondetta soils crop yield can be extremely low (<10 t/ha/yr) in plots not receiving nitrogen fertilisers.

Table 2.44 Treatments for Grassland Sulphur and Nitrogen Fertiliser Trial (Trial 330).

| Fertiliser | Levels (kg/palm/yr) | | | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| Elemental Sulphur (S) | 0 | 0.150 | 0.300 | |
| Urea (N) | 0.5 | 1.5 | 2.5 | 3.5 |

### RESULTS

Trial to begin in 2002.

## Trial 331 OIL PALM SPACING AND THINNING FOR MECHANICAL INFIELD COLLECTION TRIAL (HIGATURU)

### PURPOSE

To investigate the possibilities of field planting requirements, and how best to make use of increased inter-row spacing to facilitate for mechanical infield collection.

### DESCRIPTION

Site Ambogo Estate.

Soil Ambogo family, which is of recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam subsoil, with seasonally high water tables.

Penderetta family. Thin dark sandy loam topsoil over sandy loam subsoil derived from alluvially deposited volcanic ash. Mottling due to seasonally high water tables.

Palms Dami commercial DxP crosses to be planted (as replants) in 2001/2002 at 135 palms per hectare.

Trial to start in 36–48 months after planting.

### DESIGN

Dr. R.H.V. Corley proposed this design. It is assumed that the mature optimal density for Dami DxP planting material is about 128 palms/ha. For all avenue plantings, there will be a pattern of two rows in a normal equilateral triangular pattern, with a wide avenue interline before the next pair of rows. Two ways of achieving 14 m avenues are compared, one with close planting within the rows, and one with a lower than optimal density. A treatment with narrower avenues is also included. The standard triangular planting at 128 palms/ha will be used as a control. Two thinning treatments are also incorporated where palms are planted at 167.6 palms/ha and later thinned by 33% in avenues to 111.8 and 189.8 thinned to 126.6 palms/ha. The main aim of the trial is to find out how best to provide mechanisation avenues; responses to thinning are less important so un-thinned controls at the original densities would not be necessary. Standard triangular spaced controls at 128/ha are essential, though, to compare with avenue planting.

Table 2.45 Oil Palm Spacing and Thinning Trial Treatments (Trial 331).

| Pattern | Spacing (m) | Palms/ha | Avenue Interline (m) |
|---|---|---|---|
| Triangular, high | 9 x 9 x 9 | 142.6 | - |
| Triangular, low | 9.5 x 9.5 x 9.5 | 127.9 | - |
| Triangular, very low | 10.2 x10.2 x 10.2 | 111.0 | - |
| Avenues | 8.3 x 8.3 x 8.3 x 2 rows | 126.9 | 11.8 |
| Avenues, low density | 8.3 x 8.3 x 8.3 x 2 rows | 111.8 | 14.4 |
| Wide avenues | 7.5 x 7.5 x 7.5 x 2 rows | 127.6 | 14.4 |

Table 2.46 Trial 331 - Thinning Treatments.

| Density at Planting | Spacing (m) | Density after thinning by 33% |
|---|---|---|
| 167.6 | 8.3 x 8.3 x 8.3 | 111.8 |
| 189.8 | 7.8 x 7.8 x 7.8 | 126.6 |

There will be 8 treatments of 3 replicates each totalling 24 plots. Each plot will be of 2 ha each therefore total of 48 ha will be used. Each replicate will be in a separate field, however the 3 fields will be adjacent to each other. Within each plot there will be 4 - 6 subplots of each of which will contain different cover crops randomly allocated and planted across the main plot.

## RESULTS

Trial to be initiated in 2001/2002.

## Trial 502B FERTILISER TRIAL AT WAIGANI ESTATE

### PURPOSE

To investigate the response to N, P and K in factorial combination, with and without EFB, with a view to using EFB to replace or supplement inorganic fertiliser.

### DESCRIPTION

Site Waigani Estate, Fields 6503 and 6504.

Soil Plantation family, which is of recent alluvial origin.

Site Dami commercial DxP crosses. Planted 1986 at 127 palms/ha.
Trial started in 1994.

### DESIGN

Trial 502B relocation is a single replicate split into four blocks, each comprising factorial applications of 4x4x2x2 N, P, K and EFB treatments. There are 64 plots each containing 16 core palms. The numbers and weights of bunches of each individual core palm are recorded at intervals of 14 days. In each plot one guard row and a plot isolation trench surround the core palms.

The 64 treatments are made up from all combinations of four levels of N and K, and two levels each of TSP and EFB (Table 2.47). EFB is applied by hand as mulch between palm circles.

Table 2.47 Amount of fertiliser and EFB used in 1999 (Trial 502b).

| Type of Fertiliser or EFB | Amounts (kg/plm/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 | | |

Trenching was completed in 1995, and the first dose of fertiliser was applied in the fourth quarter of 1994. Applications of EFB started in August 1995.

### RESULTS

FFB yield results for 1999 are presented in Table 2.48. The average plot yield in 1999 was 23.4 t/ha/yr, an increase of 6.5 t/ha/yr from the 16.9 t/ha in 1998. Crop production has recovered from the low levels experienced in 1998.

Ammonium sulphate significantly increased FFB yield ($p=0.009$) and SBW ($p=0.021$) but did not have any effect on bunch numbers. Muriate of potash caused a slight increase in yield while EFB significantly increased SBW ($p=0.002$) and FFB yield ($p<0.001$). EFB increased the number of bunches however this effect was statistically not significant. TSP application did not affect yield or yield components. Similar responses are reported for 1997–1999 (Table 2.51).

In 1999 a statistically significant interaction ($p = 0.046$) between the N and K treatments was seen for the first time (Tables 2.49). Yield responses to high N levels are only seen in the presence of K with an optimum combination between 2 and 4 kg SoA and 2.5 and 5 kg MoP. Results for N and EFB combinations are also presented in Table 2.50 though the interactions were not statistically significant.

With N & EFB in 1999 and 1997-1999, high yields are only seen in the presence of EFB (Tables 2.50 and 2.53).

Table 2.48 Main effects of N, P, K, and Mg on yield and yield components in 1999 (Trial 502b).

| | Nutrient & Levels | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| Yield t/ha | 22.0 | 23.7 | 23.7 | 24.4 | ** | 1.525 | 6.5 |
| BNO /ha | 912 | 917 | 934 | 972 | ns | 69 | 7.4 |
| SBW kg | 24.1 | 25.8 | 25.4 | 25.1 | * | 1.274 | 5.1 |
| | P0 | P1 | | | | | |
| Yield t/ha | 23.4 | 23.5 | | | ns | 1.525 | 6.5 |
| BNO /ha | 925 | 943 | | | ns | 69 | 7.4 |
| SBW kg | 25.3 | 24.9 | | | ns | 1.274 | 5.1 |
| | K0 | K1 | K2 | K3 | | | |
| Yield t/ha | 22.1 | 24.0 | 23.7 | 23.9 | * | 1.525 | 6.5 |
| BNO /ha | 903 | 952 | 941 | 939 | Ns | 69 | 7.4 |
| SBW kg | 24.5 | 25.2 | 25.2 | 25.5 | Ns | 1.274 | 5.1 |
| | EFB0 | EFB1 | | | | | |
| Yield t/ha | 22.4 | 24.5 | | | *** | 1.525 | 6.5 |
| BNO /ha | 915 | 952 | | | Ns | 69 | 7.4 |
| SBW kg | 24.4 | 25.8 | | | ** | 1.274 | 5.1 |

Table 2.49 Effects of combinations of N and K fertilisers in 1999 (Trial 502b).

| Level of K | Level of N | | | |
|---|---|---|---|---|
| | N0 | N1 | N2 | N3 |
| K0 | 20.7 | 23.0 | 23.5 | 21.4 |
| K1 | 21.2 | 26.0 | 23.3 | 25.4 |
| K2 | 22.6 | 22.2 | 24.8 | 25.2 |
| K3 | 23.4 | 23.6 | 23.1 | 25.6 |

GM = 23.4, s.e.d = 1.08

Table 2.50 Effects of combinations of N and EFB fertilisers in 1999 (Trial 502b).

| Level of EFB | Level of N | | | |
|---|---|---|---|---|
| | N0 | N1 | N2 | N3 |
| EFB0 | 19.9 | 22.8 | 22.8 | 24.0 |
| EFB1 | 24.0 | 24.6 | 24.6 | 24.8 |

GM = 23.4, s.e.d = 0.76

Table 2.51 Main effects of N, P, K and EFB on FFB yield and yield components in 1997-1999 (Trial 502b).

| | Nutrient & Levels | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | Sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| Yield t/ha | 20.9 | 22.5 | 22.8 | 22.5 | * | 1.667 | 7.5 |
| BNO /ha | 988 | 987 | 1010 | 993 | Ns | 84 | 8.4 |
| SBW kg | 21.3 | 23.0 | 22.7 | 22.8 | *** | 0.865 | 3.9 |
| | P0 | P1 | | | | | |
| Yield t/ha | 22.4 | 22.0 | | | Ns | 1.667 | 7.5 |
| BNO /ha | 992 | 997 | | | Ns | 84 | 8.4 |
| SBW kg | 22.7 | 22.2 | | | * | 0.865 | 3.9 |
| | K0 | K1 | K2 | K3 | | | |
| Yield t/ha | 21.0 | 21.9 | 22.5 | 23.2 | * | 1.667 | 7.5 |
| BNO /ha | 962 | 976 | 1006 | 1033 | Ns | 84 | 8.4 |
| SBW kg | 21.9 | 22.6 | 22.5 | 22.7 | Ns | 0.865 | 3.9 |
| | EFB0 | EFB1 | | | | | |
| Yield t/ha | 21.4 | 23.0 | | | ** | 1.667 | 7.5 |
| BNO /ha | 979 | 1010 | | | Ns | 84 | 8.4 |
| SBW kg | 22.0 | 22.9 | | | ** | 0.865 | 3.9 |

Table 2.52 Effects of combinations of N and K fertilisers in 1997 – 1999 (Trial 502b).

| Level of K | Level of N | | | |
|---|---|---|---|---|
| | N0 | N1 | N2 | N3 |
| K0 | 19.7 | 21.8 | 22.2 | 20.3 |
| K1 | 20.2 | 23.1 | 21.6 | 22.8 |
| K2 | 20.9 | 22.0 | 23.4 | 23.7 |
| K3 | 22.9 | 23.0 | 23.9 | 23.3 |

Gm = 22.2 s.e.d = 2.67

Table 2.53 Effects of combinations of N and EFB fertilisers in 1997–1999 (Trial 502b).

| Level of EFB | Level of N | | | |
|---|---|---|---|---|
| | N0 | N1 | N2 | N3 |
| EFB0 | 20.0 | 21.5 | 22.0 | 21.9 |
| EFB1 | 21.9 | 23.4 | 23.5 | 23.1 |

GM = 23.4, s.e.d = 1.89

## Trial 504 MATURE PHASE FERTILISER TRIAL AT SAGARAI ESTATE

### PURPOSE

To investigate the response to N and K with an allowance made for one additional treatment in Sagarai Estate, Milne Bay Province.

### DESCRIPTION

Site Sagarai Estate, Field 0610, 0611 and 0612.

Soil Tomanau family, which is of recent alluvial origin, with deep clay loam soils and reasonable drainage status. This is a predominant soil family on the Sagarai Estate.

Palm Special Dami DxP crosses of 16 progenies that were randomised within each plot. The palms were planted in January 1991 at 127 palms/ha. Trial started in 1994.

### DESIGN

There are 64 plots, each with a core of 16 palms. The numbers and weights of bunches from each individual core palm are recorded at intervals of 14 days. In each plot a guard row and a plot isolation trench surround the core palms.

The 64 plots are divided into two replicates of 32 plots each. In each replicate there are 32 treatments, made up from all combinations of four levels each of N and K, and two levels of an additional treatment, which is currently vacant (Table 2.54).

Table 2.54 Types of treatment fertiliser and rates used in Trial 504.

| Type of Fertiliser | Amounts (kg/palm/year) and Levels | | | |
|---|---|---|---|---|
| | 0 | 1 | 2 | 3 |
| Sulphate of Ammonia | 0.0 | 2.0 | 4.0 | 6.0 |
| Muriate of Potash | 0.0 | 2.5 | 5.0 | 7.5 |
| ? | ? | ? | ? | ? |

### RESULTS

Yield results for 1999 and 1997–1999 are presented in Tables 2.55 and 2.57 respectively. In 1999 and in 1997-1999 there were no significant responses to application of ammonium sulphate. Muriate of potash significantly increased FFB yield both in 1999 ($p=0.009$) and for 1997–1999 ($p < 0.001$) up to level K2 (5.0 kg/palm) but not higher. The average mean yield for all the plots in 1999 was 21.0 t/ha/yr, an increase of 2 tonnes from the 19.4 t/ha/yr seen in 1998.

Table 2.55 Main effects of N and K on yield and yield components in 1999 (Trial 504).

| | Nutrient & Levels | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| Yield t/ha | 20.0 | 22.4 | 20.5 | 21.3 | ns | 2.74 | 13.0 |
| BNO /ha | 1101 | 1229 | 1116 | 1153 | ns | 161 | 14.0 |
| SBW kg | 18.7 | 18.7 | 19.1 | 19.2 | ns | 1.054 | 5.6 |
| | K0 | K1 | K2 | K3 | | | |
| Yield t/ha | 19.3 | 20.5 | 22.5 | 21.9 | ** | 2.74 | 13.0 |
| BNO /ha | 1090 | 1114 | 1221 | 1174 | Ns | 161 | 14.0 |
| SBW kg | 18.5 | 19.1 | 19.1 | 19.2 | ns | 1.054 | 5.6 |

Table 2.56 Effect of N and K combinations on Yield in 1999 (Trial 504).

| | Level of N | | | |
|---|---|---|---|---|
| Level of K | N0 | N1 | N2 | N3 |
| K0 | 18.1 | 17.4 | 20.0 | 21.7 |
| K1 | 17.8 | 22.8 | 20.0 | 21.4 |
| K2 | 22.5 | 24.6 | 21.3 | 21.5 |
| K3 | 21.5 | 24.8 | 20.7 | 20.4 |

GM = 21.0, s.e.d = 1.94

Table 2.57 Main effects of N and K on yield and yield components in 1997-1999 (Trial 504).

| | Nutrient & Levels | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| Yield t/ha | 23.9 | 25.1 | 24.4 | 24.5 | ns | 1.457 | 5.9 |
| BNO /ha | 1726 | 1748 | 1735 | 1724 | ns | 109 | 6.3 |
| SBW kg | 14.8 | 15.2 | 15.0 | 15.2 | ns | 0.692 | 4.6 |
| | K0 | K1 | K2 | K3 | | | |
| Yield t/ha | 23.4 | 24.2 | 25.6 | 24.8 | *** | 1.457 | 5.9 |
| BNO /ha | 1715 | 1737 | 1756 | 1726 | ns | 109 | 6.3 |
| SBW kg | 14.6 | 15.0 | 15.3 | 15.2 | * | 0.692 | 4.6 |

Table 2.58 Effect of N and K combinations on Yield in 1997 - 1999 (Trial 504).

| | Level of N | | | |
|---|---|---|---|---|
| Level of K | N0 | N1 | N2 | N3 |
| K0 | 22.0 | 22.7 | 23.7 | 25.2 |
| K1 | 23.6 | 24.9 | 24.3 | 24.2 |
| K2 | 25.9 | 26.3 | 25.2 | 24.9 |
| K3 | 24.3 | 26.7 | 24.5 | 23.7 |

GM = 24.5, s.e.d = 1.03

**Trial 511** **FERTILISER TRIAL ON INTERFLUVE TERRACES SOILS AT WAIGANI ESTATE.**

PURPOSE

To investigate the response of oil palm to applications of ammonium sulphate, Triple Superphosphate, muriate of potash and empty fruit bunch on interfluve terrace soils.

DESCRIPTIONS

Site: Waigani estate, Field 8501 and 8502.

Soil: Hagita family; texture contrast soils with very slowly permeable clay to heavy clay subsoil and very gravelly loam topsoil. Gravel maybe cemented into massive blocks of laterite. Soil dominantly poorly drained. Although these soils are dominantly poorly drained, somewhat imperfectly drained variants with olive grey subsoil have been included into this family. Mostly on gently sloping terraces, but also found on spur crest of hilly terrain.

Palms: Dami commercial DxP crosses. Planted in 1988 at 127 palms/ha. Trial started in 1994.

DESIGN

There are 64 plots each containing 16 core palms. The numbers and weight of bunches for each individual core palm is recorded at intervals of 14 days. In each plot a guard row and a plot isolation trench surround the core palms.

The 64 plots represent a single replicate split into four blocks. The treatments are made up from all combinations of four levels each of N and K and two levels each of P and EFB (Table 2.59). EFB is applied by hand as mulch between palm circles.

Table 2.59 Amounts of fertiliser and EFB used in Trial 511.

| Type of Fertiliser or EFB | Amounts (kg/plm/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 | | |

RESULTS

FFB yield results for 1999 are presented in Table 2.60. The mean plot yield in 1999 was 16.9 t, an increase of 2.0 t FFB/ha/year compared to 1998. Ammonium sulphate application significantly increased FFB yield ($p=0.003$) and single bunch weight ($p=0.005$), both with a strong linear component ($p<0.001$). Triple Superphosphate also significantly increased FFB yield ($p=0.008$) and single bunch weight ($p=0.030$). Muriate of potash did not have an effect on yield and yield components while EFB significantly increased yield ($p<0.001$), bunch numbers ($p=0.013$) and single bunch weight ($p=0.025$). Similar results are seen for mean accumulated yield data for 1997–1999 (Table 2.65).

There was a significant interaction in 1999 between SoA and TSP on FFB yield ($p=0.034$). It appears there was a strong response to SoA however this response was strongly influenced by TSP fertiliser application (Table 2.61). A similar interaction is seen between SoA and EFB though this is statistically not significant. In plots not receiving either TSP or EFB similar results are seen (Tables 2.62, 2.64, 2.67 and 2.69).

Table 2.60 Main effect of N, P, K, and EFB on yield and yield components in 1999 (Trial 511).

| | Nutrient & Levels | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | | | | | sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| Yield t/ha | 15.0 | 16.4 | 16.9 | 19.1 | ** | 2.104 | 12.5 |
| BNO /ha | 841 | 764 | 757 | 847 | Ns | 118 | 14.7 |
| SBW kg | 17.9 | 21.4 | 22.3 | 22.5 | ** | 2.876 | 13.7 |
| | P0 | P1 | | | | | |
| Yield t/ha | 16.0 | 17.8 | | | ** | 2.104 | 12.5 |
| BNO /ha | 792 | 813 | | | Ns | 118 | 14.7 |
| SBW kg | 20.1 | 22.0 | | | * | 2.876 | 13.7 |
| | K0 | K1 | K2 | K3 | | | |
| Yield t/ha | 16.7 | 16.4 | 16.4 | 18.0 | Ns | 2.104 | 12.5 |
| BNO /ha | 796 | 788 | 789 | 837 | Ns | 118 | 14.7 |
| SBW kg | 21.2 | 20.6 | 20.7 | 21.5 | Ns | 2.876 | 13.7 |
| | EFB0 | EFB1 | | | | | |
| Yield t/ha | 15.2 | 18.5 | | | *** | 2.104 | 12.5 |
| BNO /ha | 757 | 848 | | | * | 118 | 14.7 |
| SBW kg | 20.1 | 22.0 | | | * | 2.876 | 13.7 |

Table 2.61 SoA X TSP Yield Two-way Tables 1999 (Trial 511).

| | Level of N | | | |
|---|---|---|---|---|
| Level of P | N0 | N1 | N2 | N3 |
| P0 | 15.5 | 15.1 | 14.8 | 18.5 |
| P1 | 14.6 | 17.8 | 19.0 | 19.7 |

GM = 16.9, s.e.d = 1.05 Interaction at p = 0.034

Table 2.62 SoA X TSP Yield Two-way Tables 1999 (Absence of EFB) (Trial 511).

| | Level of N | | | |
|---|---|---|---|---|
| Level of P | N0 | N1 | N2 | N3 |
| P0 | 12.9 | 13.0 | 12.3 | 17.1 |
| P1 | 13.7 | 16.0 | 19.3 | 17.6 |

GM = 16.9, s.e.d = 1.49

Table 2.63 SoA X EFB Yield Two-way Tables 1999 (Trial 511).

| | Level of N | | | |
|---|---|---|---|---|
| Level of EFB | N0 | N1 | N2 | N3 |
| EFB0 | 13.3 | 14.3 | 15.8 | 17.4 |
| EFB1 | 16.8 | 18.6 | 18.0 | 20.8 |

GM = 16.9, s.e.d = 1.05

Table 2.64 SoA X EFB Yield Two-way Tables 1999 (Absence of TSP) (Trial 511).

| | Level of N | | | |
|---|---|---|---|---|
| Level of EFB | N0 | N1 | N2 | N3 |
| EFB0 | 12.9 | 13.0 | 12.3 | 17.1 |
| EFB1 | 18.1 | 17.2 | 17.3 | 19.9 |

GM = 16.9, s.e.d = 1.49

Table 2.65 Main effects on N, P, K and EFB on FFB yield and yield components in 1997-1999 (Trial 511).

| | | | | | Statiatics | | |
|---|---|---|---|---|---|---|---|
| | Nutrient & Levels | | | | Sig | SE | CV% |
| | N0 | N1 | N2 | N3 | | | |
| Yield t/ha | 13.3 | 16.1 | 17.7 | 19.6 | *** | 1.879 | 11.3 |
| BNO /ha | 849 | 894 | 932 | 1009 | * | 132 | 14.4 |
| SBW kg | 15.7 | 18.2 | 19.2 | 19.7 | *** | 1.945 | 10.7 |
| | P0 | P1 | | | | | |
| Yield t/ha | 15.7 | 17.7 | | | ** | 1.879 | 11.3 |
| BNO /ha | 896 | 946 | | | Ns | 132 | 14.4 |
| SBW kg | 17.6 | 18.9 | | | * | 1.945 | 10.7 |
| | K0 | K1 | K2 | K3 | | | |
| Yield t/ha | 16.2 | 16.3 | 16.8 | 17.3 | Ns | 1.879 | 11.3 |
| BNO /ha | 894 | 924 | 931 | 935 | Ns | 132 | 14.4 |
| SBW kg | 18.3 | 17.8 | 18.2 | 18.6 | Ns | 1.945 | 10.7 |
| | EFB0 | EFB1 | | | | | |
| Yield t/ha | 15.3 | 18.0 | | | *** | 1.879 | 11.3 |
| BNO /ha | 882 | 960 | | | * | 132 | 14.4 |
| SBW kg | 17.5 | 18.9 | | | * | 1.945 | 10.7 |

Table 2.66 SoA X TSP Yield Two-way Tables 1997-1999 (Trial 511).

| | Level of N | | | |
|---|---|---|---|---|
| Level of P | N0 | N1 | N2 | N3 |
| P0 | 13.0 | 15.0 | 16.6 | 18.2 |
| P1 | 13.6 | 17.2 | 18.8 | 21.0 |

GM = 16.7, s.e.d = 0.94

Table 2.67 SoA X TSP Yield Two-way Tables 1997-1999 (Absence of EFB) (Trial 511).

| | Level of N | | | |
|---|---|---|---|---|
| Level of P | N0 | N1 | N2 | N3 |
| P0 | 11.1 | 13.3 | 14.7 | 16.9 |
| P1 | 12.5 | 15.8 | 18.1 | 20.5 |

GM = 16.7, s.e.d = 3.01

Table 2.68 SoA X EFB Yield Two-way Tables 1997-1999 (Trial 511).

| | Level of N | | | |
|---|---|---|---|---|
| Level of EFB | N0 | N1 | N2 | N3 |
| EFB0 | 11.8 | 14.5 | 16.4 | 18.7 |
| EFB1 | 14.8 | 17.6 | 19.0 | 20.6 |

GM = 16.7, s.e.d = 0.94

Table 2.69 SoA X EFB Yield Two-way Tables 1997 – 1999 (Absence of TSP) (Trial 511).

| | Level of N | | | |
|---|---|---|---|---|
| Level of EFB | N0 | N1 | N2 | N3 |
| EFB0 | 11.1 | 13.3 | 14.7 | 16.9 |
| EFB1 | 14.9 | 16.6 | 18.5 | 19.5 |

GM = 16.7, s.e.d = 3.01

# 3. SOLOMON ISLANDS WRAP-UP REPORT

(A. Oliver)

## INTRODUCTION

1999 was a difficult year for both Solomon Islands Plantations Ltd and PNGOPRA in the Solomon Islands. Despite the fact that we were determined to ensure proper implementation of work programmes, there were major setbacks caused by both natural disasters and civil unrest. Earlier in the year we suffered two major floods three weeks apart. The first in January and the second flood in February. This resulted in four weeks of yield data lost from the trials. The new PNGOPRA vehicle was completely under water during the flood, but was cleaned out and was able to be road worthy again.

