Annual Research Report

1997

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

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Statement by the Director of Research to the Annual General Meeting

May 1998.

The Members of the Papua New Guinea Oil Palm Research Association Inc. have a research service that they can and should be proud of. The organisation remains small in size, particularly in relation to the size of the industry; however, the 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 quantity and quality of it's scientific output, as illustrated by the large increase in the number of refereed papers that have been published. The level of technical services provided to the industry has also increased dramatically with more technical reports, workshops, and formal training provided to both the extension service and plantation company officers.

Despite the marked increase in output from PNGOPRA the cost to the oil palm industry is considerably less than it was five years ago. In the years prior to 1994, the PNGOPRA levy for both smallholders and plantations alike was K0.80 to K0.88 per tonne of FFB. At the present time the levy per tonne of FFB is between K0.80 and K1.00 for plantation companies, depending on their production efficiency, and K0.56 for smallholders. During this period the value of the Kina has more than halved against the US Dollar, which is the currency in which the crop is sold.

Oil palm research in Papua New Guinea commenced with the establishment of Dami Oil Palm Research Station by Harrisons and Crosfield in 1967. Plant breeding and subsequently seed production commenced with the introduction of elite breeding material to Dami from Malaysia in 1968. Dami has now developed into one of the most highly regarded seed production and plant breeding operations in the world. As other oil palm companies started operations in Papua New Guinea it was decided that the requirement for agronomy and crop protection research could best be met by forming a single research organisation to service all producers in Papua New Guinea. This initiative between the oil palm milling companies and the Government of Papua New Guinea is what led to the formation of the Papua New Guinea Oil Palm Research Association. The PNGOPRA was incorporated in 1980 as a non-profit making association. To this day the PNGOPRA carries out all agricultural research, other than plant breeding, for all of Papua New Guinea's oil palm producers.

The research programme of the PNGOPRA is carefully structured to meet the needs of the industry as a whole. The PNGOPRA Research Committee, on which all producers are represented, meets annually to review and establish research priorities for the following year. 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. By far the most serious factor limiting oil palm production is the ubiquitous presence of nutrient deficiency. This is regarded as the Association's most important research area. The Association's Agronomy Sections carry out research into crop nutrition and fertiliser management practices. The Association's Entomology Section conducts research into the control of insects and other pests, and the recently formed Plant Pathology Section is carrying out world leading research into the control of the Basal Stem Rot of oil palm caused by Ganoderma.

The main limiting factor to maximum oil palm growth in PNG is crop nutritional deficiency. The single highest cost involved in growing oil palm is fertiliser input. Much of PNGOPRA's research effort focuses on the study of the soil chemistry and plant nutrition of oil palm growing on the wide range of PNG soil types. The goal of the research being to develop, to a high degree of precision, the most economically optimal fertiliser practices dependent upon soil type, physical environment and economic conditions. In addition specific research effort is directed towards more fundamental studies relating to magnesium, potassium and phosphorus deficiencies. Nutritional problems are particularly serious among the smallholder growers and result in very large reductions in yield. In addition other technical, 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. PNGOPRA gives close technical support to the efforts of the extension service through a large network of smallholder block demonstration, farmer field days, and training for extension officers. PNGOPRA in conjunction with Biometricians at IACR-Rothamsted is developing new methodologies, to study the smallholder production constraints with a view to assisting the development of management solutions. 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 most important insect pests of oil palm in Papua New Guinea are; Sexava (*Segestes decoratus* and *Segestidea defoliaria*), Bagworm (*Metisa corbetti* and *Clania sp*), and Rhinoceros Beetles (*Oryctes rhinoceros*). The PNGOPRA Entomology Section carries out research to develop and improve integrated pest management systems for the control of these pests. This gives economically viable and environmentally acceptable pest management. Much of PNGOPRA's current entomological research effort is directed towards developing a naturally occurring parasitic insect (*Stichotrema dallatorreanum*) for the biological control of Sexava. PNGOPRA also rears and releases egg parasitoids (*Leefmansia bicolor* and *Doirania leefmansi*) for Sexava control, and are prospecting for fungal pathogens (*Metarhizium* and *Beauveria sp*) that could be used as biological insecticides against the pest. Much of this entomology research is collaborative work with entomologists from Oxford University and the International Institute of Biological Control, and is funded by the European Union. Other areas of interest include insect pollination of oil palm, and the integrated management of the Giant African Snail (*Achatina fulica*). PNGOPRA also has on-going insect biodiversity studies in which we are particularly interested in the management of oil palm stands to preserve and promote naturally occurring biological control agents and beneficial insects. The Entomology Section has on-going training programmes for plantation and extension officers. This involves formal and informal training as well as field days and features on local radio.

PNGOPRA's Plant Pathology Laboratory was established three years ago to look at Basal Stem Rot of oil palm caused by the fungus *Ganoderma*. Although at a low incidence in Papua New Guinea, experience in both Malaysia and Indonesia provided evidence of the potential of this disease. Research at the time suggested that spores of *Ganoderma* might play a more important role in the epidemiology of Basal Stem Rot than was previously suggested. The implications of this are critical to effective control of the disease because if true then the currently accepted practices of disease control are of dubious value. The research carried out by the Plant Pathology Section has determined that the mating system of *Ganoderma boninese*, the fungus responsible for the disease, is extremely complex. It requires two spores from different parents to come together and fuse before invasion of a palm can take place. If the two parents had different forms of aggressiveness towards the palm, then because of the very strong selection pressures exerted during the infection process, a build up of aggressiveness of this pathogen is inevitable. A build up which would lead to infection being seen earlier and at a higher incidence. Such a build up has been experienced in Malaysia and Indonesia. The Plant Pathology Section has developed a strategy for the short-term control of the disease, which is based on the removal of infected palm material, and on maintaining a zero level of *Ganoderma* brackets in the oil palm. For long-term confidence of this strategy, it is important that we prove the current hypothesis. A full understanding of the mating, the extent of individual populations of the fungus and the effect range of spore dispersal is needed. This can only be done by a thorough study using modern DNA "fingerprinting" techniques. We must be able to prove not just speculate on how the fungus moves from palm to palm. This is being done by the use of DNA probes currently being developed jointly between PNGOPRA and the International Mycological Institute. The probe is designed to detect *Ganoderma* in oil palm wood and root tissues. We have also developed an aeroponics system that enables both root and leaves to be exposed to infection. This system will be used to develop a screening methodology that will allow study of the complex host pathogen relationship. The study of Basal Stem Rot at the Plant Pathology Section has produced a solid framework on which the next three years will consolidate. We have developed the techniques it is now time for the implementation.

PNGOPRA is self administered and managed by a small team comprising the Director of Research, an Accounts Superintendent, an Administrator, an Accounts Clerk, and a Secretary, all based at Dami Research Station.

Funding for PNGOPRA comprises about 50% levy from Association Members, and about 50% grant from Government and foreign aid sources. It is important that the grant funding which generally supports the direct research costs is maintained. A priority aim over the next several months is to secure further grant funding to support the continuation of the Ganoderma research and the entomology IPM research, and for the initiation of fundamental studies of the soil chemistry and plant nutritional constraints to oil palm production.

Ian Orrell
Director of Research
PNG Oil Palm Research Association Inc.