Only eleven months after assuming the responsibilities for research and technical work at SIPL, all major field research activities was suspended in June of 1999 due to the ethnic tensions on Guadalcanal. The PNGOPRA office suffered damage, including the data files for the trials. Hoping the situation would improve the resident agronomist remained in Honiara until December of 1999 when PNGOPRA's in-country operations in the Solomon Islands was suspended.

Towards the end of 1998 a major research program was planned for 1999. This included *Ganoderma* monitoring, census and implementation of the sanitation program, observations into low oil extraction rates (OER), leaf, soil and water sampling. All major activities had been progressing well until the time of the disturbances.

A number of capital items and laboratory consumables had been bought under the EU Stabex *Ganoderma* project. These included a vehicle, computer and printer, and the Magellan GPS unit. These have all been packed and left in storage in Honiara.

## STAFF

Total staff seconded to PNGOPRA from SIPL was 13, which consisted of 11 field recorders, 1 senior field supervisor (Mr Paul Awaikera) and one clerk (Ms. Hellen Kasile). The staff numbers were maintained at 13 until they had to be retrenched due to continued unrest and the closure of SIPL. SIPL provided a redundancy package for all staff except for Paul Awaikera, who remained a member of the skeleton staff at SIPL and continued to be seconded to PNGOPRA.

Paul Awaikera continued his training for a degree in Tropical Agriculture through the University of the South Pacific's (USP) extension programme centre in Honiara. A six-month training attachment was also arranged for Paul with Milne Bay Estates and PNGOPRA; in September 1999 he moved to Milne Bay Estates.

Allan Oliver was recalled to Dami in PNG on the 29$^{th}$ November 1999.

## TRIAL MANAGEMENT

Two factorial trials continued to be recorded. Management of these trials improved significantly with data being entered into the new computer system. Tissue sampling and vegetative measurements were carried out on all plots for the first time. Plot isolation trenches were also completed for trial 701. Trenching in trial 702 was still in progress when operations ceased.

## LEAF SAMPLING

Leaf sampling on all Divisions was completed in April 1999 and samples were despatched to New Zealand (Hills Laboratories) for analysis. Water samples were taken in March. Tissue sampling from the field trials was completed in May and processed. The samples were not sent for analysis and were placed in storage with SIPL in Honiara. Training sessions on leaf sampling were conducted for supervisors, Assistant Managers and Managers for all SIPL Divisions. Some analysis results were not available at the end of the year.

VISITS

| | | |
|---|---|---|
| 21st - 25th, February | - | Director of Research, PNGOPRA & Senior Plant Pathologist |
| 21st - 24th, February | - | Dr Rob Lockwood, CDC, London |
| 3rd - 14th, March | - | Keith Armstrong, VA |
| 7th - 14th, March | - | Senior Entomologist, PNGOPRA |
| 5th - 12th, May | - | Carmel Pilotti, Pathologist, PNGOPRA |

AGRONOMY

The two factorial fertilizer trials continued as in previous years, however yield data was only collected up to June 1999 and this is presented in this report. Vegetative measurements were also carried out and are presented here.

PLANT PATHOLOGY

The major activity for PNGOPRA related to the Ganoderma control work at SIPL which was partially funded by the European Union under the Solomon Islands Government Stabex funding. There are two parts to the studies. They included short-term controls, the implementation of surveys and removal of bracket-infected palms. The programme involved 6 monthly surveys covering the whole plantation and 3 monthly census surveys conducted in blocks with the highest incidence of Ganoderma.

The first 3 monthly census for Ngalimbiu A & B were completed. The first six monthly surveys for Mberande, and Mbalasuna were completed. Census in Ngalimbiu, Okea and Tetere were not completed.

ENTOMOLOGY & OTHER SERVICES

18 observation plots were set up to investigate causes of low oil extraction ratios (OER). A number of factors are thought to have been responsible. Rat trapping continued in the plots while associated observations are done after trapping; these included the extent of bunch damage, male flower damage and loose fruit theft. Weevil emergence counts were also conducted.

**Trial 701 NITROGEN AND POTASSIUM FACTORIAL FERTILISER TRIAL AT NGALIMBIU DIVISION, SIPL.**

## PURPOSE

To investigate the response to Nitrogen and Potassium fertiliser.

## DESCRIPTION

Site Ngalimbiu Division block 22

Soil Metapona soil system, which is of recent alluvial deposit, with silty clay loam over loam.

Palms Dami commercial DxP crosses. Planted 1989 at 120 palms/ha. Trial commenced in June 1996.

## DESIGN

There are 48 plots each with a core of 16 palms. The number and weights of bunches from each individual core palm are recorded at intervals of 14 days. In each plot the core palms are surrounded by at least one guard row. Plot isolation trenching began in 1998 and was completed in 1999.

The 48 plots are divided into three replicates each containing 16 treatments and these are made up of all combinations of four levels each of N and K (Table 3.1). Sulphate of ammonia (SoA) is the source of N, and muriate of potash (MoP) is the source of K.

Table 3.1 Amounts of fertiliser used Trial 701 in 1999.

| Type of fertiliser | Amount of fertiliser (kg/palm/year) | | | |
|---|---|---|---|---|
| | Level 0 | Level 1 | Level 2 | Level 3 |
| SoA | 0.0 | 2.0 | 4.0 | 6.0 |
| MoP | 0.0 | 2.0 | 4.0 | 6.0 |

Note: Ammonium sulphate and Muriate of Potash have been applied twice a year since June 1996.

## RESULTS

Yield data for 1999 and 1996-1999 are presented in Tables 3.2 and 3.4. Yield recording in the trial commenced in June of 1996. The data has been arranged to enable the analysis to be done for a one-year period. The data presented represents production from June to May of the following year. This also provides a complete set of data for the three-year period from June 1996 to May 1999.

The trial has been sited on an area that is subjected to flooding during periods of high rainfall. In February of 1999 the trial was completely under water for two weeks, no yield recording was done at this time as it took 3 weeks before harvesting of the trial resumed. Despite trenching of the trial, there is a possibility that fertiliser was washed out of the trial.

There were no significant responses to either ammonium sulphate or Muriate of Potash application. Average FFB yields in the Trial for 1998-1999 was 29.1t/ha. FFB Yields were high even in the control plots. Tables 3.3 and 3.5 shows the N x K interactions.

Table 3.2 Main effects of N and K on FFB yield and yield components in 1999 (Trial 701).

| | Level of Nutrient Elements | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | N0 | N1 | N2 | N3 | Sig | Cv% | Sed |
| Yield (t/ha/yr) | 29.8 | 28.7 | 27.5 | 30.2 | ns | 13.4 | 1.59 |
| Bunches/ha | 1393 | 1374 | 1326 | 1515 | ns | 17.4 | 99 |
| Bunch weight (kg) | 21.6 | 21.0 | 20.8 | 20.3 | ns | 10.4 | 0.89 |
| | K0 | K1 | K2 | K3 | | | |
| Yield (t/ha/yr) | 28.8 | 29.8 | 29.8 | 27.7 | ns | 13.4 | 1.59 |
| Bunches/ha | 1377 | 1420 | 1517 | 1295 | ns | 17.4 | 99 |
| Bunch weight (kg) | 21.1 | 21.1 | 20.2 | 21.4 | ns | 10.4 | 0.89 |

Table 3.3 Effect of the combinations of N and K on FFB yield (t/ha/yr) in 1999 (Trial 701).

| | Level of K | | | |
|---|---|---|---|---|
| Level of N | K0 | K1 | K2 | K3 |
| N0 | 27.0 | 29.7 | 31.0 | 31.5 |
| N1 | 28.2 | 30.0 | 28.6 | 28.2 |
| N2 | 28.3 | 27.5 | 29.0 | 25.3 |
| N3 | 31.9 | 32.2 | 30.8 | 25.9 |

Grand Mean: 29.1, Standard error: NxK 3.18

Table 3.4 Main effects of N and K on yield and yield components in 1996–1999 (Trial 701).

| | Level of Nutrient Elements | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| | N0 | N1 | N2 | N3 | sig | Cv% | Sed |
| Yield (t/ha/yr) | 28.3 | 27.4 | 27.6 | 28.7 | ns | 5.1 | 0.59 |
| Bunches/ha | 1369 | 1318 | 1329 | 1418 | ns | 8.4 | 46 |
| Bunch weight (kg) | 20.8 | 20.9 | 20.8 | 20.4 | ns | 5.7 | 0.48 |
| | K0 | K1 | K2 | K3 | | | |
| Yield (t/ha/yr) | 27.3 | 28.2 | 28.4 | 29.1 | ns | 5.1 | 0.59 |
| Bunches/ha | 1314 | 1367 | 1414 | 1340 | ns | 8.4 | 46 |
| Bunch weight (kg) | 20.8 | 20.7 | 20.2 | 21.1 | ns | 5.7 | 0.48 |

Table 3.5 Effects of combinations of N and K on yield (t/ha/yr) in 1996-1999 (Trial 701).

| Level of N | Level of K | | | |
|---|---|---|---|---|
| | K0 | K1 | K2 | K3 |
| N0 | 26.7 | 29.1 | 28.4 | 29.1 |
| N1 | 25.3 | 28.3 | 28.4 | 27.7 |
| N2 | 28.2 | 26.4 | 27.6 | 27.9 |
| N3 | 29.0 | 28.8 | 29.2 | 27.9 |

Grand Mean 28.1, Standard error NxK= 1.18

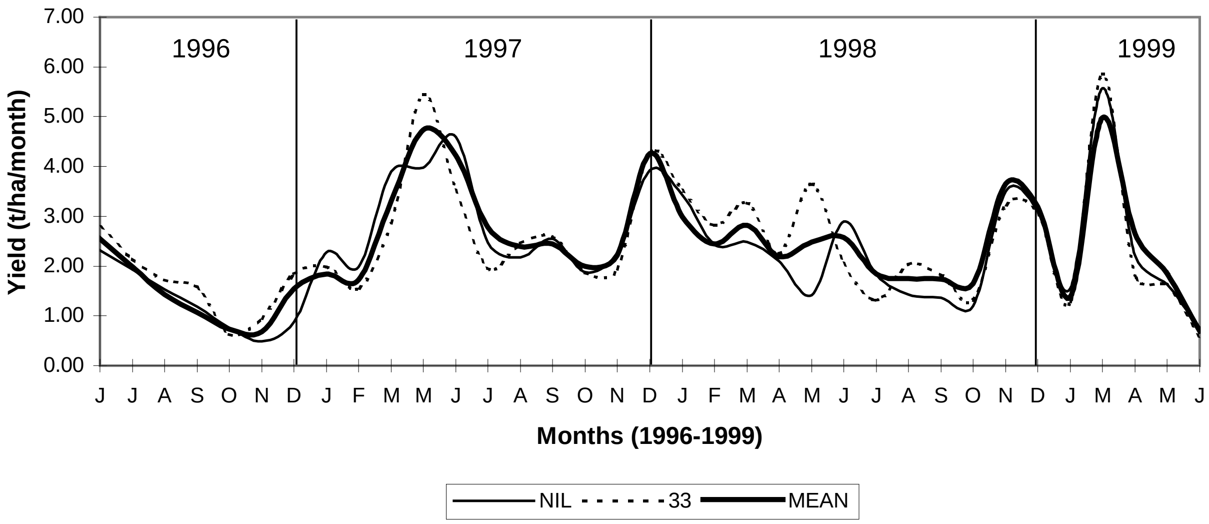
Table 3.6 shows the effects of fertiliser nitrogen on yields and yield components for the three year period from June 1996 to May 1999. Nitrogen applications had no effect on FFB yield. Yields are high even in the controls.

Table 3.6 Effect of N on FFB yield and yield components for each year from June 1996 to May 1999 (Trial 701).

| Year & | FFB yield (t/ha) | | | | Bunch number/ha | | | | Single Bunch weight (kg) | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Palm Age | N0 | N1 | N2 | N3 | N0 | N1 | N2 | N3 | N0 | N1 | N2 | N3 |
| 96-97 (7) | 23.2 | 20.2 | 22.6 | 22.4 | 1262 | 1054 | 1150 | 1214 | 18.5 | 19.2 | 19.5 | 18.5 |
| 97-98 (8) | 32.0 | 33.4 | 32.5 | 33.5 | 1453 | 1527 | 1510 | 1523 | 22.1 | 22.0 | 21.6 | 22.1 |
| 98-99 (9) | 29.8 | 28.7 | 27.5 | 30.2 | 1393 | 1374 | 1326 | 1515 | 21.6 | 21.0 | 20.8 | 20.3 |

Figure 3.1 gives the mean monthly yield for control and high N and K rates in Trial 701 for the three-year period from 1996-1999. In January of 1999 the monthly yield dropped due to flooding, and in February no records were available due to cessation of harvesting.

**Figure 3.1 Mean Monthly Yield in Trial 701 Ngalimbiu (1996 - 1999)**



Maximum monthly yields peaked between 5.7 and 6.2 t/ha in 1997 and 1999 respectively.

Vegetative measurements were carried out in 1999. There were no significant effects of nitrogen or potassium fertiliser treatments on petiole WxT, leaf area or height measurements. Tissue sampling was conducted in 1999, but the samples were not sent for analysis.

Table 3.7 Main effects of N and K treatments on vegetative measurements in 1999 (Trial 701).

| Vegetative | Level of N | | | | Statistics | | |
|---|---|---|---|---|---|---|---|
| Parameters | N0 | N1 | N2 | N3 | Sig | Cv% | Sed |
| Height (m) | 5.04 | 5.02 | 5.03 | 5.02 | ns | 5.6 | 0.115 |
| WxT ($cm^2$) | 42.4 | 43.8 | 42.9 | 44.8 | ns | 7.1 | 1.25 |
| Leaf Area ($m^2$) | 6.27 | 6.39 | 6.11 | 6.75 | ns | 10.3 | 0.27 |
| | Level of K | | | | | | |
| | K0 | K1 | K2 | K3 | | | |
| Height (m) | 5.09 | 4.92 | 5.10 | 5.00 | ns | 5.6 | 0.115 |
| WxT ($cm^2$) | 43.8 | 43.3 | 44.1 | 42.7 | ns | 7.1 | 1.25 |
| Leaf Area ($m^2$) | 6.52 | 6.19 | 6.49 | 6.31 | ns | 10.3 | 0.27 |

**Trial 702 NITROGEN, PHOSPHATE AND POTASSIUM FACTORIAL FERTILISER TRIAL AT MBALASUNA DIVISION, SIPL.**

PURPOSE

To investigate the response to N, P and K fertilisers applications.

DESCRIPTION

Site Mbalasuna Division block 70.

Soil Kongga soil system, Typic Haplustalf Pleistocene sediments mostly derived from basic volcanic material. Mostly stony red lateritic soil.

Palms Dami commercial DxP crosses. Planted 1988 at 136 palms/ha. Trial commenced in June 1996.

DESIGN

There are 54 plots each with a core of 16 recorded palms. The numbers and weight of bunches from each individual core palm are recorded at intervals of 14 days. In each plot the core palms are surrounded by at least one guard row. Plot isolation trenching of the trial commenced in 1999, but was not completed at the time operations were suspended.

The 54 plots are divided into two replicates each containing 27 treatments. Treatments are made up of all combinations of three levels each of N, P and K (Table 3.7). Sulphate of ammonia (SoA) is the source of N, Triple Super-phosphate (TSP) is the source of P and Muriate of potash (MoP) is the source of K.

Table 3.7 Fertiliser Treatments for Trial 702 in 1999.

| | Amount (kg/palm/year) | | |
|---|---|---|---|
| Type of fertiliser | Level 0 | Level 1 | Level 2 |
| SoA | 0.0 | 2.0 | 4.0 |
| TSP | 0.0 | 2.0 | 4.0 |
| MoP | 0.0 | 2.0 | 4.0 |

Notes: SoA, TSP and MoP have been applied twice a year since 1996.

RESULTS

Yield data for the trial has been calculated from June of 1998 to May 1999 to provide a complete year's data. Since recording started in the trial of June 1996, the three year's data is made complete by analysing the period from June 1996 to May 1999. The average plot yield in 1998-1999 was 22.0 tons FFB/ha/yr. For the years 1996-1999 the mean FFB yield was 18.2 tons/ha/yr.

Significant responses are observed for ammonium sulphate, Triple-Superphosphate, and Muriate of potash applications, which increased FFB yield, single bunch weight and bunch number in the period 1998-1999.

Sulphate of ammonia produced a significant linear increase in FFB yield ($p=0.014$) and bunch weight ($p=0.081$) but had no effect on bunch numbers.

Triple Superphosphate increased bunch weight ($p=0.023$), which resulted in an increase in FFB yield ($p=0.028$) (Table 3.8).

Muriate of potash significantly increased the number of bunches ($p=0.017$) which resulted in an increase in FFB yield ($p<0.001$).

Combined application of N, P & K as presented in Table 3.9 produced a maximum FFB yield of 30.9 Data for the period 1996 to 1999 also shows a significant positive yield effect of combined application of ammonium sulphate, triple-superphosphate and muriate of potash which. Yield data illustrates that the response to all three sources was linear, and a maximum FFB yield of 24.4 t/ha was achieved with applications of 4kg of ammonium sulphate 4kg of triple-superphosphate and 4 kg of muriate of potash (Table 3.11).

The soils at Mbalasuna are relatively poor in available nutrients, and the results indicate all three of the nutrients N, P & K are required maintain respectable yields.

Table 3.8 Main effects of N, P, and K application on FFB yield and yield components in 1998-1999 (Trial 702)

| | Level of Nutrient Elements | | | Statistics | | |
|---|---|---|---|---|---|---|
| | N0 | N1 | N2 | Sig | Cv% | Sed |
| Yield (t/ha/yr) | 20.6 | 21.7 | 23.7 | * | 15.9 | 1.17 |
| Bunch/ha | 1412 | 1423 | 1511 | ns | 16.0 | 77 |
| Bunch weight (kg) | 14.6 | 15.2 | 15.8 | ns | 12.8 | 0.65 |
| | P0 | P1 | P2 | | | |
| Yield (t/ha/yr) | 20.4 | 22.5 | 23.1 | * | 15.9 | 1.17 |
| Bunch/ha | 1441 | 1434 | 1471 | ns | 16.0 | 77 |
| Bunch weight (kg) | 14.2 | 15.8 | 15.7 | ** | 12.8 | 0.65 |
| | K0 | K1 | K2 | | | |
| Yield (t/ha/yr) | 19.3 | 23.0 | 23.7 | *** | 15.9 | 1.17 |
| Bunch/ha | 1318 | 1514 | 1515 | ** | 16.0 | 77 |
| Bunch weight (kg) | 14.7 | 15.2 | 15.8 | ns | 12.8 | 0.65 |

Table 3.9 Effect of combinations of N, P, and K on yield in 1998 – 1999 (Trial 702).

| | | FFB Yield (t/ha/year) | | |
|---|---|---|---|---|
| | | Level of K | | |
| Level of N | Levels of P | K0 | K1 | K2 |
| N0 | P0 | 17.5 | 15.6 | 21.6 |
| | P1 | 16.8 | 24.7 | 25.7 |
| | P2 | 20.4 | 23.7 | 19.6 |
| N1 | P0 | 22.3 | 21.4 | 20.8 |
| | P1 | 19.4 | 22.6 | 23.0 |
| | P2 | 16.1 | 23.0 | 26.5 |
| N2 | P0 | 19.8 | 23.6 | **20.8** |
| | P1 | 21.2 | 25.2 | **24.4** |
| | P2 | **20.0** | **27.6** | **30.9** |

Grand Mean: 22.0 t/ha/yr Standard Error: NxPxK=3.50

Interactions had significant linear responses at P<5%

Table 3.10 Main effects of N, P and K on FFB yield and yield components in 1996–1999 (Trial 702).

| | Level of nutrient Elements | | | Statistics | | |
|---|---|---|---|---|---|---|
| | | | | Sig | Cv % | Sed |
| | N0 | N1 | N2 | | | |
| Yield (t/ha/yr) | 17.1 | 19.1 | 20.2 | *** | 12.1 | 0.76 |
| Bunches/ha | 1341 | 1475 | 1503 | * | 15.3 | 73 |
| Bunch weight (kg) | 12.7 | 13.0 | 13.6 | ns | 13.4 | 0.59 |
| | P0 | P1 | P2 | | | |
| Yield (t/ha/yr) | 17.8 | 18.8 | 19.7 | ** | 12.1 | 0.76 |
| Bunches/ha | 1433 | 1419 | 1467 | ns | 15.3 | 73 |
| Bunch weight (kg) | 12.4 | 13.4 | 13.5 | ns | 13.4 | 0.59 |
| | K0 | K1 | K2 | | | |
| Yield (t/ha/yr) | 17.4 | 19.3 | 19.6 | ** | 12.1 | 0.76 |
| Bunches/ha | 1357 | 1477 | 1485 | ns | 15.3 | 73 |
| Bunch weight (kg) | 12.9 | 13.1 | 13.4 | ns | 13.4 | 0.59 |

Table 3.11 Effects of combinations of N, P and K on yield in 1996-1999 (Trial 702).

| | | Yield (t/ha/year) | | |
|---|---|---|---|---|
| | | Level of K | | |
| Level N | Level of P | K0 | K1 | K2 |
| N0 | P0 | 15.4 | 11.8 | 18.7 |
| | P1 | 13.6 | 20.6 | 20.6 |
| | P2 | 19.4 | 17.9 | 15.9 |
| N1 | P0 | 18.9 | 19.2 | 18.0 |
| | P1 | 19.0 | 18.8 | 18.6 |
| | P2 | 16.5 | 20.5 | 22.6 |
| N2 | P0 | 18.9 | 21.2 | 18.2 |
| | P1 | 18.8 | 20.2 | 19.4 |
| | P2 | 16.6 | 23.8 | 24.4 |

Grand Mean: 18.8 t/ha Standard Error: NxPxK=2.27

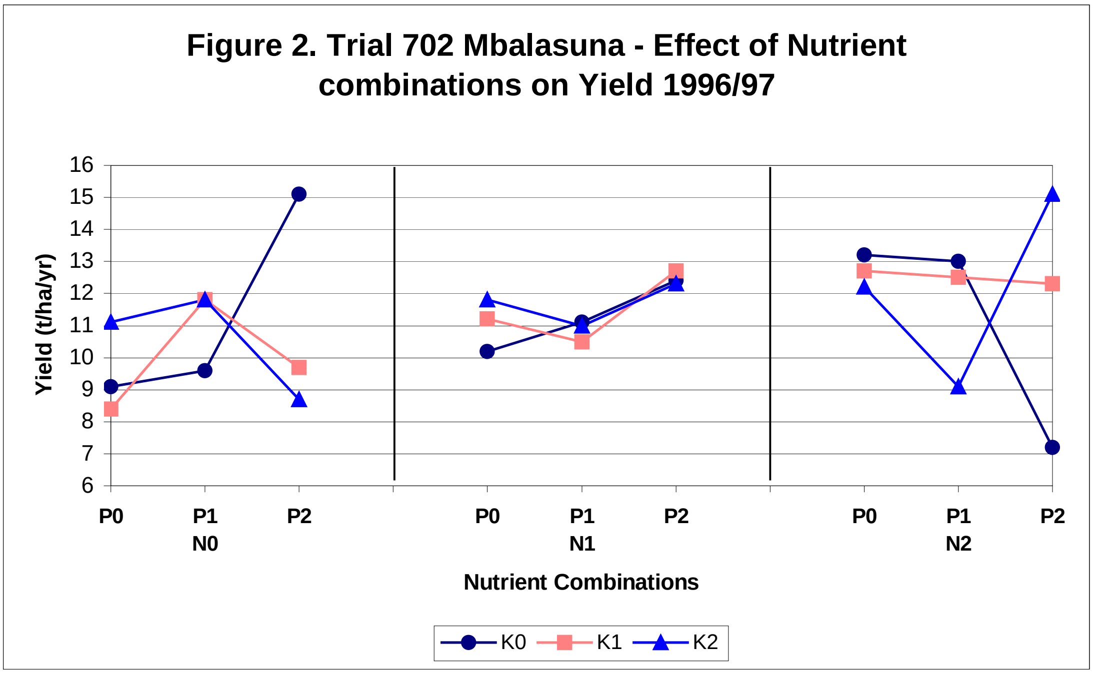
Table 3.12 Effect of the combinations of N, P and K on FFB yield and Yield components from 1996 to 1999 (Trial 702)

| Year & (Age from planting) | Yield (t/ha/year) | | | Bunches/ha | | | Bunch weight (kg) | | |
|---|---|---|---|---|---|---|---|---|---|
| | N0P0K0 | N1P1K1 | N2P2K2 | N0P0K0 | N1P1K1 | N2P2K2 | N0P0K0 | N1P1K1 | N2P2K2 |
| 96-97 (8) | 9.1 | 10.5 | 15.1 | 1032 | 1210 | 1469 | 8.8 | 8.8 | 11.1 |
| 97-98 (9) | 19.5 | 23.3 | 27.1 | 1479 | 1645 | 1593 | 13.3 | 14.1 | 17.8 |
| 98-99 (10) | 17.5 | 22.6 | 30.9 | 1347 | 1453 | 1679 | 13.0 | 15.6 | 18.8 |

An optimum applications of 4kg each of SoA, TSP and MoP is suggested as resulting in the highest FFB production.

| Treatment | Yield (t/ha/yr) | Relative yield% |
|---|---|---|
| Optimum NPK | 30.9 | 100 |
| No N | 19.6 | 63 |
| No P | 20.8 | 67 |
| No K | 20.0 | 65 |

By eliminating any one of the three nutrient elements losses in FFB yield of about 35% appears to occur. This loss equates to 10-11 tons of FFB/ha/yr.

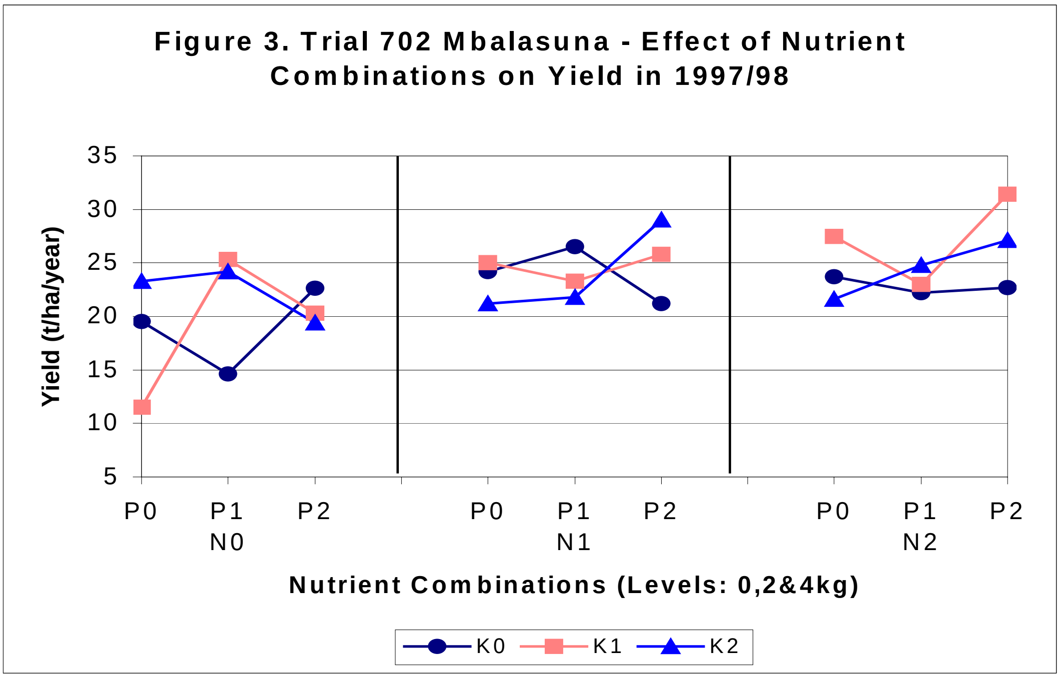



At eight years after planting, the mean FFB yield was only 11.3 tons/ha. In the absence of both SoA & MoP, TSP applied alone increased yield to around 15 t/ha. The addition of MoP depressed yield at the higher TSP rate. The absence of N was probably limiting yield.

At the lower SoA rate there was a small increase in yield due to increasing the rate of TSP.

In the absence of MoP at higher SoA rates, FFB yield declined with increasing rates of TSP. Indicating that the absence of MoP was limiting yield. At the higher SoA rate, a lower rate of MoP slightly decreased yield. There was a 6 tonne increase in yield caused by applying equal amounts of all three elements at the higher rates.

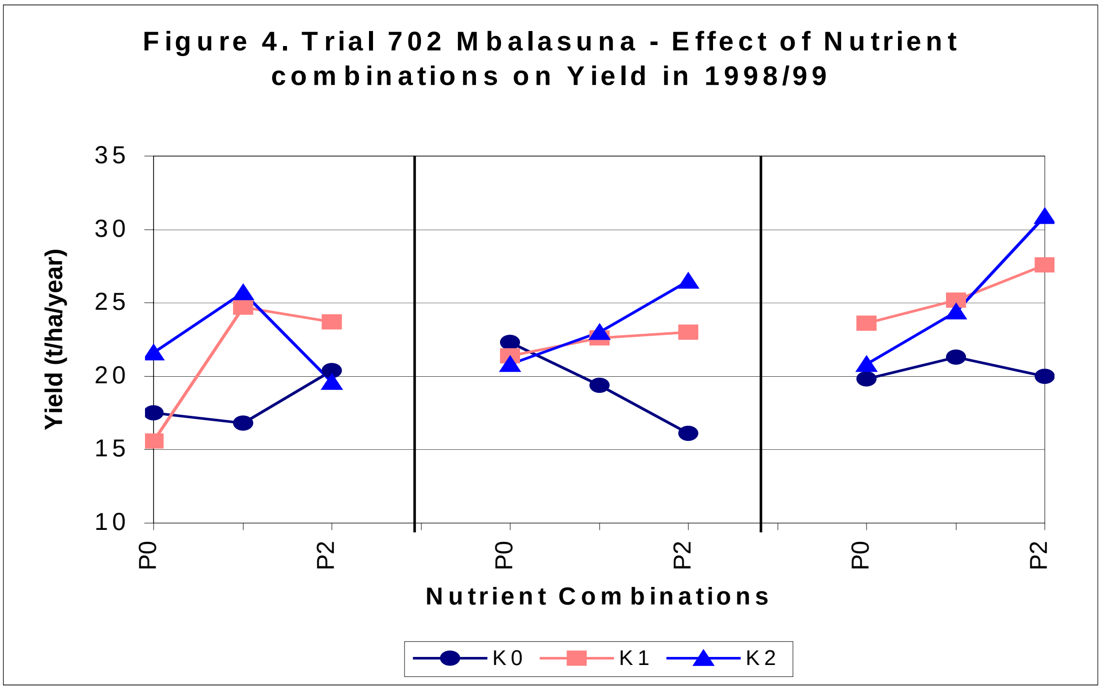
During the 1996 to 1997 period, FFB yields were low; the continued application of fertiliser should build up nutrient reserves and increase yield.



For the period 1997 to 1998, the yield responses to treatments are illustrated in Figure 3.2. In the absence of SoA, applications of 2 kg of MoP increased yield by 12 tons. In the presence of TSP and absence of SoA FFB yields were decreased; suggesting nitrogen is limiting.

At the lower SoA rate, applications of 4 kg of MoP increased yield with increasing rates of TSP. With 2 kg of MoP yield was approximately 25 tons/ha/yr. Applications of 4 kg of SoA and 4 kg of MoP produced a significant increase in yield with increasing rates of TSP. In the absence of MoP yield did not increase.

During the period 1997-1998 the mean FFB yield had increased to 23.1 t/ha compared to earlier years.




In 1998-1999 and in the absence of N and K, P alone increased the yield of FFB to just over 20 tons. In the absence of N, 2 kg of MoP and 2 kg of TSP increased yield to around 25 tons, but further application of the higher rate of TSP depressed yield by 1 ton. 4kg of MoP and 2 kg of TSP increased yield to just over 25 tons. At the higher dosage of 4 kg of TSP FFB yield dropped by 6.3 tons.

With 2 kg of SoA in the absence of MoP, increasing application of TSP further depressed FFB yield by 6.2 tons. By applying 2 kg of MoP with 2 kg of SoA, there was a small increase in yield with increasing application of TSP. At the higher rate of MoP, there was also a significant increase in FFB yield of 3 tons by applying TSP.

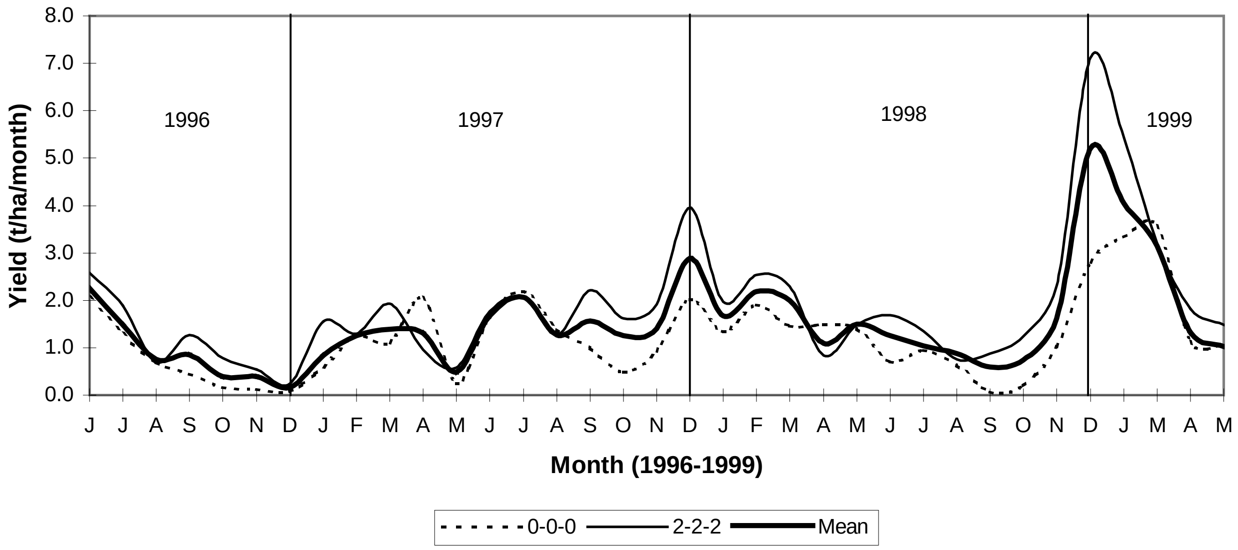
At the higher rate of SoA and in the absence of MoP, varying rates of TSP did not improve yield (remaining around 20 tons/ha). At the lower rate of MoP, FFB yield improved with increasing rates of TSP. A respectable yield of 31 tons/ha/year was achieved with the combination of the higher rates of all three nutrient sources.

The mean yield of FFB for the 1998-1999 period was 22.0 t/ha.

Figure 3.5 illustrates the mean monthly yield, for control and high treatment rates of all three nutrients period from June 1996 to May of 1999. A clear trend is showing increasing yield as nutrients are applied over time.

The highest monthly yield was recorded in December 1999. Minimum yield was around 3 tons/ha while the maximum yield was over 7 tons/ha. The mean monthly yield was just over 5 tons/ha.

**Figure 3.5 Monthly FFB Yield - (1996 - 1999) Trial 702 Mbalasuna**




Vegetative measurements and tissue sampling of all plots was carried out in 1999. Due do disruption of operations, the tissue samples were not sent for chemical analysis. The effects of N, P, and K on leaf area and WxT are shown in Table 3.12. Nitrogen and Potassium both increased leaf area and petiole WxT, but these effects were not statistically significant. Applications of TSP significantly increased both growth parameters.

Table 3.12 Effects of N, P, & K on vegetative growth in 1999 (Trial 702).

| Vegetative | | Level of N | | Statistics | | |
|---|---|---|---|---|---|---|
| Parameters | N0 | N1 | N2 | Sig | Cv % | Sed |
| Leaf Area ($m^2$) | 4.44 | 4.60 | 4.66 | Ns | 11.6 | 0.176 |
| WxT ($cm^2$) | 27.2 | 28.3 | 30.0 | Ns | 14.3 | 2.35 |
| | | Level of P | | | | |
| | P0 | P1 | P2 | | | |
| Leaf Area ($m^2$) | 4.27 | 4.74 | 4.69 | * | 11.6 | 0.176 |
| WxT ($cm^2$) | 26.2 | 29.9 | 29.4 | * | 14.3 | 2.35 |
| | | Level of K | | | | |
| | K0 | K1 | K2 | | | |
| Leaf Area ($m^2$) | 4.46 | 4.49 | 4.75 | ns | 11.6 | 0.176 |
| WxT ($cm^2$) | 27.6 | 27.8 | 30.2 | ns | 14.3 | 2.35 |

SIPL Rainfall Data for 1999 (incomplete)

| MONTH | DIVISIONS | | | | | MONTHLY TOTAL | SIPL MEAN |
|---|---|---|---|---|---|---|---|
| | Okea | Ngalimbiu | Metapona | Tetere | Mbalasuna | | |
| January | 245.1 | 313.3 | 490.5 | 515.0 | 366.7 | 1930.6 | 386.1 |
| February | 546.8 | 307.8 | 638.0 | 556.5 | 652.9 | 2702.0 | 540.4 |
| March | 86.4 | 49.2 | 36.9 | 63.5 | 120.5 | 356.5 | 71.3 |
| April | 73.4 | 95.6 | 152.9 | 154.0 | 45.9 | 521.8 | 104.4 |
| May | - | 202.0 | - | - | 150.0 | 352.0 | 70.4 |
| June | - | - | - | - | - | | - |
| July | - | - | - | - | - | | - |
| August | - | - | - | - | - | | - |
| September | - | - | - | - | - | | - |
| October | - | - | - | - | - | | - |
| November | - | - | - | - | - | | - |
| December | - | - | - | - | - | | - |
| | | | | | | | - |
| ANNUAL | | | | | | | - |

# 4. SMALLHOLDER STUDIES

(G. King & J. Papah)

## Trial 314 SMALLHOLDER DEMONSTRATION TRIALS, POPONDETTA/ORO EXPANSION PROJECTS.

### PURPOSE

To demonstrate the correct use of fertilizers to improve and maintain yield.

### DESCRIPTION

Site Experiment 314 is located on OPIC's Popondetta and Oro Expansion Oil Palm projects. The 10 blocks are located at Sorovi, Aeka and Ilimo divisions. Details of each block are given in Table 4.2.

Palms Dami commercial DxP planting material at 130 palms/ha.

Planted between 1979 and 1993.

Treatments commenced between 1994 and1997.

### DESIGN

Each of the Smallholder blocks was divided in two halves. Half of the block (demonstration - RED) receives the recommended type and amount of fertilizer (3kg/palm/year - SoA) while the other half (control - YELLOW) does not.

Table 4.1 Treatments used in Trial 314

| Treatment | Type of Fertilizer (kg/palm/year) |
|---|---|
| | Sulphate of Ammonia |
| Treated (Red) | 3.0 |
| Control (Yellow) | 0.0 |

Fertilizer was applied three times a year in February, July and December. A trench was dug between the two plots to minimise fertilizer poaching by palms from the untreated plot. Initially yields were recorded by weighing individual bunches harvested during each round. The whole block was harvested during the normal transport schedule but the bunches were left under the trees in each plot. OPRA recorders then recorded the weights of the bunches from both plots before the owner loaded the bunches onto the nets, ready for pickup by transport. This system did not work and a simpler system was introduced during 1998. At each harvest, the block owner harvests and removes the bunches to the nets ready for pick up. The number of stalks are counted by OPRA from each half block. Bunch weights are recorded four times a year only. The weight of nets recorded by the transport company is then apportioned to each half block depending on the number of stalks and average bunch weight.

Even this system did not always work as it all depends on the cooperation of the grower and the transport company.

These trials were all closed down at the end of 1999.

Table 4.2 Details of 10 smallholder demonstration sites in the Popondetta Smallholder Oil Palm Project areas of Oro Province.

| Division | Owner | Block number | Number of palms | |
|---|---|---|---|---|
| | | | Red | Yellow |
| Sorovi | Hamilton Bakovo | 121779 | 253 | 231 |
| Sorovi | Bray Kivigi | 260002 | 250 | 232 |
| Sorovi | Nathaniel Aiga | 610024 | 131 | 128 |
| Sorovi | Richie Abraham | 610047 | 61 | 60 |
| Isavene | Nelson Mungeron | 580007 | 236 | 246 |
| Igora | Johnson Ejavo | 111578 | | |
| Saiho | Kingsford Penunu | 390001 | 281 | 204 |
| Ilimo | Kingsley Isoro | 670014 | 148 | 118 |
| Ilimo | Allen Jirekari | 670015 | 135 | 120 |
| Aeka | Arthur Jombure | 640016 | 130 | 129 |

Yields recorded in 1999 are reported in Table 4.3. Even though the recording system failed in most cases, yields are higher in the treated (RED) blocks at every site. As in West New Britain each grower involved in the trial testifies that the fertilised side of his block gives higher yields than the side with no fertiliser.

Table 4.3 Yield results for Trial 314 in 1998.

| Division | Block number | No harvest recorded | Recorded Yield (t/ha/yr) | |
|---|---|---|---|---|
| | | | Treated | Control |
| Sorovi | 260002 | 11 | 19.3 | 10.9 |
| Sorovi | 121779 | 15 | 34.8 | 21.6 |
| Sorovi | 610047 | 14 | 3.8 | 1.4 |
| Sorovi | 610024 | 14 | 5.1 | 4.1 |
| Isavene | 580007 | 10 | 19.0 | 13.8 |
| Igora | 111578 | 6 | 4.6 | 3.4 |
| Saiho | 390001 | 18 | 33.6 | 9.1 |
| Illimo | 670014 | 15 | 5.4 | 3.0 |
| Illimo | 670015 | 13 | 3.6 | 3.4 |
| Aeka | 640016 | 10 | 5.2 | 4.9 |
| | Mean | 12.6 | 13.4 | 7.6 |
| | Maximum | 18 | 34.8 | 21.6 |
| | Minimum | 6 | 3.6 | 1.4 |
| | s.e. | 1.08 | 3.94 | 2.01 |

Given that smallholders are usually on a fortnightly harvest round the maximum possible number of harvests in a year is 26. The maximum number recorded for these 10 blocks was only 18 and the mean only 12.6. This indicates that infrequent harvesting is a major cause of low productivity levels in the Popondetta smallholder project.

Leaflet and rachis samples were taken from each block and analysed for nutrient content in 1999. The results of this analysis are given in Table 4.4 below. These results show that leaflet N, P, K and Cl and rachis K and Cl increased with application of SoA. Leaflet Ca and Mg decreased. Leaflet N levels are still very low even after several years of N application. K levels are also very low in some cases and it would be expected that application of MoP in these areas would result in an increase in yield. Chlorine levels are also low.

The blocks at Ilimo that do not receive SoA show quite obvious symptoms of K deficiency. It is essential that blocks in this division on this soil type receive annual applications of SoA to ensure K status is improved in the short term. However, given the low K status of these palms it is likely that in the near future applications of MoP will also be required in this area.

Table 4.4 Descriptive statistics of leaflet and rachis nutrient concentration (% on dry matter).

| Nutrient | Treatment | Mean | Minimum | Maximum | Std Error |
|---|---|---|---|---|---|
| Leaflet N | Control | 2.07 | 1.73 | 2.40 | 0.067 |
| | N only | 2.21 | 2.08 | 2.38 | 0.036 |
| Leaflet P | Control | 0.138 | 0.127 | 0.151 | 0.003 |
| | N only | 0.141 | 0.129 | 0.156 | 0.003 |
| Leaflet K | Control | 0.68 | 0.41 | 0.89 | 0.048 |
| | N only | 0.78 | 0.65 | 0.95 | 0.037 |
| Leaflet Ca | Control | 0.74 | 0.55 | 0.89 | 0.036 |
| | N only | 0.70 | 0.59 | 0.78 | 0.023 |
| Leaflet Mg | Control | 0.24 | 0.17 | 0.33 | 0.015 |
| | N only | 0.21 | 0.17 | 0.31 | 0.014 |
| Leaflet Cl | Control | 0.26 | 0.14 | 0.33 | 0.020 |
| | N only | 0.27 | 0.14 | 0.36 | 0.024 |
| Rachis K | Control | 0.76 | 0.12 | 1.34 | 0.155 |
| | N only | 0.97 | 0.32 | 1.47 | 0.128 |

The results from 10 blocks cannot be extrapolated to the whole scheme as 10 is not a sufficiently representative sample of over 4000 growers. The results that have been obtained strongly suggest that continued N amelioration is essential for smallholder oil palm production in Oro Province. However, it is impossible to determine whether P, K, Mg or Cl is also limiting yield. The leaf and rachis analysis results suggest that K and Cl are limiting but as these results are only from 10 blocks it is not possible to make any recommendations for these elements.

## Trial 506 SMALLHOLDER DEMONSTRATION TRIALS - MILNE BAY

### PURPOSE

To demonstrate the importance of fertiliser application to smallholder growers in Milne Bay Province.

### DESCRIPTION

There are 6 blocks chosen with the help of OPIC extension officers for use as demonstration blocks for other growers. Block details are summarised in Table 4.5 below.