May 1998

1. ISLANDS REGION AGRONOMY

(G. King, J. Yambun, D. Piskot)

1.1 INTRODUCTION

The islands region agronomy program has expanded considerably in 1997. OPRA agronomy staff attended 15 field days organised by OPIC for smallholders in both the Hoskins and Bialla project areas with over 1,500 growers attending. The Islands Regional Agronomist also conducted training for islands region companies and extension officers on basic crop nutrition. Trials 120 and 122 were closed down at the end of 1997. Many of the smallholder fertiliser demonstration trials in the Hoskins, Bialla and New Ireland project areas were also closed down at the end of 1997 as they had largely served their purpose. From 1998 smallholder research will involve the use of surveys and monitoring of palm nutritional status. Three new trials (125, 132, 209) were established and a site for Trial 129 (EFB x fertiliser placement trial) was identified. A second nursery fertiliser trial was established at Bebere to investigate the effect of rate of sulphate of ammonia and slow release fertilisers on seedling growth. A nursery fertiliser trial was also established at Poliamba to investigate the effects of N, P and K on seedling growth. A palm poisoning trial was conducted on a smallholder block to identify alternative herbicides for poisoning oil palm. Leaf sampling of plantations was completed for all three companies involving the collection and dispatch of over 400 samples. A paper was presented at the International Society of Oil Palm Agronomists (ISOPA) meeting in Cartagena, Colombia in September.

1.1.1 Staff

Mr. Graham King continued as Islands Region Agronomist in 1997 with Mr. Joe Yambun as Assistant Agronomist at Kapiura. Ms. Doreen Piskot resigned as Trainee Assistant Agronomist in November and her replacement Mr. Barnabas Toreu commenced duties in December 1997.

Mr. Kelly Naulis remained as Field Supervisor at Bialla. Mr. Wawada Kanama continued at Poliamba. Mr. Paul Simin at Dami replaced Mr. Jones Mole in July and Mr. Gend Konia who was recruited as Field Supervisor at Kapiura in May replaced Mr. Abraham Mai.

1.1.2 Trial Management

Analysis of the data for all trials was completed in May and the draft annual report completed in July. Visits from biometricians from IACR - Rothamsted (Janet Riley - twice) and Pacific Regional Agricultural Program (Dick Morton - once) were used to ensure that the correct analytical techniques were being used and to finalise designs of new trials. In 1997 the unopened spear leaves were counted in each trial at every harvest date to give an indication of water stress.

1.1.3 Leaf Sampling

Plantation leaf sampling for most estates was completed for New Britain Palm Oil, Hargy Oil Palms and Poliamba by the middle of April. However, the severe wet season hampered leaf sampling particularly at Navo Estate. The aim in future years will be to complete all plantation leaf sampling by the end of March to ensure that fertiliser recommendations can be made by August each year.

1.1.4 Soil Surveys

DAL Land Utilisation Section conducted a survey of all trial sites in 1996 in West New Britain to produce soil description data from all the trial sites. However, to date the report of this survey has not been produced.

1.1.5 Publications

A paper written by Graham King titled "Effect of potassium and soil depth on yield of oil palm in New Ireland, PNG" was presented at the International Oil Palm Conference organised by ISOPA and CENIPALMA/FEDEPALMA held in Cartagena, Colombia in September 1997. A copy of this paper is included in the appendix.

1.1.5 Smallholders

OPRA participated in 15 field days for smallholders in West New Britain organised by OPIC. The field days covered five topics; fertiliser, entomology, tool maintenance, fruit quality and weeding. The growers who attended these field days were also given leaflets on the benefits of fertiliser and the main insect pests of oil palm. Over 1500 growers attended these field days.

Field days were not held in the New Ireland project area in 1997.

OPRA agronomists attended Local Planning Committee meetings at Nahavio, Bialla and New Ireland whenever possible.

Three radio programs were produced and broadcast on Radio West New Britain. The topics of these radio programs covered fertiliser and entomology issues as well as a broadcast on the drought and the effects of fire.

1.1.6 Technical Recommendations

The following technical recommendations were made for the islands region in 1997.

- Nitrogen fertilisers should be applied to the frond pile to minimise losses due to erosion and leaching.
- EFB should not be applied at more than 60 t/ha/year.
- Immature phase fertiliser recommendations were reviewed. The main outcome was that application of nitrogen fertilisers should commence at planting and not three months after planting.
- Slow release fertilisers (Nursery Ace and Agroblen) are not recommended for oil palm nurseries. Applications of sulphate of ammonia and N:P:K 12:12:17:2 applied fortnightly give better growth of seedlings.

1.2 AGRONOMY TRIALS

Trial 107 RESPONSE TO FERTILISER OF MATURE SECOND GENERATION PALMS AT BEBERE PLANTATION.

PURPOSE

To provide information about the responses of oil palm to fertiliser, that will be used in making fertiliser recommendations.

DESCRIPTION

Site: Fields D8 and D9, Bebere Plantation.

Soil: Young, coarse textured, freely draining, formed on alluvially redeposited pumiceous sands, gravel and volcanic ash.

Palms: 16 selected progenies - 5 from High Bunch Number (HBN) families and 11 from families with Medium Sex Ratios (MSR).

Planted in January 1983 at 135 palms/ha.

Treatments started in January 1984.

DESIGN

There are 72 treatments, comprising all factorial combinations of N and P at three levels and K, Mg and Cl each at two levels (Table 1.1). The recorded palms are 16 different selected progenies arranged in the same array in each plot. Plot isolation trenching was completed in 1995.

Table 1.1. Rates of fertiliser used in Trial 107

	Feb 85 -Dec 88 Level			From Jan 89 Level		
	0	1	2	0	1	2
	(kg/palm/yr)			(kg/palm/yr)		
Sulphate of Ammonia (SoA)	0.0	1.0	2.0	0.0	2.0	4.0
Triple Superphosphate (TSP)	0.0	0.5	1.0	0.0	1.0	2.0
Sulphate of Potash (SoP)	0.0	1.8	-	0.0	3.6	-
Kieserite (Kies)	0.0	2.0	-	0.0	3.0	-
Sodium chloride (NaCl)	-	-	-	0.0	4.0	-

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

Sulphate of ammonia & sulphate of potash are applied as two equal doses per year. All other treatments are applied in a single dose.

There are 72 plots, each consisting of 36 palms of which the central 16 are recorded. The recorded palms are of 16 identified progenies arranged in a fixed spatial configuration in each plot. Palms 1-5 in each plot are from families with high bunch number (HBN) and palms 6-16 are from medium sex ratio families (MSR). The 72 treatments are replicated only once and are randomised amongst the 72 plots. High order interactions provide the error term in the statistical analysis.

At three months after planting all palms received 0.25 kg sulphate of ammonia and nothing else during the first twelve months. At 12 months (January 1984) half of the plots were given an application of Sulphate of ammonia (1 kg/palm) as a treatment (establishment nitrogen). In September 1995 plantation labour mistakenly applied Sulphate of Ammonia to the entire trial at the rate of 1kg/palm.