Table 4.5 Details of Demonstration Sites.

| Location | Block Number | Site Description | Plant Density No./ha |
|---|---|---|---|
| Waima | 07020 | On footslope | 127 |
| Giligili | 05006 | Alluvial Plain | 127 |
| Kerakera | 01022 | Alluvial Plain | 127 |
| Naura | 04016 | Alluvial Plain | 127 |
| Ata ata | 17009 | On footslope | 127 |
| Sagarai | 22001 | Alluvial Plain | 120 |

The demonstration blocks were started in 1995 and were trenched dividing the block into 2 with half receiving the recommended fertilisers application rate (1.5 kg SoA and 2.0 kg MoP) (Demo plot) and the other half receiving nil fertiliser (Control plot). The rates were increased to 2 kg SoA and 2.5 kg MoP per palm per year in 1998. Yield recordings are done fortnightly and done separately for fertilised and unfertilised plots by the milling company and OPIC. Leaf and rachis tissues have been taken annually for analysis. However, no samples were taken for analysis in 1999

### RESULTS

As with the smallholder trials in other project areas accurate yield recording has not been possible. Bunch weights were either not recorded properly or the bunches from the control plots were mixed with those from the demo plots by the growers or a combination of both. Bunch numbers were determined by going through the blocks after every harvest and counting the cut stalks on each palm in a block.

Results for 1999 are shown in Table 4.6. It is difficult to draw any conclusions from this data as the number of harvests recorded is in all cases less than half the expected number if the blocks were being harvested every fortnight throughout the year. Probably the best evidence to support the response to fertiliser is that each grower who participated in the trials has complained about the lost production from the plot that did not receive fertiliser for 5 years.

Leaf and rachis tissue was not sampled in 1999.

Table 4.6 Yield Records for 1999.

| Block | No. of Harvests Recorded | Control BN/Ha | Demo BN/Ha |
|---|---|---|---|
| 1022 | 10 | 526 | 545 |
| 4016 | 8 | 447 | 668 |
| 5006 | 9 | 559 | 652 |
| 7020 | 8 | 75 | 193 |
| 17009 | 4 | 297 | 425 |
| 22001 | 9 | 594 | 566 |
| | Mean | 416 | 508 |
| | Min | 75 | 193 |
| | Max | 594 | 668 |
| | s.e. | 81 | 72 |

# HOSKINS SMALLHOLDER FERTILISER USE SURVEY

## PURPOSE

To determine the main reasons why smallholders in the Hoskins Project have not been applying the fertiliser which they received in 1998.

## BACKGROUND

Over the past two years (97-98) some 2000 tonnes of ammonium chloride has been distributed to over 3000 smallholders in the Hoskins scheme each year. The fertiliser was sold to the growers at cost on credit by the company with repayments deducted from monthly payments for fruit over a 12 month period. At the end of each year many of the growers had still not applied the fertiliser. A census in February 1998 showed that some 400 growers had not applied over 200 tonnes which had been supplied in the previous year. Many reasons were suggested as to why these growers had purchased fertiliser at a cost of K350/tonne but had not applied it. The main reason put forward was laziness. This survey of growers was proposed to determine the true reasons.

The Hoskins Project LPC meeting on 23 February agreed that a survey of these growers was required and PNGOPRA was asked to design a survey.

## SURVEY PROPOSAL

OPIC extension officers conducted a census of blocks and compiled a list of all the blocks with fertiliser still not applied. As the reasons could be quite different on the settlement scheme (LSS) as compared to village oil palm blocks (VOP) 50 LSS and 50 VOP blocks were selected from the list of over 400 blocks which had not applied fertiliser. This was a stratified random sample based on whether the block was VOP or LSS and the number of bags remaining on the block.

A sample of growers who had applied all their fertiliser were also interviewed to determine differences in knowledge and attitiudes between those who had applied fertiliser and those who had not. Over 50 of these growers were to be interviewed.

The first section of the questionnaire collected basic block information on the grower and the block identity and location. Information on the planted area, planting date, 1998 production and a physical count of the number of bags remaining was also included.

The second section consisted of 9 questions that were designed to determine the level of the growers knowledge and attitudes regarding fertiliser. These questions were based on the main messages contained in the extension campaigns conducted in 1997 and 1998. In questions 6-9 the responses were separated into the various family members.

The last question asked the grower and the growers family for reasons why the fertiliser had not been applied. A list of 22 possible reasons were listed. If any of these reasons were given then a tick was placed in the first box and the person giving that response was marked in the second box alongside that reason. As more than one reason was expected they were then asked to rank the importance of their responses.

The survey was conducted by OPIC extension officers at night when the family was most likely to be in the house. The group was asked the questions and the interviewers marked the response and which member of the family gave that response.

The survey was conducted by OPIC extension staff under the supervision of OPRA. The OPIC staff interviewing the growers were trained by OPRA prior to the commencement of the survey. Survey work was to be completed by the end of May 1999. However, the OPIC officers took much longer to do the survey than expected and did not complete surveying the growers until August 1999. By that time many of the growers had finally applied their fertiliser and the survey was therefore not able to fully achieve its aims.

## RESULTS

A summary of the production figures for 1998 for all the blocks surveyed are given in Table 4.7. This shows that yield per hectare was very similar across all categories.

Table 4.7 Mean Production in 1998 from 58 LSS and 62 VOP Blocks.

| | LSS | | VOP | |
|---|---|---|---|---|
| | Applied Fertiliser | Did not Apply Fertiliser | Applied Fertiliser | Did not Apply Fertiliser |
| Hectarage | 5.1 | 5.2 | 2.6 | 2.2 |
| FFB (t) | 60.1 | 60.7 | 33.2 | 28.4 |
| Loose fruit (t) | 10.3 | 8.5 | 5.1 | 4.8 |
| Total Prod. | 70.4 | 69.2 | 38.3 | 33.2 |
| Yield (t/ha) | 14.2 | 14.0 | 15.1 | 14.4 |
| No. Bags Delivered | 23.2 | 23.9 | 12.6 | 12.4 |
| No. Bags Remaining | 0 | 6.2 | 0 | 4.6 |
| No. of Records | 40 | 18 | 37 | 25 |

The number of families who responded that one or more members had attended a field day in 1998 are given in Table 4.8. This shows that the majority of growers and/or members of their families had attended a field day the previous year. There was a slight difference between LSS and VOP with fewer VOP families responding that they had attended.

Table 4.8 Field Day attendance in 1998.

| | LSS | | VOP | |
|---|---|---|---|---|
| | Applied Fertiliser | Did not Apply Fertiliser | Applied Fertiliser | Did not Apply Fertiliser |
| No. Attending | 36 | 18 | 23 | 18 |
| No. of Records | 40 | 18 | 37 | 25 |

Only a very few growers could correctly nominate the price per bag which was K17.50 in 1998. More VOP growers knew the price than LSS growers. This apparent lack of knowledge about a major cost input suggests that greater emphasis should be placed on educating growers about the cost of fertiliser and the expected economic benefit of applying fertiliser.

Table 4.9 Number of Growers who knew the correct price.

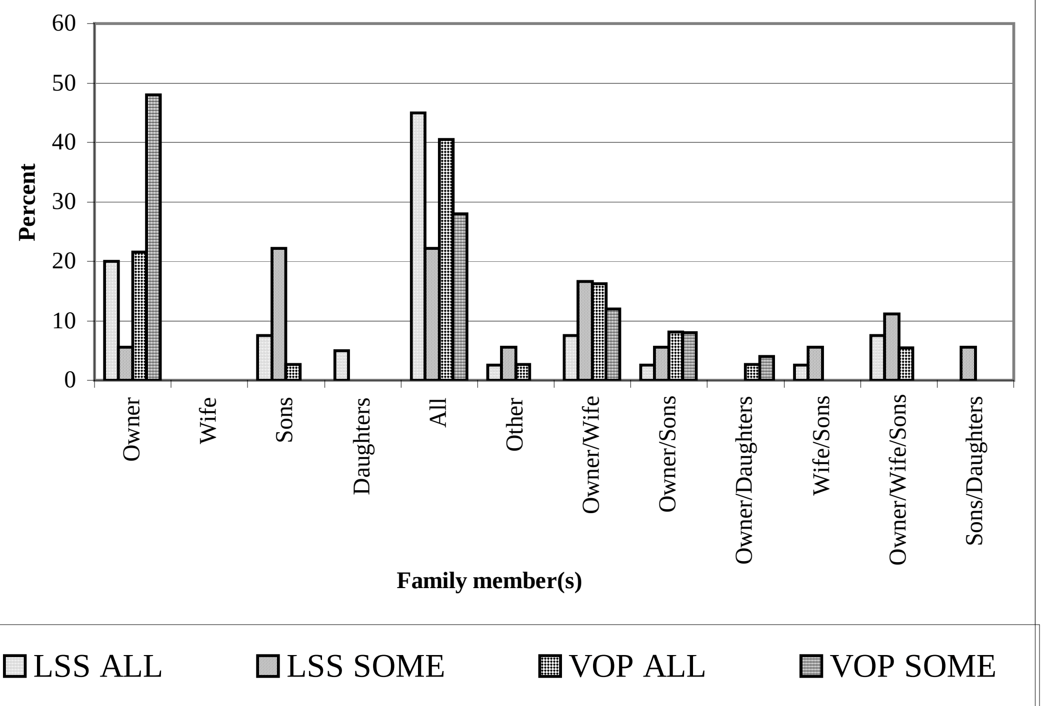
| | LSS | | VOP | |
|---|---|---|---|---|
| | Applied Fertiliser | Did not Apply Fertiliser | Applied Fertiliser | Did not Apply Fertiliser |
| Correct Price | 5 | 2 | 15 | 8 |
| No. of Records | 40 | 18 | 37 | 25 |

One of the main messages given in the field days was that the fertiliser for mature palms should be applied to the frond pile and fertiliser for young palms should be applied to the circle. This message appears to have been understood by a majority of growers (Table 4.10). A significant number of LSS growers applied the fertiliser to both frond pile and circle but on further questioning replied that the fertiliser applied to the circle was for young palms. It is likely that those growers who responded that they had applied fertiliser to the circles only had young palms. All but one of the growers responded that they thought fertiliser was good and that their palms were higher yielding as a result of fertiliser application. This indicates that the field day program has been successful in training growers to apply the fertiliser correctly and educating them about the benefits of fertiliser.

Table 4.10 Where was the fertiliser applied.

| | LSS | | VOP | |
|---|---|---|---|---|
| | Applied Fertiliser | Did not Apply Fertiliser | Applied Fertiliser | Did not Apply Fertiliser |
| Circle | 2 | 1 | 3 | 1 |
| Frond Pile | 24 | 9 | 32 | 23 |
| Both | 14 | 8 | 2 | 1 |
| No. of Records | 40 | 18 | 37 | 25 |

**Figure 4.1: Application of fertiliser by family members (%)**




This graph of the family members who applied the fertiliser shows that on both LSS and VOP blocks where all the fertiliser had been applied all family members assisted in applying the fertiliser in over 40% of cases. In many other cases the owner along with either the wife or sons or daughters applied the fertiliser. Almost 50% of the owners of VOP blocks who had not applied all their fertiliser responded that they alone applied the fertiliser. In no cases did wives alone apply fertiliser. Sons applied fertiliser on over 20% of LSS blocks which had not applied all of their fertiliser. These results show that a task such as fertiliser application is often undertaken by the family as a group. Given that a high proportion of VOP growers responded that they alone applied the fertiliser indicates that the main limitation to application of fertiliser on VOP blocks is low family input into the oil palm block. The majority of VOP families do not live on the block and much of the work is done by one or two people who walk to the block when work is necessary. In contrast, LSS families almost always reside on the block and so are more likely to work together.

The final question in the survey was to ask the families to give the reasons for not applying the fertiliser and to try and rank the reasons if more than one reason was given. This was the most difficult question in the survey and for many of the completed survey sheets it was obvious that there was confusion as to how the question should be asked and the response recorded. The results for those questionnaires completed correctly show that reasons relating to labour, health and customary obligations were the most important (Table 4.11). Customary obligations were of particular importance amongst the VOP growers. The other reason that seemed to come to the fore was that some fertiliser had been retained for split applications to immature palms.

The loose fruit collection scheme was introduced throughout the Hoskins scheme in 1998. This scheme was introduced to give wives a direct income instead of relying on infrequent handouts from their husbands. This has been very successful. In response to the perceived lack of labour available for application of fertiliser and weeding owners are now being encouraged to pay their wives in bunches for each bag of fertiliser they apply. For each bag of fertiliser applied the wife can claim 2 bunches for her net. However, the data in Figure 1 suggests that the sons are the family members who should be encouraged to apply fertiliser but it is unlikely that they will perform this task unless they are paid just as wives would not pick up loose fruit until they were able to receive payment directly. In the past youth groups have been contracted to apply fertiliser. Perhaps the best way to get fertiliser applied is to employ unemployed youths on a contract basis so that they are able to generate some income for themselves.

Table 4.11 Reasons given for not applying fertiliser.

| Reason | LSS | | | VOP | | |
|---|---|---|---|---|---|---|
| | #1 | #2 | #3 | #1 | #2 | #3 |
| Absent from block | - | - | 1 | 3 | - | - |
| Not enough labour | 5 | 2 | 1 | 3 | 2 | 1 |
| Caretaker | - | 1 | - | - | - | 1 |
| Health problems | 1 | 1 | - | 3 | 2 | - |
| Customary Obligations | 2 | 1 | - | 7 | 3 | 2 |
| Distance of block from village | - | - | - | - | 1 | 1 |
| Outside employment | - | - | - | - | 2 | - |
| Over deductions | 2 | - | - | 1 | 4 | - |
| Signed consent form to get tools | - | - | - | - | - | 1 |
| Owner does not pay for work | - | - | 1 | - | - | 1 |
| Waiting for youth group | 1 | - | - | - | - | - |
| Fertiliser too expensive | - | - | - | - | - | 3 |
| Split application | 1 | 2 | - | 3 | 2 | 1 |
| Some for immature palms | 5 | - | - | 1 | - | - |
| Unsure of application method | - | - | - | 1 | - | 1 |
| Late delivery/wet season | - | - | 1 | - | 2 | - |
| Fertiliser is poisonous | - | - | - | - | - | 1 |
| Other | - | - | - | 2 | - | - |

**FERTILISER DISTRIBUTION SURVEY**

| | |
|---|---|
| Division | |
| Block No. | |
| Section | |
| Village/Area | |
| LSS/VOP | |
| Owner | |
| Age | |

| | |
|---|---|
| 1998 Production | |

| Planting # | Area | Planting Date |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |

| | |
|---|---|
| No of bags delivered in 1998 | |
| No bags remaining on block | |

| | | |
|---|---|---|
| How many bags of fertiliser did you receive in 1998 | 0 | |
| | 5 | |
| | 10 | |
| | 20 | |
| | 30 | |
| | 40 | |

| | | |
|---|---|---|
| When did you receive them? | Month | |

| | | |
|---|---|---|
| What is the price of 1 bag? | Kina | |
| | Don’t know | |

| | |
|---|---|
| How many bags have you applied? | |

| | | |
|---|---|---|
| Where did you apply them? | Circle | |
| | Frond pile | |

| | | |
|---|---|---|
| Who applied the fertiliser | Owner | |
| | Wife | |
| | Sons | |
| | Daughters | |
| | All | |
| | Other | |

| | | |
|---|---|---|
| Who attended a field day in 1998? | Owner | |
| | Wife | |
| | Sons | |
| | Daughters | |
| | All | |
| | Other | |

| | | |
|---|---|---|
| Do you think fertiliser is good? | Owner | |
| | Wife | |
| | Sons | |
| | Daughters | |
| | All | |
| | Other | |

| | | |
|---|---|---|
| If yes why is it good | Leaves green | |
| | Bigger bunches | |
| | More bunches | |
| | Don't know | |

| Why didn't you apply all the fertiliser? | Reason | Y/N | Who P/M/ S/D | Rating 1,2,3 |
|---|---|---|---|---|
| SOCIAL | Absent from the block | | | |
| | Not enough labour | | | |
| | Caretaker | | | |
| | Health problems | | | |
| | Custom work/church | | | |
| ECONOMIC | Overdeductions | | | |
| | Waste of money | | | |
| | Signed consent form to get tools | | | |
| | Owner does not pay for work | | | |
| | Waiting for youth group | | | |
| | Did not want it | | | |
| AGRONOMIC | Fertiliser quality | | | |
| | Split application | | | |
| | Some for immature palms | | | |
| | Unsure of application method | | | |
| | Late delivery/wet season | | | |
| | Palm grows too quickly | | | |
| | No extension visit by OPIC | | | |
| | Fertiliser is poisonous | | | |
| | Fertiliser makes weeds grow | | | |
| | Other | | | |

| | |
|---|---|
| Interviewer | |
| Date | |

# HERBICIDES FOR POISONING OIL PALM IN PAPUA NEW GUINEA

## INTRODUCTION

Whilst plantations in Papua New Guinea usually use excavators to fell oil palms in preparation for replanting, herbicides are still used in the plantation sector to kill palms in steep or swampy areas where excavators are unable to operate and during thinning programmes or to remove unproductive palms from a field. Palm poisoning is the only economic method to kill palms on smallholder blocks in preparation for replanting. It would be far too expensive to move an excavator from block to block as a low-loader as well as the excavator would be required.

Sodium Arsenite has been the standard herbicide used for palm poisoning in Papua New Guinea though Milne Bay Estates have been using Glyphosate and Hargy Oil Palms have been using Paraquat. Sodium Arsenite was cheap and very effective but due to its toxicity this product is no longer available on the world market. MSMA was considered as an alternative to Sodium Arsenite but as MSMA is an Arsenical also it has now been withdrawn from sale. Three palm-poisoning trials were conducted in the Hoskins Smallholder Oil Palm Project area to identify a suitable replacement for Sodium Arsenite. The results of these trials show that the most cost effective palm-poisoning chemical is Glyphosate CT applied at a rate of 60 ml per palm in three holes per palm. The disadvantage of Glyphosate is that the palm is not completely dead until 2 months after treatment. MSMA will kill the palm in less than 1 month but was more expensive than Glyphosate CT. MSMA has now been withdrawn from sale worldwide.

## RESULTS

### Trial 1

In the first trial conducted at Kavui in 1997 Sodium arsenite (120 ml per palm) was compared with MSMA (120 ml per palm), Touchdown (45 ml/palm), Glyphosate CT (45 ml/palm) and Paraquat (120 ml/palm). The rates of Touchdown, Glyphosate CT and Paraquat were those recommended for Malaysian conditions. The Touchdown, Glyphosate CT and Paraquat were each applied in either 2 or 3 holes per palm. The Sodium arsenite and MSMA were applied to 2 holes per palm only.

The Touchdown, Glyphosate CT and Paraquat treatments had not killed any palms 5 weeks after treatment and these palms had to be retreated with Sodium arsenite so that the block could be replanted. Fronds of MSMA treated palms were totally desiccated 2 weeks after treatment and the crowns had collapsed one month after treatment. Subsequent trials by NBPOL Smallholder Affairs Department found that 90 ml of MSMA was sufficient to kill a palm. Smallholder Affairs have also determined that 40 ml of Sodium arsenite is sufficient to kill a palm in dry conditions but that 60 ml per palm is required under wet season conditions.

### Trial 2

The second trial was conducted at Sarakolok in 1998. Nufarm representatives suggested that Glyphosate might be more effective if diluted with water. Milne Bay Estates had found that 60 ml of Glyphosate CT was required to kill a palm under PNG conditions. The following treatments were included in this trial.

Table 4.12 Treatments used in Trial 2.

| Chemical | Rate/Palm (ml) | Holes per palm | Method | Dilution |
|---|---|---|---|---|
| Sodium arsenite | 60 | 2 | Chainsaw | Neat |
| Glyphosate | 30 | 2 | Chainsaw | Neat |
| Glyphosate | 30 | 2 | Chainsaw | 50/50 |
| Glyphosate | 60 | 3 | Chainsaw | Neat |
| Glyphosate | 60 | 3 | Chainsaw | 50/50 |
| Glyphosate | 60 | 3 | Spike | Neat |
| Paraquat | 120 | 2 | Chainsaw | Neat |
| Paraquat | 120 | 3 | Chainsaw | Neat |
| Paraquat | 180 | 3 | Chainsaw | Neat |
| Diquat | 120 | 3 | Chainsaw | Neat |

In this trial all of the holes were plugged with a loose fruit after chemical injection to seal the hole. Glyphosate was diluted with water in 2 of the treatments. All other treatments were applied “neat”. The spike was designed in conjunction with OPIC to test whether the oil palm trunk could be drilled manually rather than with a chainsaw.

All of the palms treated with Sodium Arsenite and Diquat were dead 14 days after treatment. After 1 month all the palms treated with Paraquat at 180 ml per palm were dead. After 2 months all of the palms treated with 60 ml of Glyphosate per palm were also dead. The treatments with 30 ml of Glyphosate and 120 ml Paraquat did not result in 100% kill. Diluting with water did not make any difference to the effectiveness of Glyphosate. All of the palms treated with 60 ml Glyphosate into a hole made with the spike were dead after 2 months.

The results of this trial suggested that Glyphosate at 60 ml per palm is the most cost effective palm poisoning chemical. The disadvantage of Glyphosate is the time taken for the palms to die. Paraquat and Diquat are too expensive to use at these rates even though they give a rapid “kill”.

**Trial 3**

Trial 3 was conducted at Buvusi in 1999. In this trial Sodium arsenite (60 ml/palm) was compared with Glyphosate (60 ml/palm) and Diquat at three rates (60 ml, 90ml and 120 ml/palm). All treatments were applied to holes made using a spike. Following treatment all the holes were immediately plugged with a loose fruit.

After 2 months the Glyphosate treatment was the only treatment that resulted in 100% kill. For some unknown reason Sodium arsenite and Diquat were not effective when applied to holes made with a spike.

The spike that was used in this trial proved to be very labour intensive. The data collected in this trial showed that 6 men using 3 spikes would be able to treat 1 hectare only in a day. Up to 8 blocks (16 ha) can be treated in one day by a team of 6 men with 2 chainsaws fitted with augur bits.

DISCUSSION

**MSMA**

MSMA (Monosodium methylarsonic acid) was not used in Trial 2 or 3 as it is an arsenical compound and it was likely that at some time in the future it will also be withdrawn. It is however, a much safer product than Sodium Arsenite. MSMA has an acute oral $LD_{50}$ for young albino rats of 900 mg MSMA/kg. Although MSMA is stable, effective short-term detoxification in the environment would be by dilution/dissipation. At the rates and frequency of application used in the oil palm industry this would not pose an environmental problem. MSMA has since been withdrawn from sale.

The main advantage of MSMA is that it is fast acting. At the latest price of MSMA obtained from Farmset (K16.00 / litre) the cost of chemical to treat 1 palm is K1.44.

**Glyphosate**

At the current price (November 1999) of K13.40 / litre for Nufarm Glyphosate CT the cost of chemical to treat a palm with 60 ml of Glyphosate is K0.80. This is the cheapest option available. Glyphosate is probably the most widely used herbicide in the world and given the competition for market share it is likely that the price of Glyphosate will remain stable. Stocks of Glyphosate are readily available within PNG and every oil palm plantation holds stock of Glyphosate at all times. Glyphosate is a very safe product with an acute oral $LD_{50}$ for rats of 5600 mg a.i./kg. Glyphosate is strongly absorbed by soil, in which decomposition is mainly by microbial activity.

The main disadvantage of Glyphosate is the time taken to kill the palm. Palms treated with Glyphosate are not dead until 2 months after treatment. No data is available on the number of palms that require re-treatment however, even if re-treatment is necessary the cost will only be marginally more expensive than a single treatment with MSMA.

In Hoskins, seedlings are not planted until the poisoned palms have died and been burnt. In the past seedlings which were planted at the same time as the palms were poisoned have been damaged by fire. In Oro, seedlings are currently being planted at the same time as poisoning to minimise the loss of income for smallholders. So far there have not been any losses caused by fire damage.