The treatments that are described in Table 1.1 were started in February 1985 and modified in 1989. The sodium chloride treatment that was started in 1989 is applied orthogonally over the earlier establishment nitrogen treatment. Its purpose is to see whether a deficiency of chlorine is limiting the yield or affecting the response to other fertilisers. Detailed analysis of the 1996 data showed that chlorine was having no effect on yield and plot leaflet chlorine levels were elevated irrespective of whether sodium chloride had been applied or not. Consequently, on the advice of the consultant biometrician, chlorine was used as a covariate rather than as a factor in the analysis of the 1997 data.

Frond 17 leaflet and rachis tissue was not sampled for chemical analysis in 1997.

RESULTS

The average plot yield in Trial 107 in 1997 was 26.5 t/ha. This is slightly lower than the average plot yield recorded in 1996 (26.9 t/ha). The mean number of bunches per hectare was 1070 in 1997 compared to 1050 in 1996. Mean single bunch weight was 24.8kg in 1997 compared to 26.0 kg in 1996.

There were no significant differences between treatments in 1997 (Table 1.2) nor for the period 1995-1997 (Table 1.4). In Table 1.3 yields recorded since 1986 are given showing that the response to nitrogen has not been consistent.

Plot isolation trenches were dug in 1995 to minimise interplot poaching of applied nutrients. The root pruning, which occurred as a result of trenching, has probably contributed to a reduction in yield in 1995 but yields have recovered in 1996 and 1997.

Detailed examination of the data from Trial 107 has indicated two problems:

a) There is a distinct possibility that N and K fertilisers are spreading form plot to plot despite trenching between the plot boundaries and

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 trial with this structure will not result in any changes to the patterns of response achieved so far.

Table 1.2. Main effects of N, P, K, Mg and progeny types on yield and yield components in 1997 adjusted for covariate (Trial 107).

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha/yr)	26.1	26.7	26.7	ns	0.906	11.8
Bunches/ha	1058	1078	1075	ns	37.1	11.9
Bunch weight (kg)	24.7	24.8	24.9	ns	0.451	6.3
	P0	P1	P2			
Yield (t/ha/yr)	26.1	26.6	26.8	ns	0.911	11.8
Bunches/ha	1060	1073	1078	ns	37.4	11.9
Bunch weight (kg)	24.6	24.8	24.9	ns	0.451	6.3
	K0	K1				
Yield (t/ha/yr)	26.3	26.7		ns	0.736	11.8
Bunches/ha	1058	1082		ns	30.2	11.9
Bunch weight (kg)	24.9	24.7		ns	0.366	6.3
	Mg0	Mg1				
Yield (t/ha/yr)	26.6	26.4		ns	0.742	11.8
Bunches/ha	1087	1054		ns	30.2	11.9
Bunch weight (kg)	24.5	25.1		ns	0.369	6.3

Table 1.3. Effect of N on FFB yield and yield components from 1986 to 1997 (Trial 107).

Year (age from planting)	Yield (t/ha)			Bunches/ha			Bunch Weight (kg)		
	N0	N1	N2	N0	N1	N2	N0	N1	N2
1986 (4)	17.3	17.0	17.8	2607	2624	2670	6.6	6.5	6.7
1987 (5)	24.2	25.4	25.3	2577	2647	2645	9.4	9.6	9.6
1988 (6)	25.9	25.9	26.1	1987	1903	1914	12.3	12.7	13.0
1989 (7)	26.3	27.8	28.0	1852	1941	1931	14.2	14.4	14.5
1990 (8)	27.9	28.6	28.1	1715	1746	1706	16.3	16.4	16.5
1991 (9)	23.5	23.9	23.4	1270	1270	1250	18.6	18.8	18.8
1992 (10)	24.9	27.0	27.0	1084	1175	1157	22.9	23.0	23.4
1993 (11)	24.5	27.4	29.0	1071	1175	1239	22.9	23.3	23.6
1994 (12)	21.1	22.0	23.0	928	932	999	23.3	24.2	23.8
1995 (13)	22.0	22.9	24.2	935	925	994	23.5	24.7	24.4
1996 (14)	25.3	27.8	27.6	1022	1068	1061	25.3	26.3	26.3
1997 (15)	26.1	26.7	26.7	1058	1078	1075	24.7	24.8	24.9

Table 1.4. Main effects of N, P, K, and Mg on yield and yield components from 1995 to 1997 adjusted for covariate (Trial 107).

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha/yr)	24.1	25.3	25.6	ns	0.814	11.2
Bunches/ha	994	1013	1027	ns	30.4	10.3
Bunch weight (kg)	24.2	25.0	24.9	ns	0.349	4.9
	P0	P1	P2			
Yield (t/ha/yr)	25.0	24.9	25.0	ns	0.819	11.2
Bunches/ha	1020	1011	1002	ns	30.5	10.3
Bunch weight (kg)	24.5	24.6	24.9	ns	0.351	4.9
	K0	K1				
Yield (t/ha/yr)	25.2	24.8		ns	0.662	11.2
Bunches/ha	1010	1013		ns	24.7	10.3
Bunch weight (kg)	24.9	24.5		ns	0.284	4.9
	Mg0	Mg0				
Yield (t/ha/yr)	24.7	25.3		ns	0.667	11.2
Bunches/ha	1007	1015		ns	24.9	10.3
Bunch weight (kg)	24.5	24.9		ns	0.286	4.9

Foliar samples were not taken in 1997.

The yield data for the 11 years from 1987 to 1997 was analysed to investigate the reasons for variation in yield. Figure 1.1 shows that monthly yield varies annually with a peak occurring around April and a trough in August and September each year.

Figure 1.1 Monthly Yield in trial 107 Jan 1987 - Dec 1997

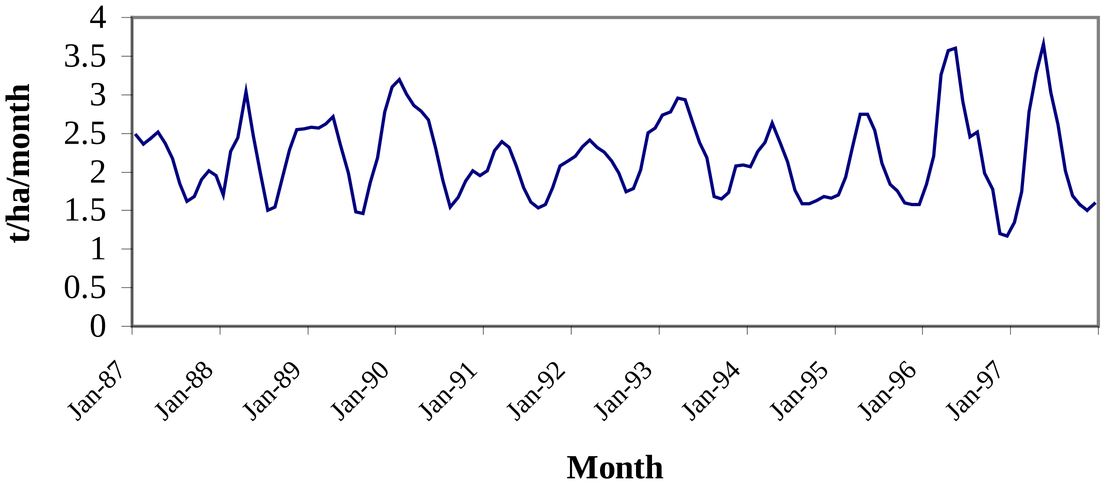
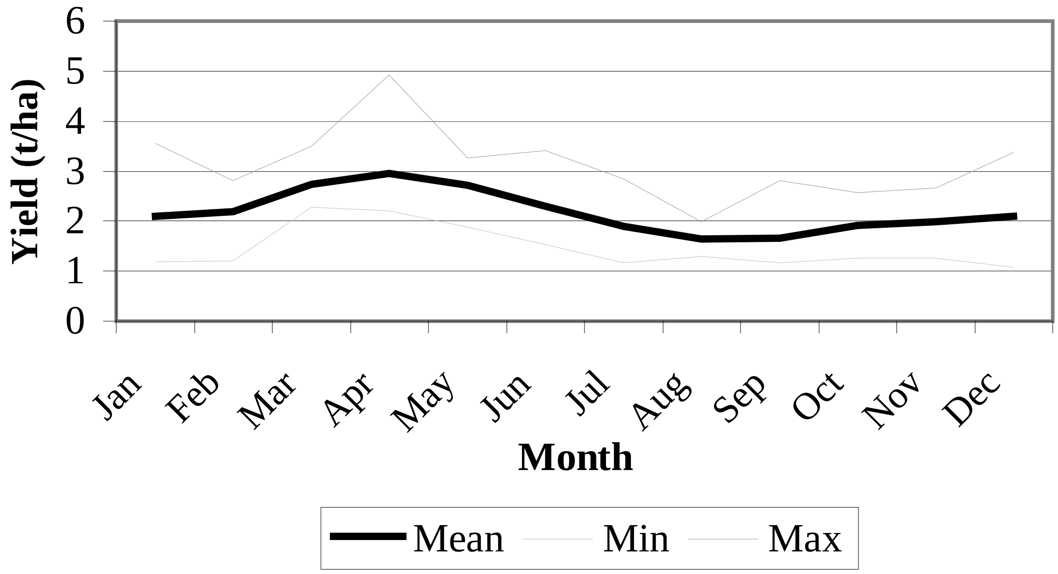


Table 1.5 gives the monthly yield data recorded in Trial 107. The mean annual yield for all years was 26.2 t/ha. Figure 1.2 shows the mean monthly yield with the minimum and maximum yields recorded in all months.

Table 1.5: Monthly yield (t/ha) from January 1987 to Dec 1997.

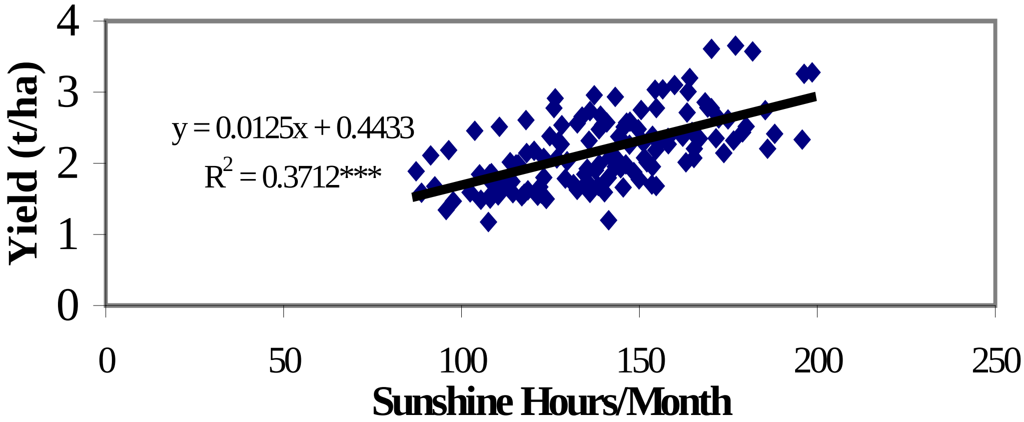
Year	Month											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1987	2.48	2.04	2.55	2.71	2.29	2.11	2.13	1.30	1.43	2.31	1.96	1.77
1988	2.13	1.20	3.47	2.65	3.00	1.78	1.17	1.56	1.90	2.31	2.66	2.66
1989	2.36	2.73	2.62	2.50	3.02	1.53	1.40	1.53	1.47	2.58	2.50	3.25
1990	3.55	2.80	2.67	3.10	2.58	2.33	2.01	1.32	1.31	2.37	1.95	1.74
1991	2.17	2.13	2.54	2.49	1.92	1.82	1.66	1.33	1.62	1.79	1.98	2.46
1992	1.99	2.16	2.85	2.23	1.88	2.67	1.88	1.41	1.94	2.00	2.15	3.38
1993	2.19	2.63	3.51	2.73	2.56	2.68	1.90	1.97	1.16	1.83	2.22	2.17
1994	1.87	2.16	2.77	2.20	2.92	2.00	1.48	1.81	1.47	1.49	1.92	1.63
1995	1.43	2.06	2.30	2.68	3.26	2.31	2.04	1.98	1.51	1.76	1.51	1.45
1996	1.76	2.32	2.53	4.92	3.27	2.63	2.84	1.90	2.80	1.26	1.26	1.08
1997	1.18	1.77	2.28	4.28	3.27	3.41	2.42	1.99	1.64	1.45	1.65	1.40
Mean	2.10	2.18	2.74	2.95	2.72	2.30	1.90	1.65	1.66	1.92	1.98	2.09
se	0.19	0.14	0.12	0.26	0.16	0.16	0.14	0.09	0.13	0.13	0.12	0.23
min	1.18	1.20	2.28	2.20	1.88	1.53	1.17	1.30	1.16	1.26	1.26	1.08
max	3.55	2.80	3.51	4.92	3.27	3.41	2.84	1.99	2.80	2.58	2.66	3.38

Figure 1.2 Monthly yield from Trial 107



One of the main factors determining yield in West New Britain is sunshine at sex determination, which occurs at 25 months prior to anthesis or 30 months prior to harvest. This relationship is shown in Figure 1.3.

Figure 1.3: Effect of sunshine 30 months before harvest on yield



Trial 120 NITROGEN/ANION FERTILISER TRIAL AT DAMI PLANTATION.

PURPOSE

To investigate the response of oil palm to the application of various combinations of inorganic fertiliser with a view to providing information that will be useful in developing fertiliser recommendations.

DESCRIPTION

Site: Dami Plantation, Field 9.

Soil: Young very coarse textured freely draining soils formed on alluvially reworked andesitic pumiceous sands and gravel.

Palms: Dami commercial DxP crosses.

Planted in 1983 at 135 palms/ha.

Treatments started in April 1989.

DESIGN

There are twelve treatments (Table 1.6) made up from muriate of potash or kieserite (or neither of these) combined with nitrogen from one of three sources (or no nitrogen). The three nitrogen sources are diammonium phosphate, ammonium sulphate, and ammonium chloride. The twelve treatments are replicated in four randomised complete blocks, giving a total of 48 plots. Each plot has 25 palms of which the central 9 are recorded. Plot isolation trenches were completed in February 1996.

Table 1.6. Rates of fertiliser and resulting combinations of elements used in Trial 120.