**Paraquat**

180 ml of Paraquat are required to kill a palm. At the current price of K13.00 / litre the cost of chemical to treat 1 palm is K2.34. This is much more expensive than either Glyphosate of MSMA.

**Diquat**

Diquat was used in 2 trials. It was found to be very effective when applied at a rate of 120 ml per palm with a chainsaw and augur bit. It was not effective when applied to holes made with a spike. The kill in Trial 2 was rapid. However, Diquat is now over K20.00 per litre and is not readily available.

**Application Method**

The palm-poisoning spike was developed so that a smallholder grower could poison his own palms using a "safe" product such as Glyphosate. This method has been tried and found to be too slow and labour intensive. A smallholder would probably be more likely to fell his palms with an axe than use the spike. It could be used for thinning on the plantation if chainsaws with augur bit attachments are not available however, Haella Plantation have found that a man with an axe can remove unproductive palms more efficiently than a poisoning team with a chainsaw and augur bit attachment. The most efficient method to apply chemical to large areas of palms is to use a chainsaw fitted with an augur bit.

A plastic measuring pipette fitted with a rubber bulb is required to measure the correct quantity of chemical. The pipette should preferably be graduated and be capable of measuring up to 30 ml. NBPOL uses a battery acid tester after the hygrometer has been removed. However these glass pipettes are not graduated and must be calibrated. Unfortunately, calibrated drenching guns used with some insecticides and animal health products contain metal springs that are quickly corroded by Glyphosate.

**Recommended Chemical**

Glyphosate (60 ml / palm) is the most cost effective treatment currently available.

Three holes 2 cm in diameter should be drilled in each palm to a depth of 15 cm at a downward angle. After the hole is drilled, sawdust must be removed from the hole with a stick. Chemical should be applied immediately, following which the hole should be plugged with a loose fruit to prevent water entering the hole.

# 5. ENTOMOLOGY

(R. Caudwell)

## THE INTEGRATED MANAGEMENT OF SEXAVA IN THE OIL PALM AGROECOSYSTEM IN PAPUA NEW GUINEA.

### INTRODUCTION

The principal pests of oil palm in PNG are a group of species from the Tettigoniidae family (Orthoptera), known as bush crickets, long-horned grasshoppers or treehoppers. This group of species is collectively called Sexava. Three species of Sexava are pests of oil palm in PNG, *Segestes decoratus* Redtenbacher, *Segestidea defoliaria* Uvarov and *Segestidea novaeguinea* Brancsik. These insects cause damage by feeding on the oil palm fronds and defoliation levels can be very severe where high population densities occur.

PNGOPRA set up a project in 1995 to research and develop Sexava biological control and IPM (Caudwell and Orrell, 1997; Kathirithamby *et al.*, 1998; Caudwell, 1999). This work was partly funded through the European Union's STABEX aid scheme, and involved collaboration between scientists at PNGOPRA, Oxford University (UK) and the International Institute of Biological Control (UK). A second phase of this project commenced in January 2000, involving field trials with Sexava biocontrol agents in West New Britain.

In line with the general philosophy of integrated pest management a system was developed with the following components: (1) a knowledge of the biology and ecology of the pest, (2) economic thresholds, (3) monitoring system for the pest, (4) precise targeting of chemical control agents, (5) biological control and (6) cultural and physical controls. This IPM system is summarized in Figures 1 and 2.

### CHEMICAL CONTROL

The control of a large and rapidly increasing Sexava population is dependent on the use of precisely targeted chemical control agents. This involves the use of trunk-injected monocrotophos (Nuvacron or Azodrin) (Sarjit, 1986; Matthews, 1992). The control of Sexava using trunk injection involves the application of monocrotophos (10ml of 400ml ai/l formulation) into a single 1.5cm diameter hole, 15cm deep and drilled at a 45$^o$ angle into the trunk, 1m above the ground. Monocrotophos persists for approximately 60 days in the leaf tissue of the palm. A follow up treatment is required after approximately 12 weeks to coincide with the emergence of nymphs from eggs laid by the original pest population.

The improved monitoring system that has been developed as a component of the IPM system has resulted in Sexava outbreaks being reported very early, and has therefore enabled chemical treatment to be undertaken before the populations have had time to spread and affect large areas of oil palm. The oil palm growing areas in West New Britain that required chemical treatment for economically significant levels of Sexava damage during 1999 area shown in Table 1. From Table 5.1 it can be seen that during the year there were 12 outbreaks that were recommended for chemical treatment, with a total area of approximately 548 ha. Approximately 1370 litres of monocrotophos were used for these treatments, at a total insecticide cost of 37,100 kina and a unit insecticide cost of 67.7 kina/ha. The oil palm growing areas in West New Britain that required chemical treatment for economically significant levels of Sexava damage during 1996, 97,98 and 99 are shown in Table 5.2. From Table 5.2 it can be seen that during 1996 a total of 910 ha were treated at an insecticide cost of 42,330 kina, during 1997 215 ha were treated at a cost of 13,819 kina, and during 1998 36 ha were treated a cost of 2,043 kina.

Figure 5.1 Strategies for Sexava IPM

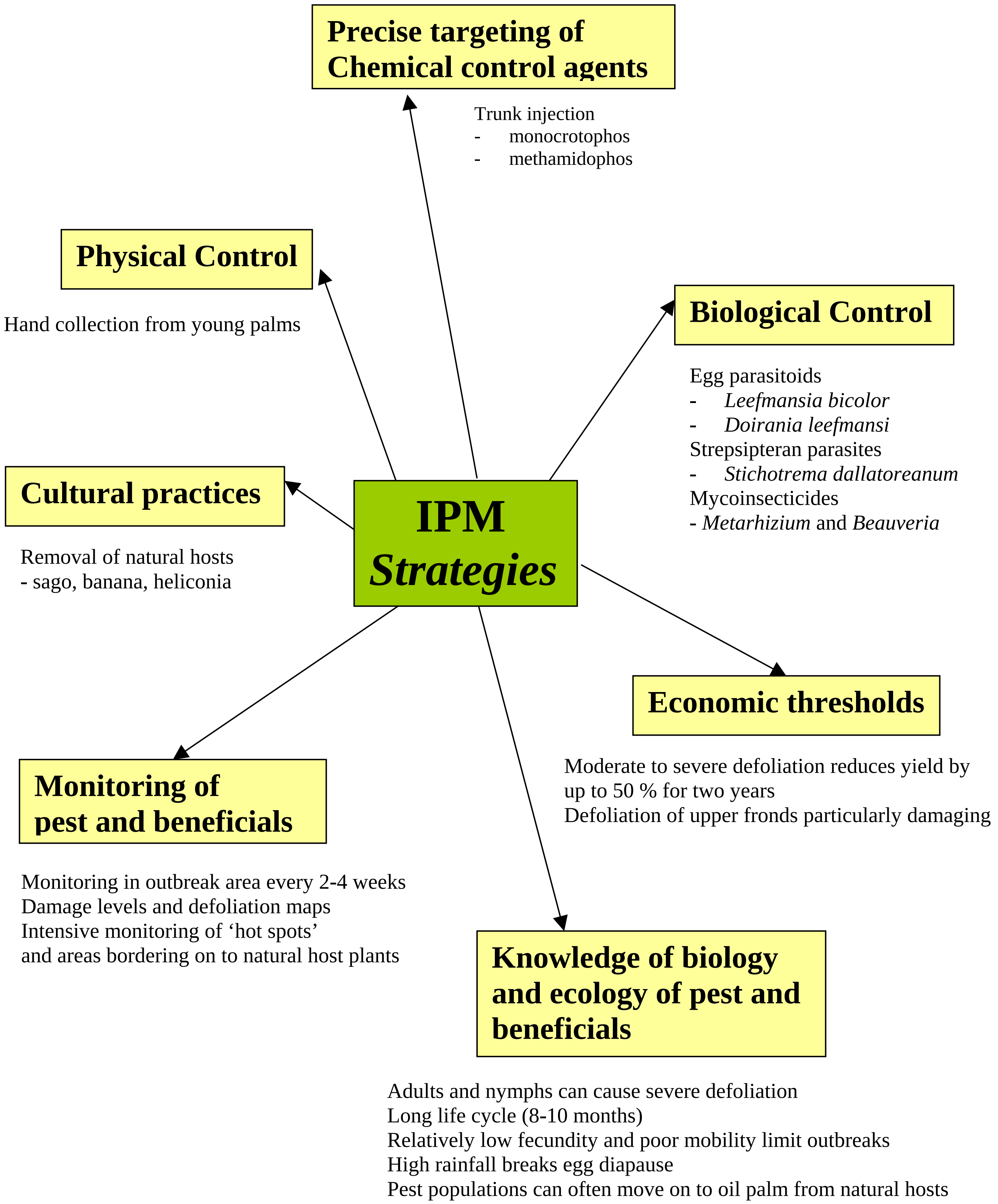


Figure 5.2 Schematic representation of the integrated pest management system developed for Sexava pests of oil palm in Papua New Guinea.

## IPM *Strategies*

### Precise targeting of chemical control agents

Use of trunk-injected insecticide
- monocrotophos
No indiscriminate use of insecticides
Monocrotophos persists for 60 days in leaf tissue of oil palm
Follow up treatment after 12 weeks
Timed to coincide with emergence of second generation eggs

### Biological control

1. Fungal pathogens
Possible use of deuteromycetes fungi
- Metarhizium and Beauveria
Surveys undertaken to find fungal isolates from Sexava hosts and soil
No effective isolate yet found
2. Strepsipteran parasites
Stichotrema dallatoreanum infects Sexava in some oil palm areas
Reduces feeding and reproduction in Sexava host
Parasite will infect species of pest Sexava from West New Britain
Field trials to test if parasite can be used for biocontrol of these species
3. Egg parasitoids
Leefmansia bicolor and Doirania leefmansi reared as biocontrol agents
Several million released each year
Effective in combination with other methods

### Cultural and physical control

Use of agronomic practices to prevent or suppress outbreaks
Removal of natural host plants from vicinity of oil palm areas
- sago, banana, heliconia
Nymphs and adults prefer shade
Oil palm must be kept well pruned to avoid old fronds giving shade
Hand collection of nymphs and adults from young oil palms

### Economic thresholds

Moderate to severe defoliation reduces yields by approx. 44% for up to 2 ½ years
Sexava populations poorly regulated
Light defoliation (<10%) tends to develop into moderate to severe damage
Thresholds based on defoliation levels not pest numbers, light defoliation used as threshold

### Monitoring system

Three stages: alert, census, action
Alert stage undertaken by plantation staff and smallholder growers
Given regular training in entomology
Most oil palm workers are able to recognize early signs of insect damage
Census stage undertaken by specialist entomology units
Visual assessments and scoring of defoliation levels into three categories
- light, moderate, severe
Defoliation maps drawn up

### Knowledge of biology and ecology of the pest

Adults and nymphs can cause severe defoliation of oil palm
Most eggs laid in soil at base of oil palms
Females lay up to 40 eggs, take 40-100 days to hatch
Nymphs climb up to oil palm canopy and feed on fronds
Long life cycle (8-10 months)
Relatively low fecundity and poor mobility limit outbreaks
High rainfall results in synchronous egg hatch
Adults and nymph are more active during wet season
Pest populations can often move on to oil palm from natural hosts
- sago, banana, heliconia

Table 5.1 The oil palm growing areas in West New Britain that required chemical treatment for economically significant levels of Sexava damage in 1999

| Date | Plantation / Smallholders | Site | Approximate Area (ha) | Volume of formulation |
|---|---|---|---|---|
| 02 Jan | Hoskins smallholders | Sarakolok | 76 | 190 |
| 2 Mar | NBPOL Numundo | Navarai | 150 | 375 |
| 11 Mar | Hoskins Smallholders | Sarakolok | 12 | 30 |
| 14 June | Hargy Oil Palms | Navo | 90 | 225 |
| 05 Aug | Hoskins smallholders | Kapore | 36 | 90 |
| 05 Aug | Hoskins smallholders | Sarakolok | 4 | 10 |
| 05 Aug | Hoskins smallholders | Siki | 8 | 20 |
| 18 Aug | NBPOL Mosa | Bebere | 30 | 75 |
| 18 Oct | Hoskins smallholders | Sarakolok | 20 | 50 |
| 18 Oct | Hoskins smallholders | Siki | 4 | 10 |
| 18 Nov | Hargy Oil Palms | Navo | 54 | 135 |
| 01 Dec | Bialla smallholders | Soi | 64 | 160 |
| | | TOTAL | 548 | 1370 |
| Percentage of WNBP oil palm growing area treated | | | | 1.37% |
| Insecticide costs – Nuvacron/Azodrin K27.08/l | | | | 37,100 |
| Unit insecticide costs – per hectare | | | | 67.7 k/ha |

Table 5.2 The oil palm growing areas in West New Britain that required chemical treatment for economically significant levels of Sexava damage in 1996, 97,98 and 99

| Year | Approx. area (ha) | Volume of formulation (l) | Insecticide cost (kina) | Unit insecticide cost (K/ha) |
|---|---|---|---|---|
| 1996 | 910 | 2,275 | 42,330 | 46.5 |
| 1997 | 215 | 538 | 13,819 | 64.27 |
| 1998 | 36 | 90 | 2,043 | 56.75 |
| 1999 | 548 | 1370 | 37,100 | 67.7 |

BIOLOGICAL CONTROL

**Egg Parasitoids**

The first recorded use of Sexava egg parasitoids in PNG was in 1933, when the Hymenopteran egg parasitoids *Leefmansia bicolor* and *Doirania leefmansi* were introduced from Amboina in the Moluccas and established in a number of coconut growing areas on New Hanover Island (Froggatt, 1935). PNGOPRA has reared these two parasitoids in the laboratory for several years. They are reared on sexava eggs and then released into oil palm growing areas where low-level sexava populations are present. Several million of these egg parasitoids are usually released into the field each year. Table 3 gives details of the releases of egg parasitoids during 1999.

The precise role of the egg parasitoids in regulating sexava populations remains unclear. The vast majority of sexava eggs are laid in the soil at the base of oil palm trees (Young, 1985). However, Froggatt and O'Connor (1940) reported that the highest levels of parasitism by *L. bicolor* and *D. leefmansi* occurs in eggs laid on the trunks, and in the fibres and crowns, and that it is relatively low in eggs laid in the soil. Evidence from the field seems to suggest that the egg parasitoids play some role in regulating sexava populations in the oil palm agroecosystem (R. Prior, personnal communication). The egg parasitoids are a useful biocontrol tool for sexava IPM as they can be used in conjunction with trunk-injected insecticides to manage high-level pest damage, and can also be combined with cultural and physical control methods to provide long-term regulation of low-level populations of sexava.

Table 5.3 The oil palm growing areas in West New Britain in which Sexava egg parasitoids were released during 1999.

| Location | Number of parasitised *L.bicolor* eggs | Number of adult *L.bicolor* expected to emerge |
|---|---|---|
| ***Plantations*** | | |
| Dami | 850 | 17,000 |
| Navarai | 1,818 | 36,360 |
| Navo | 1020 | 20,400 |
| Bebere | 330 | 6,600 |
| ***Smallholders*** | | |
| Sarakolok | 1,480 | 29,600 |
| Kapore | 680 | 9,200 |
| Siki | 1170 | 23,400 |
| Wilelo | 220 | 4,400 |
| Tiauru | 560 | 11,200 |
| Sale | 350 | 7,000 |
| Galai | 110 | 2,200 |
| Mamota | 120 | 2,400 |
| ***Village Oil Palm*** | | |
| Banaule | 330 | 6,600 |
| Morokia | 110 | 2,200 |
| Galilo | 120 | 2,400 |
| Silanga | 120 | 2,400 |
| ***Coconuts*** | | |
| Cape Gloucester District | 1,496 | 29,920 |

**Strepsipteran Parasites**

O'Connor (1959) reported that in certain areas of PNG sexava adults and nymphs were parasitized by a Strepsipteran, *Stichotrema dallatorreanum* Hofeneder. This species belongs to the family Myrmecolacidae, and Ogloblin (1939) reported that the males of this family parasitize a different host from the female. In PNG, female *S. dallatorreanum* parasitize sexava, but little is know about the males that are thought to parasitize larva of the ant, *Camponotus papua* (Young, 1987a). High levels of parasitism (30-40%) of the sexava species, *S. novaeguinea* by *S. dallatorreanum* occurs in oil palm growing areas in mainland PNG (PNGOPRA, 1998) and chemical control has not been required on plantations in these areas for many years. Whereas in West New Britain regular intervention has been required to control *S. defoliaria* and *S. decoratus*. *S. dallatorreanum* has not been reported to parasitize these two species of species of sexava in West New Britain.

The first phase of the sexava project concentrated on the development of the use of *S. dallatorreanum* as a biological control agent for sexava. A series of infectivity trials were undertaken in the laboratory to assess whether the parasite would infect the two species of sexava that are pests of oil palm in West New Britain. Nymphs of the two species were exposed to first instar *S. dallatorreanum* in replicated and controlled cage experiments. The infection levels in test insects from the two species ranged from approximately 70-90%, relative to the healthy control insects (see Table 5.4).

Field studies were undertaken to survey for male *S. dallatorreanum.* However, relatively few males of the parasite were found during the study period and the role of the males in the life history of the parasite remains unclear. Kathirithamby (personnel communication) suggests that the female *S. dallatorreanum* that infect *S. novaeguinea* in the oil palm growing areas of mainland PNG may be parthenogenetic, or may express this mode of reproduction under certain conditions. In accordance with this, Kathirithamby (personnel communication) also suggests that first instar *S. dallatorreanum* may not be sexually dimorphic, and that reproduction occurs by a combination of parthenogensis, polyembryony, and vivaparity.

The next phase of the sexava project aims to introduce the parasite into the oil palm growing areas of West New Britain. Attempts will be made to get it established in field populations of *S. defoliaria* and *S. decoratus*, and this will first be done in a number of trial areas. Nymphs of the two species will be infected with *S. dallatorreanum* in the laboratory, using the methodology developed during the infectivity trials. Infected sexava will then be released into the trial areas at regular intervals over a period of several months. Surveys will then be undertaken to assess the degree of parasitism in the field populations of sexava. Field studies will also be carried out to determine the possible role, if any, of males in the life history of *S. dallatorreanum.* This work commenced in January 2000 and will be reported in next years Annual Report.

Table 5.4 A summary of the infectivity trials using *S. defoliaria* and *S. decoratus* exposed to first instar *S. dallatorreanum*

| | **Segestidea defoliaria** | | **Segestes decoratus** | |
|---|---|---|---|---|
| | Treated | Control | Treated | Control |
| Percentage infection by *S. dallatorreanum* | 88% | 0% | 70% | 0% |

**Monitoring System for Sexava**

In other oil palm growing countries effective monitoring systems have been developed for use in the management of insect pests (Chung *et al.* 1995). Wood (1976) describes a system that is divided into three stages: alert, census and action. The alert stage requires the training of plantation workers to recognize early damage symptoms, and then to report it to plantation managers, who then inform specialist entomology units. The census stage is activated once the damage has been reported to the entomology unit and involves field studies to determine the pest species, developmental stage, pest numbers and height of the canopy. The information from these studies is then used to recommend appropriate action strategies. This system has been used in for oil palm in Malaysia for many years, and improvements included computerized data processing and the generation of colour coded maps to facilitate decision making in IPM.

In PNG up until 1995 poor monitoring meant that pest damage was usually not found until it had become severe, and subsequent control operations then occurred too late to prevent significant economic yield losses. Oil palm is harvested on a 10-15 day cycle, so most plantation fields or blocks are visited 2-3 times a month for harvesting, pruning and general maintenance. It therefore seemed appropriate to set up a similar system to the one described by Wood (1976), whereby the initial detection component of the monitoring system, or alert stage, be undertaken by plantation workers and smallholder growers. Since 1995 we have therefore undertaken a regular programme of training in entomology for plantation workers, smallholder growers, and extension officers. This has involved both formal and informal training, as well as features on rural radio stations. Table 5 summarizes our training schedule for 1999. The result is that most people that are directly associated with oil palm growing in West New Britain Province are now able to recognize the very early signs of insect damage.

Table 5.5 A summary of the entomology training schedule for 1999

| Month | Location | Activity |
|---|---|---|
| January | OPIC Bialla | Field day at Wilelo |
| May | OPIC Popondetta | 3 field days in Oro Province |
| | OPIC Hoskins | 2 field days at Hoskins |
| | OPIC Bialla | Field day at Noau |
| June | OPIC Popondetta | 2 field days in Oro Province |
| August | OPIC Popondetta | 1 field day in Oro Province |
| | OPIC Buvussi | 3 field days at Buvussi |
| September | OPIC Kavui | 3 field days at Kavui |
| | OPIC Nahavio | 4 field days at Nahavio |
| | NBPOL Garu and Healla | Training day |
| | OPIC Bialla | Field day at Mamota |
| | OPIC Bialla | Field day at Silanga |
| October | OPIC Hoskins | 2 field days |
| | NBPOL Garu and Healla | Training day |
| | OPIC Bialla | Field day at Bialla |
| | OPIC Siki | 3 field day at Siki |
| | OPIC Bialla | Field day at Bialla |
| November | OPIC Bialla | Field day at Wilelo |
| December | OPIC Bialla | Field day at Soi |

**Conclusions**

Since 1996 an integrated pest management system has been developed the control of sexava. This IPM system is sustainable and environmentally acceptable to the industry. The knowledge of the biology and ecology of the main pest, although far from complete, is enough to enable effective decision making in the other components of the IPM system. The impact of the pest on the yield components of the crop is sufficiently well understood to enable economic thresholds to be determined. The economic thresholds are effective at a field level, and can be used in the area-wide monitoring system for the pest. Pest monitoring is efficient, as evidenced by the regular detection of low level pest damage, and it requires a relatively small input from specialist entomologists. There is no indiscriminate use of insecticides, with the trunk-injection technique providing precise targeting of chemical control agents, thus preventing contamination of the environment, as well as preserving beneficial and non-target organisms. Furthermore, during the last few years relatively small areas of oil palm have required insecticide application by trunk injection.

Future research involving the development of novel agents for biological control is likely to improve this IPM system still further. Successful introduction of the parasitic Strepsipteran, *S. dallatorreanum* into the oil palm growing areas of West New Britain may have a significant impact on the pest status of the two species of sexava in these areas. This is likely to result in further reductions in the use of insecticides, and therefore provide further cost benefits to the oil palm industry in PNG.

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**A STUDY OF DIPTERAN AND HYMENOPTERAN BIODIVERSITY ASSOCIATED WITH THE OIL PALM AGROECOSYSTEM IN PNG**

## INTRODUCTION

A great deal of agriculture and plantation forestry is based on the concept that ecosystems with low species and genetic diversity of crop plants are more efficient in maximising crop yields. Anderson (1996) suggested that this premise is broadly true, but argued that there are costs of uniformity in terms of the sensitivity of monocultures to outbreaks of pests and pathogens, and the economic and environmental costs of subsequent management operations. An alternative approach has been to re-establish the 'natural balance' of plantation ecosytems by the conservation, augmentation and introduction of natural enemies and beneficial organisms (Mariau 1991; 1993).

In terms of insect pest management by biological control the role of diversity at the functional level is controversial, with many authors claiming for example that increased parasitoid diversity generally results in better population regulation (Ehler, 1990). However Anderson (1996) contended that historical records show that diversity is not necessarily associated with the degree of pest control. There are many examples of successful biological control of insect pests in palm plantations that have involved the introduction of a single predator, parasitoid, or pathogen (Talhouk, 1991, Mariau, 1991; 1993).