	Nil		Muriate of potash		Kieserite	
Nil	---	1	K+Cl	5	Mg+S (9)	9
Diammonium phosphate	N+P	2	N+P+K+Cl	6	N+P+Mg+S	10
Ammonium sulphate	N+S	3	N+S+K+Cl	7	N+2S+Mg	11
Ammonium chloride	N+Cl	4	N+2Cl+K	8	N+Cl+Mg+S	12

Diammonium phosphate	= 3.9 kg/palm/year
Ammonium sulphate	= 3.8 kg/palm/year
Ammonium chloride	= 3.0 kg/palm/year
Muriate of potash	= 4.2 kg/palm/year
Kieserite	= 3.7 kg/palm/year

RESULTS

The average plot FFB yield in 1997 was again high at 31.1 t/ha/year.

The overall treatment effects for 1997 and the 1995 to 1997 cumulative data were not significant (Table 1.7). The highest yield recorded in 1997 was from the treatment receiving both muriate of potash and either di-ammonium phosphate or ammonium chloride though there was no significant differences.

The treatment contrasts given in Table 1.8 show that ammonium chloride produces larger bunches than di-ammonium phosphate and sulphate of ammonia though this was not significant. The results from this trial have not been consistent over time. The site was extremely fertile and it has not been possible to draw any conclusions from the trial.

This trial is to be closed down at the end of 1997.

Table 1.7 Effect of fertiliser treatments on yield and yield components in 1997 and 1995 to 1997 (Trial 120).

Treatment		1997			1995 to 1997		
		Yield (t/ha/yr)	Bunch number /ha	Bunch weight (kg)	Yield (t/ha/yr)	Bunch number /ha	Bunch weight (kg)
1	Nil	29.3	1193	25.1	28.3	1169	24.4
2	DAP	31.4	1240	26.4	29.5	1221	24.4
3	SoA	30.9	1223	25.6	30.3	1244	24.5
4	AC	33.1	1211	28.2	30.7	1184	26.3
5	MoP	27.7	1071	26.5	29.2	1161	25.5
6	MoP + DAP	33.4	1253	27.4	30.4	1180	26.0
7	MoP + SoA	31.7	1223	27.4	30.5	1237	25.3
8	MoP + AC	33.4	1249	27.4	29.7	1180	25.4
9	Kies	27.3	1095	25.3	27.3	1115	24.7
10	Kies + DAP	32.5	1328	25.3	30.0	1263	24.1
11	Kies + SoA	30.3	1185	26.2	30.5	1241	24.8
12	Kies + AC	32.5	1216	27.5	31.5	1245	25.7
	significance	ns	ns	ns	ns	ns	ns
	sed	2.215	87.3	1.35	1.517	73.2	0.928
	cv%	10.1	10.2	7.2	7.2	8.6	5.2

Table 1.8 Treatment contrasts for yield and yield components (Trial 120)

		1997						1995 to 1997					
	Contrast	Yield (t/ha/yr)		Bunch Number		SBW (kg)		Yield (t/ha/yr)		Bunch Number		SBW (kg)	
1	- N (- K & Mg)	29.3	ns	1193	ns	25.1	ns	28.3	ns	1169	ns	24.4	ns
	+ N (- K & Mg)	31.8		1225		26.7		30.1		1216		25.1	
2	DAP + SoA (- K & Mg)	31.2	ns	1232	ns	26.0	ns	29.9	ns	1233	ns	24.4	ns
	AmC (- K & Mg)	33.1		1211		28.2		30.7		1184		26.3	
3	DAP (- K & Mg)	31.4	ns	1240	ns	26.4	ns	29.5	ns	1221	ns	24.4	ns
	SoA (- K & Mg)	30.9		1223		25.6		30.3		1244		24.5	
4	- Mg (- N)	**29.3**	*	1193	ns	25.1	ns	28.3	ns	1169	ns	24.4	ns
	+ Mg (- N)	**27.3**		1095		25.3		27.3		1115		24.7	
5	- Mg (+ N)	31.8	ns	1225	ns	26.7	ns	30.1	ns	1216	ns	25.1	ns
	+ Mg (+ N)	31.8		1243		26.3		30.6		1250		24.8	
6	- K (- N)	29.3	ns	**1193**	*	25.1	ns	28.3	ns	1169	ns	24.4	ns
	+ K (- N)	27.7		**1071**		26.5		29.2		1161		25.5	
7	- K (+ N)	**31.8**	*	1225	ns	26.7	ns	30.1	ns	1216	ns	25.1	ns
	+ K (+ N)	**32.8**		1242		27.4		30.2		1199		25.6	

Trial 122 NITROGEN AND CROP RESIDUE TRIAL AT KUMBANGO PLANTATION.

PURPOSE

To investigate the response of oil palm to applications of empty fruit bunches (EFB), palm kernel cake (PKC), pruned fronds and the combined application of these crop residues and inorganic nitrogen and magnesium fertiliser. It is hoped that by integrating the application of inorganic fertiliser and crop residue, the efficacy of nitrogen and magnesium fertiliser application will be improved.

DESCRIPTION

Site: Field number E12, Division II, Kumbango Plantation, Nr Kimbe, WNBP. The trial is situated about 1.5 km west of the Dagi River on its flat alluvial plain and about 6 km from the coast.

Soil: Young coarse textured freely draining soils formed on alluvially redeposited andesitic pumiceous sands and gravel with inter-mixed volcanic ash.

Palms: Dami commercial DxP crosses.

Planted in 1978 at 120 palms/ha.

Trial was initiated in November 1991, treatment applications started in July 1992.

DESIGN

The trial consists of 13 treatments (Table 1.9) in 4 randomised complete blocks. 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 1.9 Treatments used in Trial 122.

Treatment Number	Crop Residue	Fertiliser Applied (kg/palm/yr)	Fertiliser Placement
1	Nil	3.0kg SoA & 3.0kg Kies	Weeded Circle
2	fronds	3.0kg SoA & 3.0kg Kies	Weeded Circle
3	fronds	3.0kg SoA & 3.0kg Kies	Frond Pile
4	fronds & EFB	3.0kg SoA & 3.0kg Kies	Weeded Circle
5	fronds & EFB	3.0kg SoA & 3.0kg Kies	Frond Pile
6	fronds & EFB	3.0kg SoA & 3.0kg Kies	EFB
7	fronds & PKC	3.0kg SoA & 3.0kg Kies	Weeded Circle
8	fronds & PKC	3.0kg SoA & 3.0kg Kies	Frond Pile
9	fronds & PKC	3.0kg SoA & 3.0kg Kies	PKC
10	Nil	Nil	Nil
11	fronds	Nil	Nil
12	fronds & EFB	Nil	Nil
13	fronds & PKC	Nil	Nil

The EFB is applied with a Giltrap EFB applicator at approximately 50 t/ha. The PKC was applied with a Kuhn spinning disc fertiliser spreader at a rate of 1.8 t/ha in previous years. However, this machine was no longer operational in 1997 so the PKC was applied by hand at the same rate of 1.8 t/ha.

RESULTS

Mean yield in 1997 was 22.5 t/ha. Although there was no significant difference the highest yield was recorded from the treatment receiving fronds & EFB and fertiliser applied to the frond pile. The highest bunch weights were recorded from the treatments receiving EFB (Table 1.10).

In 1994 and 1995 EFB was applied at very high rates (120 t/ha), which led to a reduction in yield. In 1996 and 1997 application rates were reduced to the recommended 50 t/ha. The 1996 and 1997 yield results indicate that the high application rates have not had any long lasting effects.