In its early stages the oil palm plantation is a simplified ecosystem made up of the oil palm *Elaeis guineensis* together with the cover crop, usually the legume *Pueraria spp.* The cover crop, once it is well established, leaves very little space for other plants to grow. As the plantation matures, shade from the palms slows down the development of the cover crop, which is gradually replaced by other plant species.

Bagworms, *Mahesena corbetti* Tams and *Metisa plana* Walker (Lepidoptera: Psychidae), are occasional pests of oil palm in Papua New Guinea. Moderate to severe defoliation by these pests can reduce subsequent yield of oil palm by as much as 44% (Wood *et al.,* 1973; Wahid, 1993). Management of Bagworms in PNG is dependent on regular population monitoring and surveying, combined with the timely application of trunk injected monocrotophos (Nuvacron or Azodrin) (Sarjit, 1986; Matthews, 1992).

The bagworm has many species of natural enemies, and Wood (1971) provided circumstantial evidence that these were important in the regulation of bagworm populations. By spraying bagworm populations with a broad spectrum, long residual, contact insecticide Wood (1971) was able to demonstrate the loss of population regulation resulting from the disruption of this pest – natural enemy balance. In a more recent study Basri *et al.* (1995) reported that natural enemies played a key role in suppressing Bagworm populations in the oil palm agroecosytem.

In PNG there are a number of areas where Bagworms outbreaks have become rather persistent during the last few years. Observations from the field suggest that persistent outbreaks are occurring in areas of intensively managed plantation. In these areas the widespread use of herbicides for ground and epiphyte spraying has resulted in a loss of ground cover in the plantations. Beneficial soft weeds and herbaceous plants provide a source of food for the free living stages of Dipteran and Hymenopteran natural enemies that play a key role in regulating bagworm populations. The loss of these, as well as reductions in the general levels of ground cover, may have a negative effect on insect biodiversity, particularly with regard to populations of Dipteran and Hymenopteran natural enemies of Bagworms.

The objectives of this study are:

1. To determine the Dipteran and Hymenopteran biodiversity associated with the oil palm agroecosystem in areas that have experienced persistent outbreaks of Bagworms.
2. To assess the impact of management practices on Dipteran and Hymenoptera biodiversity, with particular reference to population levels of Bagworm natural enemies.

## MATERIALS AND METHODS

The site used for this study was located at Kautu plantation, which forms part of the Kapiura plantation group at New Britain Palm Oil Limited, West New Britain Province, Papua New Guinea. This plantation was developed in 1985 from low-lying Sago swamp with a high water table. It has a total area of approximately two thousand hectares. The combination of shade resulting from the dense palm canopy, and swampy soil conditions resulting from the high water table has meant that ground cover has been difficult to establish. This problem with lack of ground cover has been confounded by the widespread and intensive use of herbicides for the maintenance of clear circles and paths, as well as for the removal of trunk epiphytes.

A total of four experimental blocks were used for the study. Each trial block was 30 hectares in area, and each of the four separated from each other by at least 1km. All four of the blocks had low level bagworm populations, with light defoliation to the oil palms contained within them. None of the blocks had received chemical treatment during the previous two years.

All four blocks were epiphyte sprayed using Gramoxone in January 1996. However only two of the blocks were subsequently epiphyte sprayed in January 1997 and January 1998, the other two left untreated. The experimental design therefore consisted of two treatments – epiphyte sprayed and untreated controls, with two replicates used for each treatment. For future work we intend to keep the control blocks unsprayed for several years in order to re-establish ground cover and beneficial weeds. This will involve eliminating the practice of epiphyte spraying, as well as restricting the use of herbicides for the maintenance of harvesting paths and circles.

Malaise traps were used to sample the Dipteran and Hymenopteran biodiversity associated with the four experimental blocks over a three-month period from March to June 1999. These are passive traps, designed to catch flying insects at any time during the day or night, and are particularly effective for catching Hymenoptera and Diptera.

The trap is divide into two parts; a tent like structure and a collecting head. The former is made of polyester fabric netting, and is erected as a square pyramid with the corners attached to ropes and pegged to the ground. The bottom half of the tent is made up of four flaps that are attached to the underside of the corners of the top sector and extend to the top of the pyramid. Flying insects trapped in these flaps crawl to the top of the structure where the collecting head is situated. The collecting head is made of hard clear plastic and consists of a cylindrical chamber with a fitted cap. A truncated funnel is located inside the base of the cylinder, and is inverted to allow trapped insects to enter the chamber from the netting. The trap head is removable and is fixed into a plastic housing on top of the netting and secured with a rubber band.

The malaise traps were put out for seven days every second week during the study period. One trap was placed in the centre of each experimental block. The traps were emptied every second day and the specimens taken back to the laboratory. The specimens were then killed by freezing, placed in 70% ethanol, and sorted into Diptera and Hymenoptera. Insects from other orders were discarded. At the end of the three-month trapping period the Diptera and Hymenoptera were identified to family level. It was also noted whether these insects were known Bagworm natural enemies.

## RESULTS

The trap-catch data for the survey period is summarized in Tables 6 and 7, and full details given in Table 5.8. Table 5.9 gives brief details of the Dipteran and Hymenopteran families represented in the 1999 trials.

Table 5.6 Summary of trap-catch data for 1999

| Site | Diptera | | Hymenoptera | |
|---|---|---|---|---|
| | No families | No individuals | No families | No individuals |
| 1 – sprayed | 17 | 1949 | 7 | 36 |
| 2 – not sprayed | 16 | 2752 | 5 | 26 |
| 3 – not sprayed | 16 | 3637 | 4 | 46 |
| 4 – sprayed | 16 | 3148 | 3 | 19 |
| Total sprayed | 33 | 5097 | 10 | 55 |
| Total not sprayed | 32 | 6389 | 9 | 72 |
| Chi-square | 0.062 | 145.33 | 0.053 | 2.28 |
| Probability | $P>0.05^{NS}$ | $P<0.001^{***}$ | $P>0.05^{NS}$ | $P>0.05^{NS}$ |

Of these families the Ichneumonoidea, Braconidae, and Tachinidae are known to contain species that are Bagworm natural enemies. Table 7 summarizes the number of individuals from each of these families caught at sites 1-4 during the survey period.

Table 5.7 The number of individuals from the families Ichneumonoidea, Braconidae and Tachinidae caught at sites 1-4 during the survey period

| | Number of individuals from families of Bagworm natural enemies | | |
|---|---|---|---|
| Site | Ichneumonoidea | Braconidae | Tachinidae |
| 1 – sprayed | 1 | 18 | 0 |
| 2 – not sprayed | 1 | 14 | 1 |
| 3 – not spayed | 0 | 9 | 0 |
| 4 – sprayed | 0 | 6 | 1 |
| Total sprayed | 1 | 24 | 1 |
| Total not sprayed | 1 | 23 | 1 |
| Chi-square | Ns | 0.0212 | Ns |
| Probability | Ns | $P>0.05^{NS}$ | Ns |

Table 5.8 Trap catch data for 1999 Biodiversity trials

*Plot One (sprayed):*

| Diptera Family | No individuals | Hymenoptera Family | No individuals |
|---|---|---|---|
| Asilidae | 2 | Braconidae | 18 |
| Cecidomyiidae | 941 | Elasmidae | 3 |
| Ceratopogonidae | 18 | Eulophidae | 1 |
| Chironomidae | 76 | Formicidae | 24 |
| Culicidae | 8 | Ichneumonidae | 1 |
| Dolichopodidae | 62 | Pompilidae | 1 |
| Drosphilidae | 3 | Vespoidea | 6 |
| Micropezidae | 2 | | |
| Muscidae | 1 | | |
| Mycetophilidae | 29 | | |
| Periscelidae | 1 | | |
| Phoridae | 16 | | |
| Psychodidae | 498 | | |
| Sciaridae | 17 | | |
| Stratiomyidae | 109 | | |
| Tephritidae | 1 | | |
| Tipulidae | 165 | | |
| Total No families | 17 | Total No families | 7 |
| Total No individuals | 1949 | Total No individuals | 36 |

*Plot two (not sprayed)*

| Diptera Family | No Individuals | Hymenoptera Family | No Individuals |
|---|---|---|---|
| Asilidae | 2 | Braconidae | 14 |
| Cecidomyiidae | 1600 | Formicidae | 9 |
| Ceratopogonidae | 35 | Ichneumonidae | 1 |
| Chironomidae | 241 | Pompilidae | 1 |
| Culicidae | 8 | Scoliidae | 1 |
| Dolichopodidae | 119 | | |
| Drosphilidae | 3 | | |
| Micropezidae | 5 | | |
| Muscidae | 1 | | |
| Mycetophilidae | 110 | | |
| Phoridae | 13 | | |
| Psychodidae | 447 | | |
| Sciaridae | 25 | | |
| Stratiomyidae | 32 | | |
| Tachinidae | 1 | | |
| Tipulidae | 110 | | |
| Total No families | 16 | Total No families | 5 |
| Total No individuals | 2752 | Total No individuals | 26 |

*Plot three (not sprayed)*

| *Diptera Family* | *No Individuals* | *Hymenoptera Family* | *No Individuals* |
|---|---|---|---|
| *Cecidomyiidae* | *2377* | *Agaonidae* | *1* |
| *Ceratopogonidae* | *25* | *Braconidae* | *9* |
| *Chirinomidae* | *242* | *Elasmidae* | *2* |
| *Culicidae* | *9* | *Eucoilidae* | *1* |
| *Dolichopodidae* | *96* | *Formicidae* | *25* |
| *Drosphilidae* | *4* | *Scoliidae* | *1* |
| *Lauxaniidae* | *1* | *Vespidae* | *7* |
| *Muscidae* | *1* | | |
| *Mycetophilidae* | *124* | | |
| *Mycropezidae* | *4* | | |
| *Phoridea* | *58* | | |
| *Psychodidae* | *511* | | |
| *Sciaridae* | *26* | | |
| *Stratiomylidae* | *13* | | |
| *Syrphidae* | *1* | | |
| *Tipulidae* | *145* | | |
| *Total No families* | *16* | *Total No families* | *4* |
| *Total No Individuals* | *3637* | *Total No individuals* | *46* |

*Plot four (sprayed)*

| Diptera Family | No Individuals | Hymenoptera Family | No Individuals |
|---|---|---|---|
| Cecidomyiidae | 1865 | Braconidae | 6 |
| Ceratopogonidae | 50 | Diapriidae | 1 |
| Chironomidae | 240 | Formicidae | 12 |
| Culicidae | 3 | | |
| Dolichopodidae | 128 | | |
| Drosphilidae | 3 | | |
| Muscidae | 2 | | |
| Mycetophilidae | 15 | | |
| Mycropezidae | 1 | | |
| Phoridea | 26 | | |
| Pompilidae | 2 | | |
| Psychodidae | 638 | | |
| Sciaridae | 19 | | |
| Stratiomyiidae | 23 | | |
| Tachinidae | 1 | | |
| Tipulidae | 132 | | |
| Total No families | 16 | Total No families | 3 |
| Total No individuals | 3148 | Total No individuals | 19 |

Table 5.9 Details of the insect families represented in the biodiversity trials for 1999.

| *DIPTERA* | |
|---|---|
| *Asilidae* | *A very large family of predatory flies. Adults live mainly in open forest country and are aggressive predators. Feed on Dipterans and Hymenopterans, attack almost all insects. Eggs laid in soil or attached to leaves or bark of plants.* |
| *Cecidomyiidae* | *Gall midges. A large, cosmopolitan family of small to minute flies, most with delicate wings and reduced venation. Most live in galls or other deformities in living plants.* |
| *Ceratopogonida* | *Sand flies and biting midges. A widespread family of small to minute blood-sucking flies. A few genera have species with wing spans up to 5mm, but most are much smaller. All have elongate, piercing mouth-parts, usually associated with a predatory or blood sucking habit.* |
| *Chironomidae* | *Midges. A large, cosmopolitan family, diverse in form but mostly small, delicate flies, some superficially resembling mosquitoes. Adults are common, particularly in vicinity of bodies of water. Larvae are aquatic.* |
| *Culicidae* | *Mosquitoes. A large family, with characteristic venation and with scales along the veins and posterior margin of the wing. Most have elongate mouth-parts, forming typical proboscis.* |
| *Dolichopodidae* | *Large family of flies, with a rather slender build and moderate to small size. Adults are very common, and often found on foliage, tree trunks etc. All are predacious, some prey on small arthropods, and some are useful predators on pest species of aphids etc.* |
| *Drosphilidae* | *Distinguished mainly by the position of the reclinate fronto-orbital bristle near the eye and absence of the mesopleural bristle. Larvea of most species are fungivorous, some eating yeasts in decaying fruit, others recorded ar predators / parasitoids of Hemiptera.* |
| *Lauxaniidae* | *Largest and commonest of acalyptrates with a wide range of feeding habitats such as mangrove, grassland, and forest. Larvae live in rotting vegetation.* |
| *Muscidae* | *A large and variable family, with many species of economic and veterinary importance.* |
| *Mycetophilidae* | *Fungus gnats. Number highest in wet areas. Adults are mainly crepuscular or nocturnal. Larvea are mostly peripneustic, and usually found in association with fungi.* |
| *Micropezidae* | *Larvae live in decaying wood and other vegetable material. Adults have elongated legs.* |
| *Phoridae* | *Family of small to minute flies, with characteristic hunchbacked appearance. Larval habits vary greatly. Many are scavengers in carrion and other decomposing organic matter.* |
| *Periscelidae* | *Size small to moderate. Found in wet forest areas. Larvae found from wounds in tree-trunks, and from phytoelmata of monocotyledonous plants.* |
| *Psychodidae* | *Moth flies. A cosmopolitan family of small flies. Larvea feed on decomposing organic matter, usually at the edges of freshwater habitats or in rotting vegetation and dung.* |
| *Sciaridae* | *Extremely widespread family. Adults are crepuscular or nocturnal. Larvea, usually wit pale body and shiny black head-capsule, tend to be gregarious and are found in rotting vegetable matter or highly organic soils.* |
| *Sttratiomyidae* | *A cosmopolitan family, found in swampy areas, both coastal and montane. A few genera contain some good wasp mimics. Larvea are distinctive, being elongate, flattened, with permanently exserted heads, and densely shagreened cuticles.* |
| *Syrphidae* | *Hover flies. Common and widesread family of flies with yellow markings on body. Some mimic and fly in association with bees and wasps. Some are* |

| | |
|---|---|
| | pollinators. |
| *Tachinidae* | *An immense family. Most species are stout bodied, strongly bristles, and drab in colouration. Adults are ubiquitous, larvea are all endoparasitic in other athropods, principally insects. Reproduction is oviparous or ovoviviparous. Parasite leaves host to pupate in soil. Family includes parasites of Lepidoptera, Coleoptera, Hemiptera and Orthoptera.* |
| *Tipulidae* | *Crane flies, daddy-long-legs. Found in moist habitats. Larvea are hemicephalic, and found either in water or wet soil or decomposing vegetable matter.* |
| *Tephritidae* | *Larvae of this family are fruit insects.* |

| *HYMENOPTERA* | |
|---|---|
| *Agaonidae* | *Small insects, 1.0-10mm in length. Family is associated with the Fig tree.* |
| *Braconidae* | *Minute to large (1-80mm) solitary or gregarious parasites of immature or adult stages of various insects. Females usually attack larvae but some oviposit into eggs and development is delayed until the host larva is nearly mature.* |
| *Diapriidae* | *Small (1-6mm). Most are endoparasitic on prepupae or pupae of Diptera. Adults are most common on low vegetation on moist, shaded habitats, in areas of high rainfall. Often wings are reduced or absent, especially in females.* |
| *Elasmidae* | *Minute insects (1-3mm long). Mostly ectoparaties of larvae of Lepidoptera or hyperparasites of Lepidoptera and Diptera in leaf mines.* |
| *Eucoilidae* | *Distinguished by a raised plate on scuttellum. Most are endoparasitic, some of Diptera.* |
| *Eulophidae* | *Include ecto- and endoparasites and hyperparasites of a variety of hosts, especially larvae of Lepidoptera and Diptera in leaf mines. A few are phytophagous.* |
| *Formicidae* | *Eusocial ants with wingless worker caste* |
| *Ichneumonidae* | *Minute to very large (1.5-120mm) solitary or gregarious parasites of larvea and pupae of various endopterygote insects. Adults frequent flowers, extrafloral nectaries and dew drops, especially in the early morning. Eggs attached externally to host cuticle or within host's body. Pupation occurs in host's own pupation chamber or feeding recess.* |
| *Scoliidae* | *Mostly large (9-36mm), stout bodied, densely hairy and extensively modified for fossorial habit. Females dig into soil or wood, paralyse coleopterous larvae and deposit egg transerversely.* |
| *Pompilidae* | *Small insects (0.5-6mm). Ectoparasites or endoparassites of Lepidoptera and Diptera in leaf mines.* |
| *Vespoidea* | *Mostly large (5-32mm). Are solitary or eusocial. Nest in soil or pre-existing cavities, or in free mud nests. Some provision their larval cells with pollen and nectar.* |

## DISCUSSION

The results for 1999 show that there were no significant differences in the trap catch data between the sprayed and not sprayed treatments for the number of Dipteran families, number of Hymenopteran families, and the number of Hymenopteran individuals. However, there were differences in the number of Dipteran individuals, with significantly more individuals trapped in the sites that were not sprayed. There were no significant differences in the numbers of insects caught from the Ichneumonoidea, Braconidae and Tachinidae families between the sprayed and not sprayed treatments.

It is somewhat early to draw any meaningful conclusions from these results. Hence the effect of epiphyte spraying on Dipteran and Hymenopeteran biodiversity, particularly on the population levels of Bagworm natural enemies, remains unclear. The 1999 trials demonstrated that there were significantly more Dipteran individuals caught in the not sprayed treatments, but this result is by no means unequivocal and requires further experimental proof before any conclusions can be drawn.

The two control sites have not been sprayed for trunk epiphytes since 1997, and so during the 1999 trials there was therefore quite a difference between these and the sites that had been recently sprayed, in terms of the levels of epiphyte growth. However, it remains unclear as to what the precise role of trunk epiphytes is in promoting and / or sustaining insect biodiversity, particularly with regard to families of natural enemies of insect pests.

Beneficial weeds and general ground cover certainly do have an important role in promoting insect biodiversity, as well as in maintaining populations of natural enemies for insect pests of oil palm (Mexcon and Chinchilla, 1999). The role of trunk epiphytes is however unclear and merits further investigation. The spraying of trunk epiphytes is expensive and time consuming, as well as being potentially hazardous to the environment and to human health. It does however allow the harvester to get unrestricted access to bunches, and improves the efficiency of loose fruit collection. It therefore plays an integral role in plantation management and, as such, its effect on insect biodiversity merits further investigation.

A further trapping period is planned for 2000. This will follow the same procedure as in the two previous trapping periods. The results from this will then be written up and presented to the Scientific Advisory Committee for evaluation. A decision will then be made on the long-term future of this work.

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# THE INTEGRATED MANAGEMENT OF *ORYCTES RHINOCEROS* IN THE OIL PALM AGROECOSYSTEM OF PAPUA NEW GUINEA

## BIOLOGY OF *ORYCTES RHINOCEROS*

*Oryctes rhinoceros* is primarily found attacking coconut and oil palm. It is endemic to the coconut-growing regions of South and South-East Asia from Pakistan to the Philippines (CIE, 1967). It was accidentally introduced into New Britain [Papua New Guinea], New Ireland [Bismarck Archipelago], Manus Island, Western and American Samoas, Tonga, Fiji, Wallis Island, Micronesia, Mauritius and the Cocos Islands (Bedford, 1974, 1980).

*O. rhinoceros* eggs are laid in rotting palm materials including trunks, tree stumps, compost heaps, dung hills, sawdust or garbage dumps. The eggs are yellowish-white, and measure 3 mm in diameter. The eggs hatch after 8-12 days and the entire larval stage is spent inside the breeding medium. Development of the larva takes 80-200 days: first instar takes 10-21 days, second instar takes 12-21 days and third instar takes 60-125 days. The larval stages are usually yellowish-white in colour and may grow to about 60-100 mm long or more (Wood, 1968a, Ooi, 1988). The larval stages may look similar to other species within the scarabeid family (i.e. Xylotrupes gideon, Scapanes australis, Trichogomphus fairmairei, Oryctes centaurus and Oryctoderus sp.). A key to differentiate the larval stages of these species has been provided by Bedford (1974). Lucanid and cetoniine beetles, which often share the same breeding sites, may be confused with the early instars of O. rhinoceros (Wood, 1968a).

The beetle then enters the pre-pupal stage of about 8-13 days, subsequently pupating within a pupal chamber made from the food substrate. The pupal stage lasts 17-30 days. The *O. rhinoceros* pupa is yellowish-brown in colour and measures up to 50 mm in length. It is segmented on the dorsal surface. The length of the horn-shaped protuberances on the anterior may indicate the sex of the adult.

The adult beetles are stout looking, dark brown to black, shiny, 35-50 mm long and 20-23 mm wide, with a prominent horn on head (Wood, 1968a; Bedford, 1974). The males have a relatively longer horn than the female. The males can be differentiated more accurately by having a rounded shiny terminal abdominal segment while the female has a relatively hairier ‘tail’ (Wood, 1968a). Adults may live up to 6 months or more (Bedford, 1980; Khoo et al., 1991). A key to Oryctes species is given by Endrödi (1985).

On oil palms, *O. rhinoceros* bores into the cluster of spears, causing wedge-shaped cuts in the unfolded fronds or spears. In young palms where the spears are narrower and penetration may occur lower down, the effects of damage can be much more severe than in older palms (Wood, 1968a). The young palms affected by the beetle damage are believed to have a delayed immaturity period (Liau and Ahmad, 1991). Thus, early oil palm yields could be considerably reduced after a prolonged and serious rhinoceros beetle attack. Although Wood et al. (1973) suggested that the damage to the immature palms results in relatively small crop losses, field experiments conducted by Liau and Ahmad (1991) revealed an average of 25% yield loss over the first 2 years of production. This was possibly caused by the reduction in the canopy size of more than 15% for moderately serious to higher damage levels (Samsudin et al., 1993). In India, the infestation in oil palm was more prevalent in mature plantations (10-15 year old) compared to immature or younger plantings (Dhileepan, 1988).

## INTEGRATED MANAGEMENT OF *ORYCTES RHINOCEROS*

*O. rhinoceros* was first found feeding on oil palm in West New Britain Province, Papua New Guinea in 1994 (PNGOPRA, 1996). It has since spread into new areas from its origin at Numundo Plantation, New Britain Palm Oil Limited. Since 1996 an integrated pest management system has been developed for *O. rhinoceros.* This IPM system is illustrated in Figure 5.3. It has the following components:

1. Knowledge of the biology and ecology of the pest and beneficals.
2. Monitoring of the pest and beneficials.

3. Economic thresholds.
4. Precise targeting of chemical control agents.
5. Biological control.
6. Physical control
7. Cultural control.

The IPM system that has been developed is dependent on the use of a synthetic aggregating pheromone, ethyl 4-methyloctanoate that was developed for O. rhinoceros in Costa Rica. The pheromone is stored in a small, heat-sealed, polymer membrane bag and placed on top of interlocking iron vanes mounted on a plastic bucket. The beetles attracted by the pheromone are trapped inside the bucket. The pheromone is effective and as an economical control method, when placed at a density of one trap for every 2 ha.

O. rhinoceros virus and the pathogenic fungus Metarhizium anisopliae have been utilized further for field control of this pest in several countries (George and Kurian, 1971; Latch and Falloon, 1976; Zelazny, 1979; Bedford, 1986; Darwis, 1990). The adult beetles are dipped in a suspension of ground, infected grubs. They are then allowed to crawl about for 24 hours through sterilized sawdust mixed with the above suspension. They are then released back into the plantation to infect other grubs in the breeding sites (Bedford, 1976a).