The 1997 results also show PKC is not a particularly useful fertiliser as can be seen from the comparison of treatments 12 and 13.

Analysis of the 1995-1997 cumulative data (Table 1.11) shows that the highest yield (27.9 t/ha) was recorded from treatment 5 that received EFB with fertiliser applied to the frond pile. This was due to a significantly higher bunch weight.

There was no tissue sampling carried out in 1997.

Table 1.10 Effects of treatments on yield and yield components in 1997 (Trial 122).

Treatment Number	Crop Residue	Fertiliser Applied	Fertiliser Placement	FFB Yield (t/ha/yr)	Number of Bunches/ha	Bunch weight (kg)
1	Nil	N + Mg	Weeded Circle	21.5	777	29.9
2	fronds	N + Mg	Weeded Circle	22.7	818	28.5
3	fronds	N + Mg	Frond Pile	22.1	772	29.1
4	fronds & EFB	N + Mg	Weeded Circle	24.6	785	32.3
5	fronds & EFB	N + Mg	Frond Pile	25.7	816	32.8
6	fronds & EFB	N + Mg	EFB	22.8	779	30.6
7	fronds & PKC	N + Mg	Weeded Circle	22.4	809	29.4
8	fronds & PKC	N + Mg	Frond Pile	23.1	787	31.1
9	fronds & PKC	N + Mg	PKC	21.2	753	29.5
10	Nil	Nil	Nil	20.2	727	28.5
11	fronds	Nil	Nil	23.1	812	29.2
12	fronds & EFB	Nil	Nil	25.4	806	32.6
13	fronds & PKC	Nil	Nil	17.4	648	28.3
			significance	ns	ns	**
			sed	2.438	97.3	1.267
			cv%	15.3	17.7	5.9

Table 1.11 Effects of treatments on yield and yield components for 1995 to 1997 (Trial 122).

Treatment Number	Crop Residue	Fertiliser Applied	Fertiliser Placement	FFB Yield (t/ha/yr)	Number of Bunches/ha	Bunch weight (kg)
1	Nil	N + Mg	Weeded Circle	25.1	1016	26.5
2	fronds	N + Mg	Weeded Circle	23.8	979	25.3
3	fronds	N + Mg	Frond Pile	23.8	1015	25.4
4	fronds & EFB	N + Mg	Weeded Circle	25.3	989	27.3
5	fronds & EFB	N + Mg	Frond Pile	27.9	1044	28.4
6	fronds & EFB	N + Mg	EFB	24.9	978	26.7
7	fronds & PKC	N + Mg	Weeded Circle	24.4	1031	25.3
8	fronds & PKC	N + Mg	Frond Pile	25.8	1016	27.2
9	fronds & PKC	N + Mg	PKC	26.2	1078	26.1
10	Nil	Nil	Nil	24.4	992	25.9
11	fronds	Nil	Nil	25.7	1030	26.4
12	fronds & EFB	Nil	Nil	26.2	1016	27.8
13	fronds & PKC	Nil	Nil	23.1	948	25.9
			significance	ns	ns	**
			sed	1.618	67.2	0.828
			cv%	9.1	9.4	4.4

Leaf and rachis tissue was not sampled in 1997. The area in which this trial is located is due to be replanted in 1998 and 1997 will be the last year of yield recording in this trial.

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 redeposited andesitic pumiceous sands and gravel with inter-mixed 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 will be 15 fertiliser treatments in each replication and 3 control plots (Table 1.12). The 15 treatments will be replicated four times in a randomised complete block design. The three control plots will be plots on the edge of the trial from which yield will be 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 1.12 Treatments used in Trial 125

Fertiliser	Level (kg/palm/year)		
	1	2	3
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 pretreatment yield data had been collected. 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

Yields and yield components for 1997 are presented in Table 1.13. Fertiliser treatments were not applied until June 1997 and as expected there were no differences recorded between types of fertilisers at this early stage.

Table 1.13 Yield and yield components in Trial 125 in 1997

Fertiliser Type	Yield (t/ha)	Single Bunch Wt (kg)	Number of Bunches/ha
Control	18.8	9.8	1908
Ammonium Chloride	18.0	9.7	1871
Sulphate of Ammonia	18.9	9.4	2024
Urea	18.3	9.6	1919
Ammonium Nitrate	18.3	9.5	1931
Di-Ammonium Phosphate	17.8	9.5	1906
sig. eff.	ns	ns	ns
sed	0.739	0.238	69.2
cv (%)	9.9	6.1	8.8
Fertiliser Rate (gN/palm/year)	**Yield (t/ha)**	**Single Bunch Wt (kg)**	**Number of Bunches/ha**
520	18.0	9.7	1864
1040	19.1	9.4	2050
2080	17.7	9.5	1877
sig. eff.	ns	ns	ns
sed	0.573	0.184	53.6
cv (%)		6.1	8.8

The results of the pre-treatment leaflet analysis are given in Table 1.14. This data and pre-treatment rachis cross-section may be used as covariates in analyses of yield data in future years.

Table 1.14 Pre-treatment leaflet analysis and rachis cross section.

Nutrient (%)	Mean	Min	Max	SE
Ash	16.4	14.6	18.0	0.092
N	2.50	2.27	2.66	0.010
P	0.158	0.150	0.165	0.0004
K	0.85	0.75	0.95	0.005
Ca	0.89	0.73	1.01	0.008
Mg	0.18	0.14	0.23	0.002
Cl	0.63	0.52	0.77	0.006
WxT (mm^2)	2365	2076	2853	23.9

Trial 126 FACTORIAL FERTILISER TRIAL AT MALILIMI PLANTATION.

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?

DESCRIPTION

Site: Malilimi Plantation, WNBP.

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.
Treatments are to be started in May 1996.

DESIGN

There are 72 treatments comprising all factorial combinations of sulphate of potash (K), sulphate of ammonia (N) each at three levels and triple superphosphate (P), kieserite (Mg) and sodium chloride (Cl) each at two levels (Table 1.15). The 72 treatments will be replicated only once and will be divided among two blocks. The 3 factor interaction '2x2x2' will be confounded with blocks. Third and higher order interactions will 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 1.15 Fertiliser rates used in Trial 126.

Fertiliser	Level (kg/palm/year)		
	0	1	2
Sulphate of potash	0.0	3.0	6.0
Sulphate of ammonia	0.0	3.0	6.0
Triple superphosphate	0.0	4.0	---
Kieserite	0.0	4.0	---
Sodium chloride	0.0	4.0	---

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

The sulphate of ammonia and sulphate of potash will be 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.

The trial was physically initiated in 1994. 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.

Frond 17 leaflet sampling was carried out for each plot in December 1994, and subsequently analysed for nutrient element content (Table 1.16). Due to the delay in commencing fertiliser treatments frond 17 leaflet and rachis sampling was repeated in May 1996 (Table 1.17). These analyses will be used as pre-treatment data for the control of residual variance in later statistical analysis. It should be noted that the whole site had been receiving a fertiliser schedule that comprises nitrogen and magnesium amelioration.

Table 1.16 Summary statistics for pre-treatment frond 17 leaflet tissue analysis - Dec 1994 (Trial 126).

Element (%)	Mean	Minimum	Maximum	Standard Deviation
Nitrogen	2.39	2.26	2.58	0.057
Phosphorus	0.146	0.138	0.152	0.003
Potassium	0.81	0.65	0.95	0.065
Magnesium	0.13	0.09	0.18	0.018
Calcium	0.85	0.68	1.04	0.075
Chlorine	0.34	0.28	0.45	0.037

Table 1.17 Summary statistics for pre-treatment frond 17 tissue analysis - May 1996 (Trial 126).

Element	Mean	Minimum	Maximum	Standard Deviation
Leaflet				
Nitrogen	2.30	2.16	2.44	0.065
Phosphorus	0.141	0.135	0.152	0.004
Potassium	0.76	0.67	0.91	0.048
Calcium	0.81	0.63	0.93	0.065
Magnesium	0.13	0.10	0.17	0.016
Chlorine	0.27	0.22	0.38	0.028
Rachis				
Nitrogen	0.23	0.20	0.28	0.016
Phosphorus	0.041	0.028	0.054	0.004
Potassium	0.93	0.69	1.14	0.104
Calcium	0.37	0.30	0.45	0.038
Magnesium	0.03	0.02	0.04	0.002
Chlorine	0.11	0.07	0.18	0.021

RESULTS

Yields recorded in the twelve months from January to December 1997 are given in Table 1.18. The only significant response was an increase in yield with the application of chlorine. This was as a result of an increase in single bunch weight.

Table 1.18 Main effects of N, P, K, Mg and Cl on yield and yield components in 1997 (Trial 126).

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha/yr)	29.0	30.5	30.1	ns	0.718	8.3
Bunches/ha	1266	1323	1285	ns	42.6	11.4
Bunch weight (kg)	23.6	23.6	24.0	ns	0.375	5.5
	K0	K1	K2			
Yield (t/ha/yr)	29.5	30.6	29.5	ns	0.718	8.3
Bunches/ha	1292	1346	1236	ns	42.6	11.4
Bunch weight (kg)	23.5	23.5	24.1	ns	0.375	5.5
	P0	P1				
Yield (t/ha/yr)	30.2	29.6		ns	0.586	8.3
Bunches/ha	1302	1281		ns	34.8	11.4
Bunch weight (kg)	23.7	23.7		ns	0.306	5.5
	Mg0	Mg1				
Yield (t/ha/yr)	30.2	29.6		ns	0.586	8.3
Bunches/ha	1316	1267		ns	34.8	11.4
Bunch weight (kg)	23.6	23.8		ns	0.306	5.5
	Cl0	Cl1				
Yield (t/ha/yr)	29.2	30.5		*	0.586	8.3
Bunches/ha	1278	1305		ns	34.8	11.4
Bunch weight (kg)	23.3	24.1		*	0.306	5.5

Trial 129 CROP RESIDUE AND FERTILISER PLACEMENT TRIAL

PURPOSE

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

DESCRIPTION

Site: Kumbango Plantation, Division 1

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

Palms: Dami commercial DxP crosses.

Planted in October 1996 at 120 palms/ha.

Treatment applications will start 36 months after planting.

DESIGN

This trial has been designed by biometricians from IACR - Rothamsted and the Pacific Regional Agricultural Program and will replace Trial 122 that is to be replanted in 1998. There will in fact be two separate trials side by side but the results will be reported together.

In Trial 129a there will be 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 1.19) will be arranged in a randomised complete block design with 4 replications.

Table 1.19 Treatments to be used in Trial 129a.

Treatment Number	Crop Residue	Fertiliser Applied (kg/palm/yr)	Fertiliser Placement
1	EFB	3.0kg SoA & 3.0kg Kies	Weeded Circle
2	EFB	3.0kg SoA & 3.0kg Kies	Frond Pile
3	EFB	Nil	-
4	Nil	3.0kg SoA & 3.0kg Kies	Weeded Circle
5	Nil	3.0kg SoA & 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 1.20). The four treatments will be arranged in a randomised complete block design with 8 replications.

Table 1.20 Treatments to be used in Trial 129b.

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

PROGRESS

This trial was approved in the PNGOPRA Scientific Advisory Board meeting in October 1996. The site has been identified and plot and palm labelling will be completed in 1998.

Experimental fertiliser treatments will be started in August 1999 after pre-treatment yield data has been collected. Until this time the palms will receive a standard immature palm fertiliser input. Frond 17 leaflet, rachis and cross-section sampling will be carried out prior to treatments being applied. The palms in this trial site suffered severe moisture stress in 1997. Their recovery will be monitored closely.

Trial 131 NURSERY FERTILISER TRIAL NO. 2 AT BEBERE

PURPOSE

To provide information which will be used to make nursery fertiliser recommendations

DESIGN

There were 18 treatments in a randomised complete block design with three replications. Each of the 54 plots consisted of a single row of 44 plants in a bed at Bebere nursery. Each replicate of 792 seedlings was a single progeny. The total number of seedlings included in the experiment was 2376. The trial was planted in December 1996 and treatments were first applied in January 1997

The nursery staff planted the germinated seed directly into large planter bags as provided by Dami. PNGOPRA staff applied all fertiliser fortnightly and was responsible for all data recording. Weeding, irrigation and culling were the responsibility of nursery staff.

Seedling height and leaf number was measured every month from month 1 to month 10. Bole diameter was measured at the end of month 10. Five palms were selected at random from each plot at the end of month 10 for determination of dry weight of root and top.

TREATMENTS

There were 18 treatments as per the following table (Table 1.21).

Table 1.21 Treatments used in Trial 131.

Treatment	1 - 5 Months	6 - 10 Months
1	24g SOA/fortnight	48g SOA/ fortnight
2	24g SOA/ fortnight	24g SOA/ fortnight
3	24g SOA/ fortnight	20g Urea/fortnight
4	24g SOA/ fortnight	10g Urea/fortnight
5	24g SOA/ fortnight	5g Urea/fortnight
6	12g SOA/ fortnight	48g SOA/ fortnight
7	12g SOA/ fortnight	24g SOA/ fortnight
8	12g SOA/ fortnight	20g Urea/fortnight
9	12g SOA/ fortnight	10g Urea/fortnight
10	12g SOA/ fortnight	5g Urea/fortnight
11	6g SOA/ fortnight	48g SOA/ fortnight
12	6g SOA/ fortnight	24g SOA/ fortnight
13	6g SOA/ fortnight	20g Urea/fortnight
14	6g SOA/ fortnight	10g Urea/fortnight
15	6g SOA/ fortnight	5g Urea/fortnight
16	5 tabs Nursery Ace one month after planting	
17	50g Agroblen at planting	15g SOA/ fortnight at 9 months
Control	15g SOA/fortnight commencing at 12 weeks	15g SOA/fortnight

RESULTS

The effect of fertiliser treatment on bole diameter, leaf number, seedling height, dry weight root and dry weight top at the end of the experiment (month 10) are given in Table 1.22. The treatment producing the highest dry weight of top was treatment 12 that received 6g of SOA per fortnight followed by 24g of SOA per fortnight. This treatment gave the highest dry weight of top and root combined of 309.4g.

Table 1.22 Bole diameter, leaf number and height of 10-month-old seedlings.