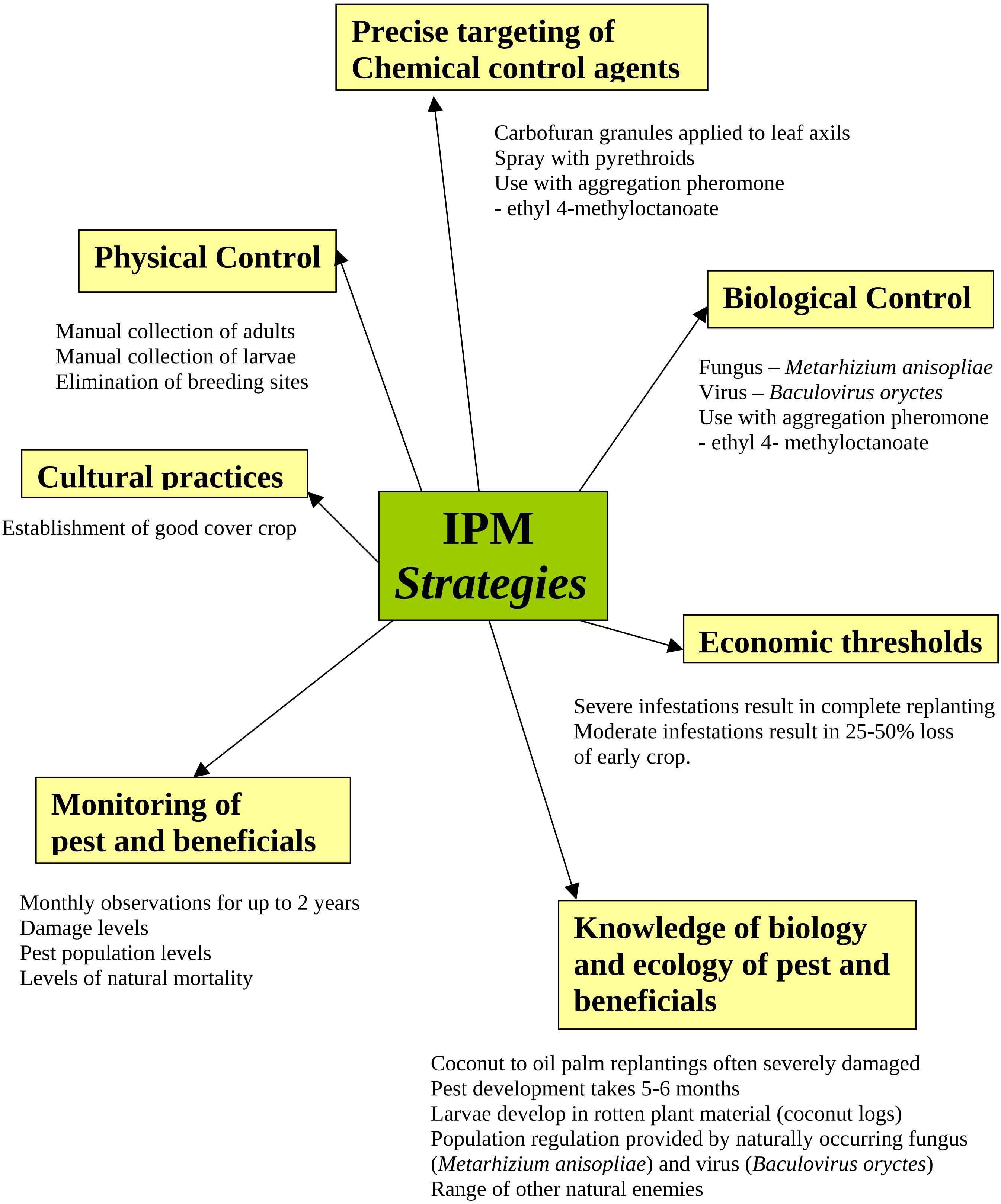
The IPM system that has been developed for *O. rhinoceros* involves the use of pheromone traps to catch adult beetles, some of which are then infected with the baculovirus and released back out into the field, so as to spread the virus amongst the pest populations of *O. rhinoceros.* This method is used in conjunction with a single application of a granular formulation of carbofuran to the leaf axils in outbreak areas (Sadakathulla and Ramachandran, 1990; Ho and Toh, 1982). This is done before the capture – release programme is started.

Sanitation within and surrounding the plantations, especially destruction of the potential or existing breeding sites of this pest, also provides an important component of the IPM system (Wood, 1968a; Turner, 1973). The establishment of a good, fast-growing ground cover provides a vegetative barrier that hampers the movement of the adult beetle looking for suitable breeding sites (Wood, 1968b). This restricts the damage in oil palm to low levels (Wood et al., 1973).

This IPM system has been implemented effectively for *O. rhinoceros* in three separate outbreaks areas in West New Britain:

- During 1996 at Numundo Plantation (94 plantings)
- During 1997 at Numundo Plantation (95 plantings)
- During 1999 at Walindi Plantation (97 plantings)

Figure 5.3 Strategies for Rhinoceros Beetle IPM



**The use of pheromone traps to catch adult *O. rhinoceros***

The pheromone traps were used for three separate trials:

- During 1996 at Numundo Plantation (94 plantings)
- During 1997 at Numundo Plantation (95 plantings)
- During 1999 at Walindi Plantation (97 plantings)

The traps were placed at spacing of 1 every 2 hectares. There were 10 traps used for the first trial, 40 in the second, and 25 in the third. The trap catch data for the three trials are shown in Figure 5.4.

**Assessments of immature stages of *O. rhinoceros* at Walindi Plantation**

The results of the assessments of immature stages of *O. rhinoceros* at Walindi Plantation are shown in Table 5.10. These assessments were undertaken monthly, from August 1999 to February 2000. The assessments involved examining 1 metre lengths of rotting oil palm logs at six locations, evenly distributed within Walindi plantation. Between 7-10 rotting logs were examined at each location. Table 5.10 gives the mean values for each log that was examined during each of the seven monthly surveys. The surveys were undertaken during the second half of the pheromone trapping programme.

Table 5.10 A summary of the data from the assessment of immature stages of *O. rhinoceros* at Walindi Plantation.

| Month | Mean number per log | | | | | |
|---|---|---|---|---|---|---|
| | Eggs | Small larvea | Medium larvea | Large larvea | All larvea | Pupa |
| Aug 99 | 0.42 | 0.07 | 0.45 | 1.55 | 2.06 | 0 |
| Sept 99 | 0.06 | 0.73 | 0.93 | 0.73 | 2.4 | 0 |
| Oct 99 | 0.33 | 0.74 | 0.29 | 0.03 | 1.36 | 0.02 |
| Nov 99 | 0.07 | 0.65 | 0.61 | 0.34 | 1.60 | 0.03 |
| Dec 99 | 0 | 0.69 | 0.37 | 0.31 | 1.36 | 0.02 |
| Jan 2000 | 0.21 | 0.98 | 0.22 | 0.40 | 1.60 | 0.01 |
| Feb 2000 | 0.03 | 0.49 | 0.54 | 0.32 | 1.35 | 0 |

**Damage assessments at Walindi Plantation**

The results of damage assessments at Walindi Plantation are shown in Table 5.11. These assessments were undertaken monthly, from August 1999 to February 2000. The assessments involved examining a total of 250 palms along a transect running from boundary to boundary, parallel to the main highway at Walindi plantation. Table 5.11 gives the mean values for a number of damage categories that were recorded for the palms along the transect. The surveys were undertaken during the second half of the pheromone trapping programme.

Table 5.11 A summary of the data from the assessment of *O. rhinoceros* damage at Walindi Plantation.

| Damage category | Aug 99 | Sep 99 | Oct 99 | Nov 99 | Dec 99 | Jan 00 | Feb 00 |
|---|---|---|---|---|---|---|---|
| % with spear cluster damage | 3.2 | 7.6 | 12.8 | 3.6 | 0.8 | 2.0 | 0.8 |
| % with fronds broken off | 76 | 74 | 84 | 89 | 79 | 73 | 74 |
| Mean number fronds broken off | 2.0 | 2.3 | 2.9 | 2.8 | 2.4 | 2.2 | 1.9 |
| % with partly damaged fronds | 64 | 77 | 70 | 70 | 69 | 60 | 70 |
| Mean number of partly damaged fronds | 1.4 | 2.1 | 2.9 | 2.1 | 1.7 | 1.4 | 1.8 |
| % with leaf damage | 78 | 77 | 84 | 87 | 65 | 73 | 65 |
| Mean number of fronds with leaf damage | 2.4 | 4.0 | 5.8 | 5.2 | 1.8 | 4.0 | 1.9 |

## DISCUSION

The data for immature and damage assessments is relatively limited, as these studies only commenced when the Senior Entomologist was transferred to Dami Research Station at the end of July 2000.

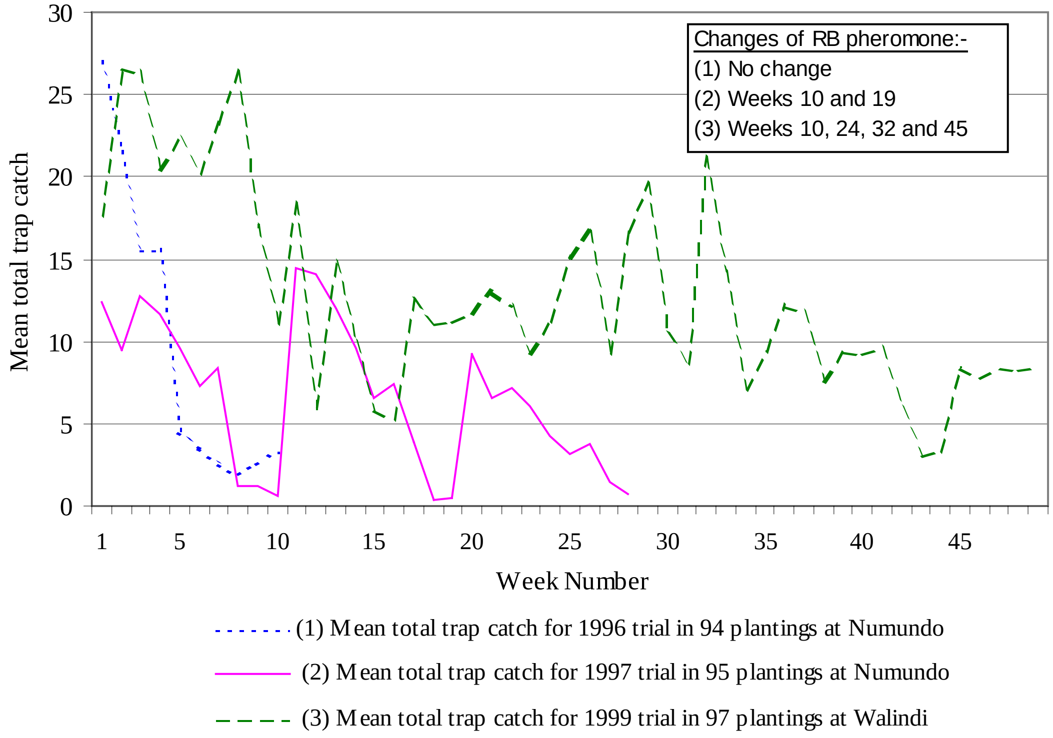
The data does however illustrate that the general level of the immature population of rhinoceros beetles was relatively low during the second half of the trapping period at Walindi. It would have been very useful to be able to compare this data to the population levels at the beginning of the trapping programme, but unfortunately this data is not available. The data set will however serve as a very useful reference point for future work.

The damage assessment data shows that the extent of primary damage to palms, expressed as percentage spear cluster damage, was relatively low during the second half of the trapping period at Walindi. Again, it would have been very useful to be able to compare this data to the damage levels at the beginning of the trapping programme, but unfortunately this data is not available. The data set will however serve as a very useful reference point for future work.

The trap catch data shows that the level of the Rhinoceros beetle population remained high at Walindi relative to the two previous trials at Numundo, with mean trap catches of between 10-20 adults even after 30-35 weeks of trapping. Reasons for this remain unclear, although field observations suggest that there is a high population of Rhinoceros beetles in the surrounding bush at Walindi, and that these may be continually re-invading the area where the trapping programme is being undertaken.

The Rhinoceros beetle IPM programme has been generally successful in all these locations, with probably no economically significant yield losses being experienced. Large areas of Numundo were planted to oil palm from coconuts during 1999 and 2000 with no new outbreaks of Rhinoceros beetles reported. Large scale coconut to oil palm developments are planned for this area, which will be monitored for Rhinoceros beetle outbreaks and the IPM system implemented where necessary.

Figure 5.4 Oryctes Integrated Pest Management. The mean total trap catches for three RB pheromone trials undertaken during 1996,97 and 99.

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# MINOR INSECT PESTS OF OIL PALM DURING 1999

## PNG Islands Region

Bagworms (Lepidoptera: Psychidae)

There were only two minor outbreaks of Bagworm damage during 1999, one at Kumbango and the other at Bebere. The overall area treated was however less than one hectare.

There were isolated outbreaks of Bagworms at Dami and Bebere nursery. Chemical treatment was not required for these outbreaks.

Leafhoppers (Hemiptera: Cicadelloidea)

Feeding by *Zophiuma lobulata* causes Finschhafen disorder of coconuts and oil palm. The prevalence of Finschhafen disorder in West New Britain seemed to stabilise during 1999. There has been little evidence of further spread from coconuts to oil palm, furthermore there seems to be a significant reduction in the severity of symptoms on coconuts.

A major research project for the IPM of Finschhafen disorder is therefore no longer being considered.

Mealybugs (Hemiptera: Coccoidea)

There was a minor outbreak of Mealybugs, probably *Dysmicoccus* spp. in the prenursery at Kapiura. The outbreak was controlled using three applications of orthene.

Armyworm (Lepidoptera: Noctuidae)

There was a minor outbreak of *Spodoptera litura* in the nursery at Bebere. No chemical treatment was required.

## PNG Mainland Region

Stick insects (Phasmatodea: Phasmidae)

Species of stick insects, *Eurycantha* species, have previously been recorded as important pests of oil palm in Oro Province, with the first economic damage reported in 1986. Further economic damage was reported in 1989 and 1990. Damage by this pest usually occurs in conjunction with Sexava damage, however recent observations have demonstrated that stick insects alone are capable of causing economic damage to oil palm.

There seems to have been an increased incidence of stick insect damage to oil palm in Oro Province during the last 4 years. During 1997 there was a total of 4 smallholder blocks at Koropata division that were recommended for chemical treatment for the control of stick insects. A further 7 smallholder blocks in the same division were recommended for treatment in 1998, and 34 blocks during 1999. The 1999 outbeaks were at Koropata (18 blocks) and New Warisota VOP (16 blocks).

Chemical treatment is by trunk injection of monocrotophos (Nuvacron or Azodrin) in the same way as is undertaken for Sexava control, although only a single application is required for stick insect control.

Bagworms (Lepidoptera: Psychidae)

Damage by bagworms, *Mahasena corbetti* (rough bagworm), *Clania* species (smooth bagworm), and the ‘ice-cream cone’ bagworm remained low and of no economic significance throughout 1999, in both Milne Bay and Oro Provinces. The occurrence of field populations was sporadic and isolated, with light damage of no economic significance.

*Acria* moth (Xyloryctidae)

*Acria* moth is widespread throughout Milne Bay Estates from Giligili to Hagita, Waigani and Sagarai. During 1999 some damage to oil palm was observed in areas throughout these locations. Although this pest has been causing damage, no control measures have been recommended since 1994. There appears to be a wide range of naturally occurring biological control agents that usually provided adequate population regulation.

Chafer beetles (Coleoptera: Melonothinae)

Chafer beetles are widespread throughout the oil palm growing areas of Oro Province. Population levels are however usually very low, and damage levels light.

Light to moderate levels of Chafer beetle damage occurred at Embi Plantation (Higaturu Oil Palms) during 1999. This was caused by two species (*Dermolopida* sp and *Litura* sp). No control measures were recommended and the population subsequently declined during the second half of the year, a similar pattern to that observed in previous years We continue a programme of monthly population and damage monitoring at Embi Plantation.

Longicorn beetles (Coleoptera: Cerambycidae)

Longicorn beetles (*Mulciber* sp) were found at Embi Plantation during 1997. Damage levels were light during 1998 and 1999, with no treatment recommended. We are however conducting monthly monitoring of this insect.

Armyworm (Lepidoptera: Noctuidae)

There was a minor outbreak of *Spodoptera litura* in the nursery at Higaturu Oil Palms. The outbreak was controlled using several applications of orthene.

POLLINATION TRIALS

The number of male flowers at anthesis and the number of female flowers at the receptive stage in the three trial plots at Mamba Estate, HOPPL are shown in Figure 5.5 and Figure 5.6.

The mean number of weevil progency emerging from each spikelet and the mean percentage fruitset in the three trial plots at Mamba Estate, HOPPL are shown in Figure 5.7 and Figure 5.8.

The mean number of weevil progency emerging from each spikelet in the four trial plots at Kapiura Plantation, NBPOL is shown in Figure 5.9.

Figure 5.5 The number of male flowers at anthesis (average/days/135 palms) in the three trial plots at Mamba Estate, HOPPL, Oro Province during 1999.

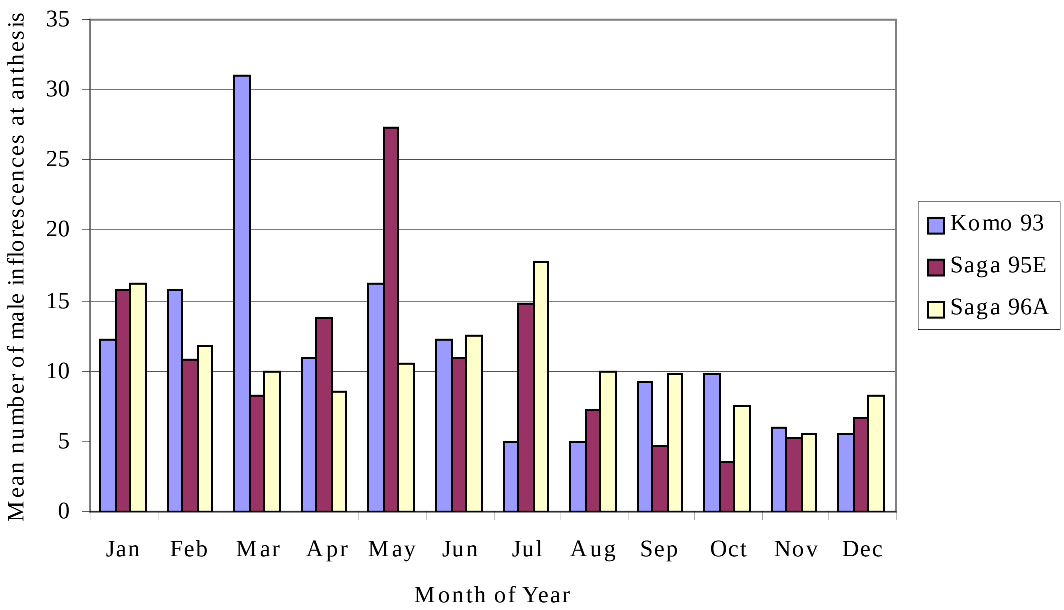


Figure 5.6 The number of female flowers at anthesis (average/days/135 palms) in the three trial plots at Mamba Estate, HOPPL, Oro Province during 1999.

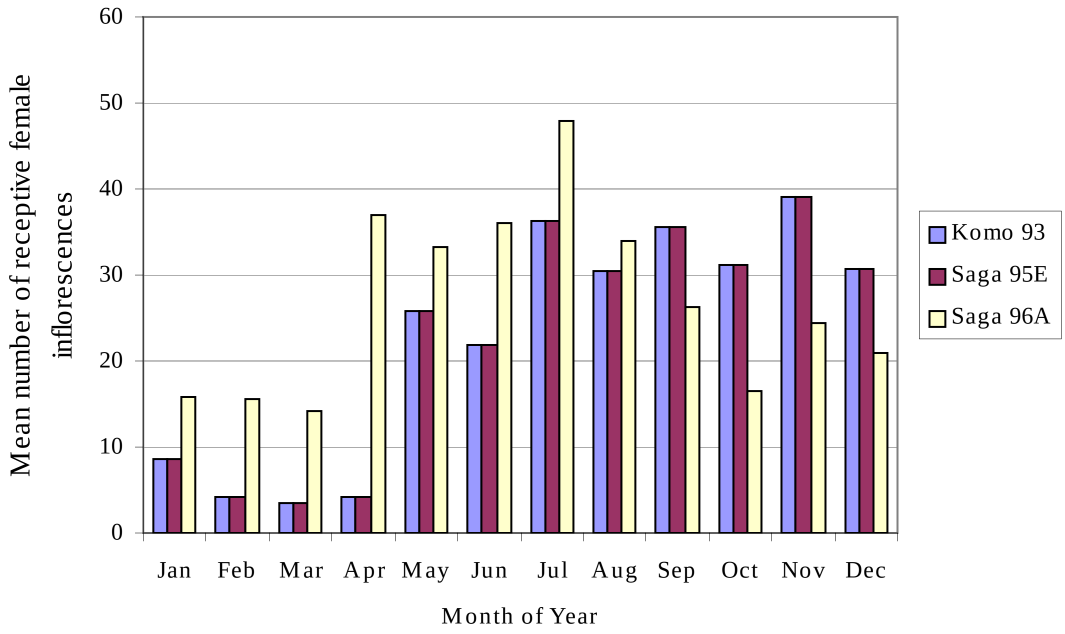



Figure 5.7 The mean number of weevil progency emerging from each spikelet from the trial plots at Mamba Estate, HOPPL, Oro Province during 1999.

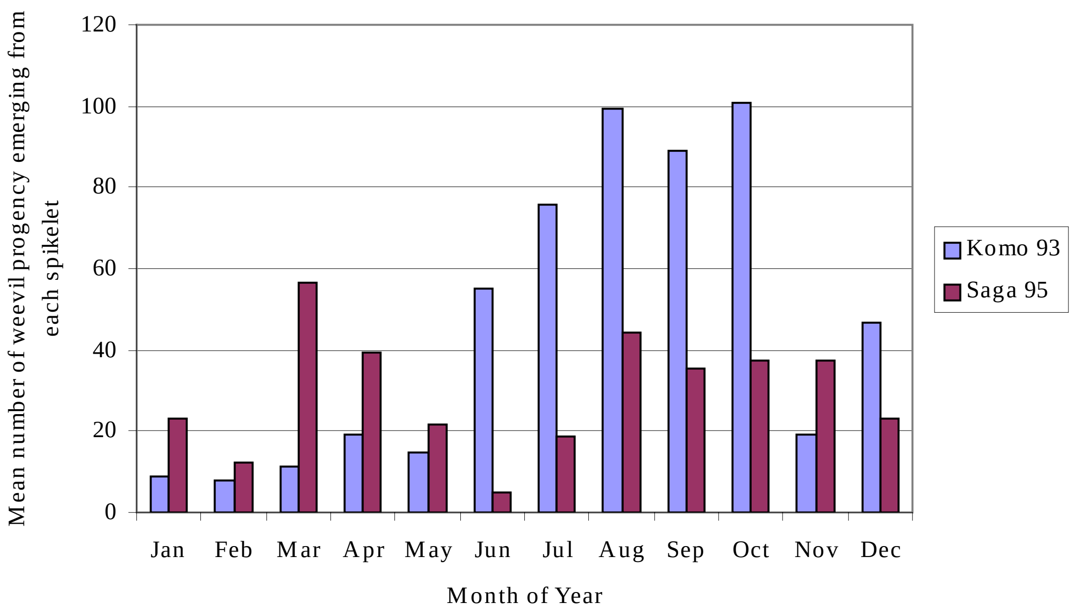


Figure 5.8 The mean percentage fruitset for the trial plots at Mamba Estate, HOPPL, Oro Province during 1999.

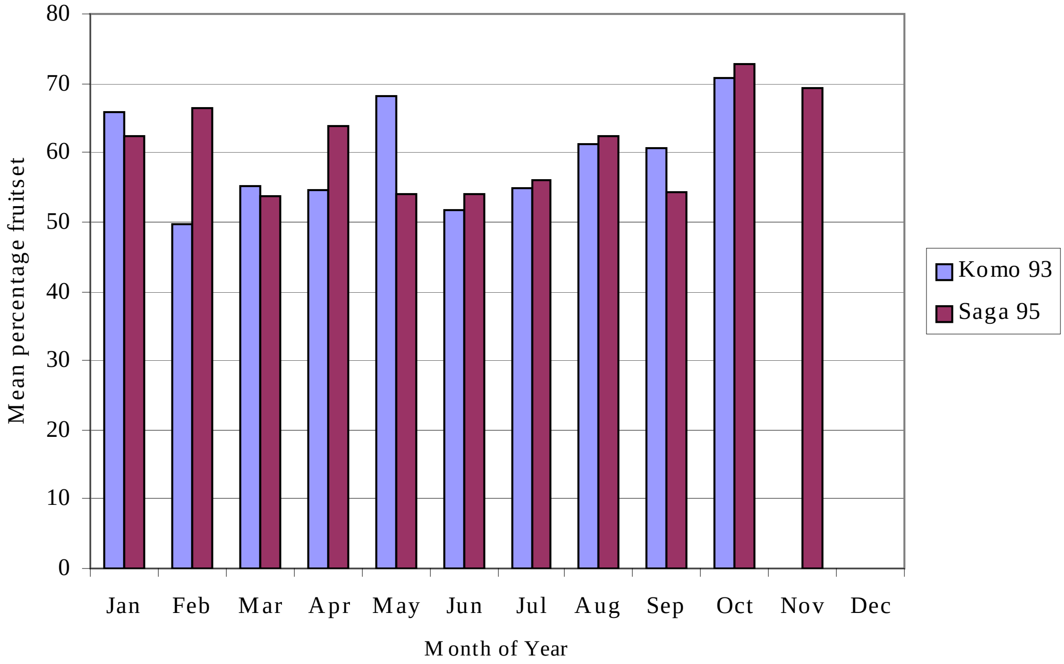
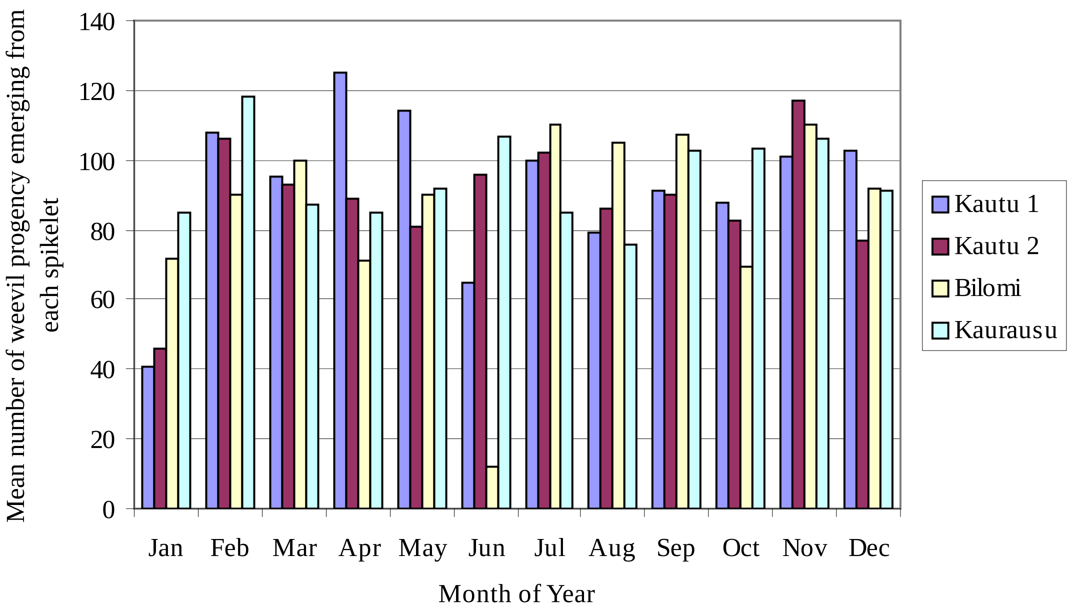



Figure 5.9 The mean number of weevil progency emerging from each spikelet from the trial plots at Kapiura Plantation, NBPOL, WNBP during 1999.



## PUBLICATIONS, CONFERENCES, CONSULTANTS, AND STAFF

The paper entitled ‘Integrated management of insect pests (Orthoptera: Tettigoniidae) of oil palm in PNG’ by R.W. Caudwell was accepted for publication by The Planter.

A paper entitled ‘A sustainable IPM system for oil palm in Papua New Guinea’ by R.W Caudwell was accepted for the Brighton Crop Protection Conference (2000).

Dr Kathirithamby continues to advise as part of the Sexava biocontrol project. She will be retained throughout 2000 and 2001, but will not be visiting PNG as part of this work.

The Senior Entomologist, Dr Rob Caudwell, was transferred to Dami Research Station at the end of July 1999.

Ross Safitoa (Assistant Entomologist) was moved from Dami to Popondetta in June 1999.
Takis Solulu (Assistant Entomologist) started a PhD programme at University of Queensland in June 1999.

Work commenced on the improvements to the entomology facility at Dami in November 1999.

# 6. PLANT PATHOLOGY

(F. R. Sanderson & C. A. Pilotti)

## SURVEYS AND IMPLEMENTATION OF THE CONTROL STRATEGY: MILNE BAY ESTATES

Two surveys were again completed during 1999. Data was entered into the computer using an MS Access programme that enabled reports to be generated more readily including lists of palms for removal.

During the later part of this year trials were carried out to assess the feasibility of using GPS receivers to log the geographical position of the *Ganoderma* infected palms and at the same time use the GPS unit as a data logger enabling entry of survey data such as symptoms, presence of brackets, male flowers, fruit bunches and site information such as previous land use. At the end of each day the survey data was downloaded directly into the Milne Bay Estates database, from which lists of palms for removal and maps were generated.

## RESULTS

The only statements which can be made with any degree of certainty, are that the number of infected palms being recorded each year is still on the increase, and, as is well demonstrated by the incidence recorded 1997, which was an exceedingly dry year, is that rainfall appears to be having an effect on the incidence of basal stem rot.

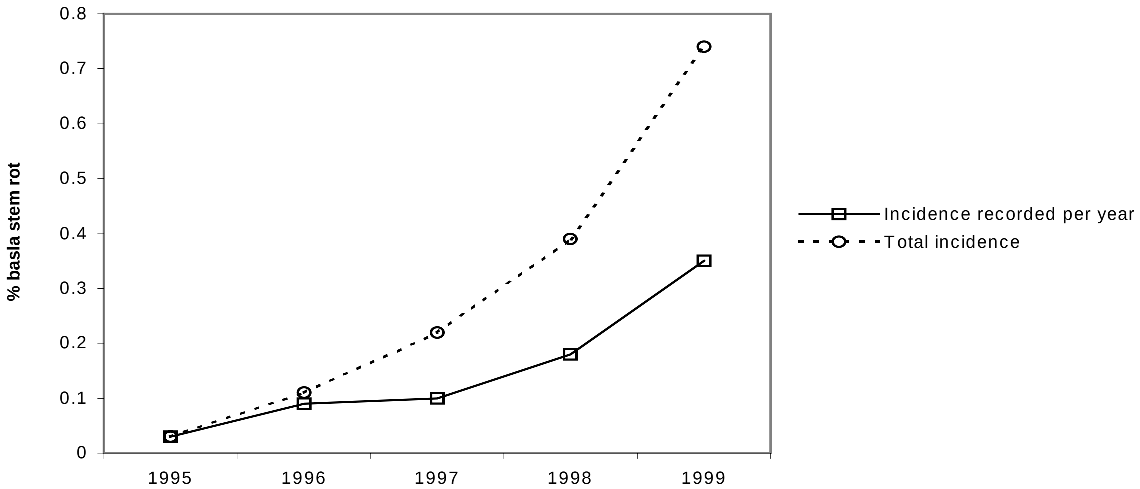



Figure 6.1 Incidence of basal stem rot in Milne Bay Province for the five years of surveys.

## INFECTION OF SEEDLINGS BY ROOT-ROOT CONTACT.

The basic work presented in the paper *The Comparative Importance of Different Oil Palm Tissues as Infection Sources for Basal Stem Rot in Replantings* by Hasan and Turner was repeated under the lower disease pressures occurring in Milne Bay Province. Thirty palms were felled leaving a stump of 1 meter. Ten of the palms were selected because of extensive basal rot, ten palms because they had top symptoms of basal stem rot, brackets of *Ganoderma* but no exposed basal rot. Ten sterile palms with no symptoms of basal stem rot were selected as controls. Ten seedlings were planted in a ring around each stump at a distance of between 50 and 75 cm from the stump. Because of a limited supply of 9 months old seedlings growing in Polybags, the balance of seedlings used were 3 to 6 month old volunteer seedlings collected from within the oil palm plantation.

## RESULTS

At the end of the first year 25 stumps were still being recorded. These comprised of 11 with basal rot (two of the palms felled as steriles subsequently developed basal rot), 9 palms with internal basal rot with brackets, and 5 of the original stumps from sterile palms. The attrition was mainly due to either over zealous field staff employed to weed around the base of palms, or bored plantation workers with bush knives.

Fifteen percent of the 3–6 month old seedlings planted around the sterile stumps were dead or almost dead at the end of the first year, 21% of those around the infected stumps with brackets and 39% of seedlings around those infected stumps with basal stem rot.

In contrast, none of the larger 9–12 month old seedlings, transplanted from Polybags are showing any evidence of infection.

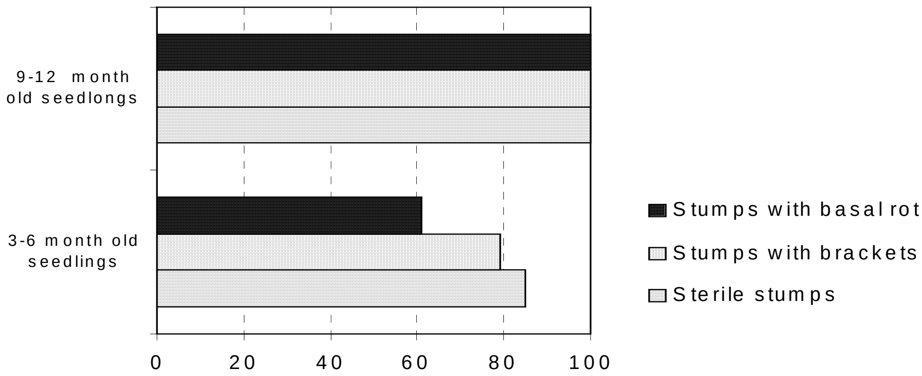



Figure 6.2 Percentage of healthy plants remaining after 12 months of either 3 – 6 month old seedlings or 9–12 month old seedlings planted next to stumps with basal rot, stumps with brackets or healthy sterile stumps.

Although only a preliminary trial the results demonstrate that the infection is arising from the basal rot and not from the active brackets. It would also appear that by the age 9–12 months, seedlings have or are already starting to develop resistance to invasion of *Ganoderma* via the root system. Infection might not be prevented but it is at least delayed.

A second trial is in the process of being established. Thirty stumps have been cut and 6, 8, and 13 month old seedlings will be planted around the base of these stumps within the next few weeks.

## MYCOLOGICAL STUDIES

An enigma that we face when considering spores as the route for initiating infection is that when given an effective inoculum source, why do we not routinely get multiple infections?

To help answer this double inoculations were made into wood fibre and the fungus grown until fruiting bodies were produced. Vegetative compatibility tests between the original isolates used to inoculate the bags and the dikaryons isolated from the resultant basidiocarp, demonstrated that dikaryons maintain their integrity. That is, no somatic fusion occurred between dikaryons to give rise to chimeric dikaryons.

This suggests that dikaryotic isolates found on palms in the field are derived from either a union of two compatible spores or by subsequent di-mon mating, and that multiple isolates arise from separate events at different sites.

Table 6.1 Somatic compatibility of resultant dikaryons from the basidiocarp with the two original dikaryons used to inoculate the bag. (399=145 and not 121; 400=123 and not 145; 401=150 and not 169).

| | | Basidiocarp isolates | | |
|---|---|---|---|---|
| | | 399 | 400 | 401 |
| Original dikaryons | 121 | **Incompatible** | | |
| | 123 | | **Compatible** | |
| | 145 | **Compatible** | **Incompatible** | |
| | 150 | | | **Compatible** |
| | 169 | | | **Incompatible** |

These results have been confirmed by PCR RAPDs.

## CHARACTERIZATION OF THE GANODERMA POPULATIONS

### Development of Molecular Markers

(i) Probes were generated from cloned fragments of *G. boninense*. Twenty probes have been purified and are awaiting screening. The probes will be used to determine variation in the *Ganoderma* population on oil palm by RFLPs. Although the probes had been developed by early 1999, the work was suspended pending the availability of funds to purchase consumables.

(ii) PCR of mitochondrial DNA has revealed some within species variation in *Ganoderma* isolates but not in *G. boninense*. Mitochondrial DNA RFLPs have not been investigated as a potential marker for *G. boninense* isolates due to lack of funds for reagents.

(iii) Inheritance of RAPD markers are being analysed in F1 progeny of a synthesized dikaryon with the possibility of using RAPDs as an alternative to RFLPs.

### *G. boninense* Isolates on Oil Palm

Selected blocks in Milne Bay have been sampled. So far, 641 isolates have been collected, cultured and stored for further analysis.

Spore prints have been collected for isolates appearing in ‘clusters’ in plantation blocks. Reciprocal crosses have been carried out for a number of these samples. Mating types from all samples within these blocks have been out-crossed with each other. A total of 880 crosses for block 7213 and another 1008 crosses for blocks in Waigani have been completed so far. Three isolates within reasonably close proximity to each other have been found to share a single mating allele. This indicates that the primary inoculum has come from a population of inter-breeding individuals.

Opportunity to sample palms next to each other has been limited. Previous sampling has shown that all isolates on adjacent palms are not closely related. However, a recent sampling of adjacent palms has revealed a single common mating allele in one pair. (Figure 6.4)

### Species of Ganoderma Associated with Oil Palm

Since May 1988 when brackets from poisoned palms in Kapiura were received we have been investigating the possibility that there are two species of *Ganoderma* associated with oil palm in PNG.

The predominant species has always been *G. boninense* but small numbers of the second species found on the poisoned palms in Kapiura, have been found on live oil palms in Milne Bay.

Of the 294 palms that were recorded with brackets during 1999, 86% were *G. boninense*. Of the 40 records of the hardwood species of *Ganoderma*, two (of 121) were recorded at the base of palms with no other symptoms of basal stem rot, 11 (of 60) were associated with rotten frond bases of infected palms or exposed basal rot, 3 (of 18) were on collapsed infected palms, 1 (of 15) was an invasion of the cut surface of the healthy log remaining after sanitation, 21 (of 65) were invasions of the basal plates or logs of felled sterile palms, and 2 (of 15) were invasions of poisoned sterile palms.

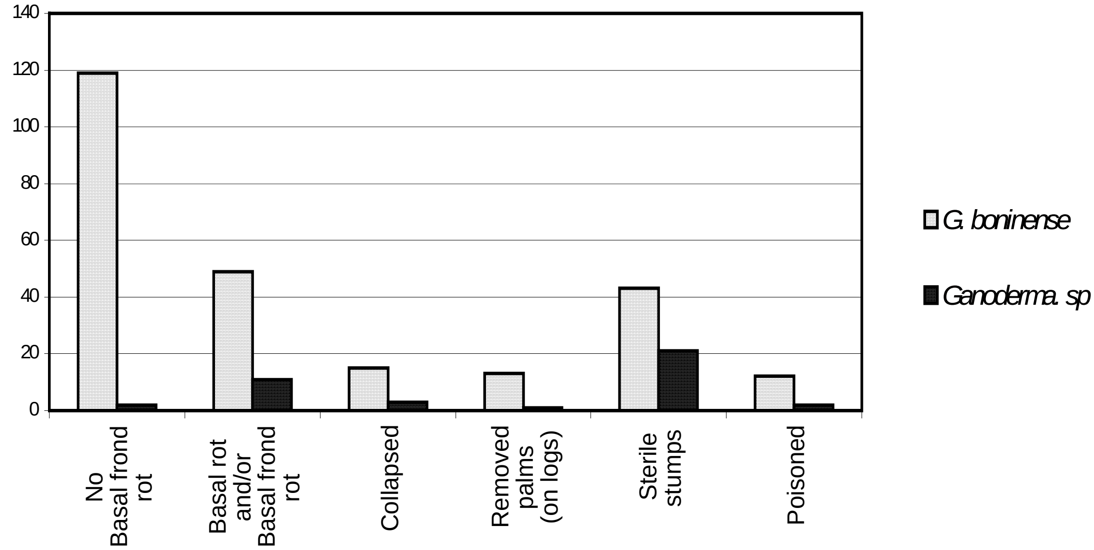



Figure 6.3 Numbers of the hardwood species of *Ganoderma* found on oil palm during 1999.

Idris Bin Abu Seman, in his thesis presented as part of his PhD thesis at Wye College under Professor Terry Swinburne (1999) using isozymes and RAPDs concluded that there were two species involved in the disease complex in Malaysia. These were *G. boninense* which was strongly pathogenic and the second which was weakly pathogenic and which he called *G. zonatum*. However, ITS sequence data carried out by J.M. Moncalvo at Duke University, places this hardwood species in the *G. australe* complex.

The two instances in Milne Bay of the hardwood species occurring on oil palms with no symptoms would support the idea of a second species with limited pathogenicity. All the other recordings were in situations that would be more readily explained by secondary invasion.

This second species is normally found as a saprophyte on both hardwoods and felled coconut. In four blocks of young oil palm planted into coconut in New Ireland, one was predominantly colonised by the hardwood species, one was predominantly *G. boninense*, and the other two were a mixture of both. It can be reasonably assumed that the block colonised predominantly by G. *boninense* is the one at greatest risk to basal stem rot. It then poses the question of can the hardwood species be used as a biological control agent of basal stem rot by colonising sites which could be utilised by *G. boninense*?

The hardwood species of *Ganoderma* has a similar mating system to *G. boninense*, and a number of isolates from dead coconut, dead oil palm, dead hardwood and live oil palm have successfully mated. Conversely, all were sterile with isolates of *G. boninense* confirming that it is a different species.

**Pathogenisity Tests**

Five experiments were conducted to look at the possibility of infecting short lengths of leaf rachis with cultures of *Ganoderma*. Five cm lengths of 3-month-old rachis tissue were surface sterilised and placed in water agar in clear plastic bottles. Results to date are far from encouraging and no penetration of the rachis tissue by the *Ganoderma* cultures was observed.

This work continues.

## AEROPONICS

We are still on the learning curve and 1999 was a year of frustration. At the 1998 annual meeting in Milne Bay the consensus of participants was that the yellowing of the leaves that was very prevalent was pH related.

During the year a number of steps were taken to address this problem.

1. Because the reticulated water contained excessive amounts of silica and calcium and had a high pH, a rainwater tank was installed. Unfortunately the proximity to the mill resulted in mill ash having an unfortunate effect of the rainwater pH.
2. Bore water was trucked to the site, which although having a pH which fluctuated around pH 7, was still too high in salts such as silicon. Over the next 6 months 2 further bores and water from the demineralising plant were tested. In all cases, although the pH was satisfactory, the water was always high in silica and it was found impossible to maintain an acceptable pH.
3. A switch has subsequently been made to rain water collected 10 km from the factory and as a result we are finally seeing a marked improvement in plant growth.

## COLLABORATION WITH CABI BIOSCIENCE

This facet of the programme was put on hold in August 1998 when funds from the first phase of the project were spent. Due to funds not being released by the EU for the second phase of the project until December 1999 no work was undertaken during 1999.

Dr Paul Bridge was appointment the Kew Professor of Mycology at Birkbeck College, University of London in October 1999. A framework of co-operation was discusses with staff of both CABI Bioscience and Professor Paul Bridge in the UK in October 1999. A work programme was formulated and draft agreements discussed.

## FUTURE FUNDING

For the past three years discussions have been held with staff of the European Union regarding future funding. It was suggested on a number of occasions that because we were looking at funding in both Papua New Guinea and the Solomon Islands, that the best approach would be through the Secretariat of the Pacific Community as a Regional Project. An application to the Secretariat of the Pacific Community for Regional Funding for research into Basal Stem Rot of Oil Palm caused by the fungus *G. boninense in* Papua New Guinea and the Solomon Islands was submitted in September. The application was subsequently discussed with Dr Mick Lloyd and Ms Jacqui Wright in October. The application was received favourably, however, it was suggested that the best approach for funding would be to the FAO as a TCDC project. This avenue is actively being pursued.

## CONFERENCES & PAPERS

APPS Conference. Canberra. September 1999. C A Pilotti

Intraspecific Variation of *Ganoderma* spp. Pathogenic on Oil Palm. Pilotti, Sanderson & Aitken. APPS Meeting, Canberra, August 1999.

## REPORTS

*Ganoderma* Research. STABEX Project No. 4.2 End of Project Report 1995-98

| Palm 4 (41-9) | | | Palm 3 (17-2) | | | | Palm 2 (10-14) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A31 B31 | A32 B31 | A31 B32 | A26 B26 | A26 B27 | A27 B27 | A26 B26 | A3 B4 | A4 B4 | A4 B1 | A3 B1 | | |
| + | + | + | + | + | + | + | + | + | - | - | A1 B1 | Palm 1 (10-15) |
| + | + | + | + | + | + | + | + | + | + | + | A1 B2 | |
| + | + | + | + | + | + | + | + | + | - | - | A2 B1 | |
| + | + | + | + | + | + | + | + | + | + | + | A2 B2 | |
| + | + | + | + | + | + | + | + | + | + | + | A29 B29 | Palm 6 (93-16) |
| + | + | + | + | + | + | + | + | + | + | + | A30 B29 | |
| + | + | + | + | - | - | + | + | + | + | + | A29 B27 | |
| + | + | + | + | - | - | + | + | + | + | + | A30 B27 | |
| + | + | + | + | + | + | + | + | + | + | + | A33 B33 | Palm 5 (42-9) |
| + | + | + | + | + | + | + | + | + | + | + | A34 B34 | |
| + | + | + | + | + | + | + | + | + | + | + | A33 B34 | |
| + | + | + | + | + | + | + | + | + | + | + | A34 B33 | |

Figure 6.4 1,888 crosses were made between isolates from two blocks of oil palm, and only in three instances was there less than 100% mating, and in all three instances, only one of the four alleles, was common.
Palm 1 and 2 were adjacent (row 10 palms 14 and 15) and had the allele B1 common. Palms 3 and 6 were 76 rows apart (rows 17 and 93) and had the allele B27 common. Palms 4 and 5 were also adjacent but did not share alleles (palms 9 in rows 41 and 42).
For this to have occurred, infection had to have arisen from spores of a naturally occurring inter-breeding population.