Treat.	1-5 months	6-10 months	Bole Diameter (cm)	Leaf Number	Height (cm)	Dry Wt Root (g)	Dry Wt. Top (g)
1	24g SOA	48g SOA	43.4	11.9	83.7	35.4	253.0
2	24g SOA	24g SOA	49.9	11.5	84.7	42.8	242.0
3	24g SOA	20g Urea	41.4	12.0	81.1	35.1	196.0
4	24g SOA	10g Urea	42.6	10.9	84.6	38.8	234.0
5	24g SOA	5g Urea	41.7	12.2	79.7	34.7	211.0
6	12g SOA	48g SOA	46.5	11.3	83.2	32.3	241.0
7	12g SOA	24g SOA	48.9	12.6	86.9	39.0	250.0
8	12g SOA	20g Urea	43.2	11.9	82.4	41.4	229.0
9	12g SOA	10g Urea	47.9	12.2	87.1	40.7	245.0
10	12g SOA	5g Urea	43.7	13.1	82.9	39.0	222.0
11	6g SOA	48g SOA	43.0	11.5	85.8	38.4	236.0
12	6g SOA	24g SOA	43.6	12.7	84.1	39.4	270.0
13	6g SOA	20g Urea	51.1	12.0	77.5	28.7	195.0
14	6g SOA	10g Urea	43.6	11.1	84.0	42.2	233.0
15	6g SOA	5g Urea	41.4	12.8	84.8	42.0	237.0
16	N/Ace		47.0	13.1	77.6	30.7	166.0
17	Agroblen		38.7	12.2	75.6	30.4	164.0
18	Control		39.9	11.5	71.8	18.0	124.0
Mean			44.3	12.0	82.1	36.1	219.0
sig eff			ns	ns	*	***	***
sed			4.44	0.782	3.92	3.72	24.4
cv%			12.3	8.0	5.8	12.7	13.6

The results of this experiment show very clearly that the slow release products Nursery Ace and Agroblen do not provide sufficient nitrogen for growth of oil palm seedlings at Bebere Nursery. After 4 months seedlings receiving the slow release treatments were noticeably shorter and yellower than seedlings receiving SOA. Seedlings receiving the control treatment did not receive any fertiliser until they were 14 weeks old. The results of this experiment clearly show that this is not a good practice. The first application of sulphate of ammonia should be applied 2 weeks after planting to obtain good early growth. Additional sulphate of ammonia was applied to the palms receiving the slow release fertilisers and control treatment to recover the seedlings from what was severe nitrogen deficiency. However, at the end of the trial these seedlings were still much shorter than those receiving sulphate of ammonia throughout the trial period.

The results of this experiment also confirm the fact that urea is not a good source of nitrogen for oil palm seedlings. The results of a previous trial (Trial 130) showed that urea retarded root growth of young seedlings. This trial showed that seedlings that received urea from 6-9 months had smaller tops than seedlings receiving SOA. The treatments receiving 20g of urea had significantly lower top dry weight than seedlings receiving SOA.

The main visual effect of fertiliser treatment was to increase seedling height (Table 1.23). Leaf number at 10-months (Table 1.24) was not significantly affected by the treatments given in this experiment however, up until the last two-months there were significant differences between treatments.

Table 1.23: Height of oil palm seedlings from February to October 1997.

Treatment	Height (cm)								
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
T1	17.8	23.3	28.9	35.7	45.9	52.9	68.8	75.7	83.7
T2	17.8	23.6	29.8	37.2	46.6	54.8	71.3	77.2	84.7
T3	17.5	23.6	29.4	36.3	46.1	52.5	69.2	74.3	81.1
T4	18.1	24.1	29.6	37.4	47.0	53.9	71.0	81.7	84.6
T5	17.4	22.8	28.1	34.0	43.9	51.3	68.0	72.7	79.7
T6	17.2	23.3	29.8	37.8	47.0	54.0	69.6	77.1	83.2
T7	17.6	23.5	29.5	36.9	47.2	54.1	70.9	77.8	86.9
T8	18.2	23.8	30.3	37.4	48.1	55.1	70.4	74.8	82.4
T9	17.7	23.1	30.0	37.9	47.9	55.5	72.5	78.7	87.2
T10	17.5	23.0	28.5	35.7	45.3	52.2	68.0	75.8	82.9
T11	18.3	24.0	30.7	38.3	47.9	54.7	71.4	78.1	85.8
T12	18.0	23.4	29.6	36.5	51.1	52.9	71.1	77.6	84.1
T13	17.8	23.4	29.6	37.5	47.7	55.0	71.0	75.8	77.5
T14	17.7	23.8	30.2	37.4	48.7	55.6	71.6	77.7	84.0
T15	17.4	23.3	29.8	36.5	47.3	54.6	70.7	77.8	84.8
T16	16.1	21.6	26.8	33.6	44.4	51.0	67.6	72.2	77.6
T17	16.9	22.0	27.7	33.7	44.5	50.8	64.9	70.4	75.6
T18	16.7	20.7	25.2	28.6	35.6	41.0	50.8	61.5	71.8
Mean	17.5	23.1	29.1	36.0	46.2	52.9	68.8	75.4	82.1
sig effect	***	*	***	***	***	***	***	***	*
sed	0.399	0.842	0.670	1.13	2.03	1.34	1.93	2.69	3.92

Table 1.24 Leaf number of oil palm seedlings from February to October 1997.

Treatment	Leaf Number								
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
T1	2.24	3.54	4.66	6.71	7.75	8.94	9.05	10.4	11.9
T2	2.25	3.40	4.59	6.63	8.00	9.19	8.97	10.5	11.5
T3	2.39	3.43	4.56	6.92	7.43	8.86	9.13	9.76	12.0
T4	2.27	3.45	4.70	6.75	7.63	9.38	8.99	10.8	10.9
T5	2.17	3.43	4.29	6.51	7.52	8.82	8.40	10.4	12.2
T6	2.21	3.39	5.39	6.79	8.14	9.12	10.0	9.48	11.3
T7	2.36	3.41	4.55	6.69	7.97	9.07	9.37	10.3	12.6
T8	2.33	3.42	4.68	6.93	7.67	9.01	9.22	10.9	11.9
T9	2.14	3.37	4.77	6.75	8.02	9.53	9.18	11.0	12.2
T10	2.41	3.47	4.52	6.69	7.64	8.97	9.11	9.28	13.1
T11	2.24	3.44	4.81	6.74	8.83	9.88	9.55	11.1	11.5
T12	2.46	3.47	4.95	6.67	7.76	9.76	9.25	11.3	12.7
T13	2.24	3.46	4.77	6.80	7.95	9.35	9.29	10.3	12.0
T14	2.23	3.41	4.92	6.72	7.85	9.26	8.96	10.2	11.1
T15	2.19	3.45	4.66	6.45	7.82	9.44	9.03	10.4	12.8
T16	2.13	3.05	4.27	6.19	7.36	9.17	9.09	10.1	13.1
T17	2.26	3.25	4.47	6.19	7.29	9.30	8.84	9.53	12.2
T18	2.09	3.00	4.30	5.46	6.26	7.14	7.94	9.11	11.5
Mean	2.56	3.38	4.66	6.59	7.72	9.12	9.08	10.3	12.0
sig effect	ns	***	ns	***	**	***	*	ns	ns
sed	0.130	0.095	0.292	0.222	0.426	0.408	0.428	0.887	0.781

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 1.25).

Table 1.25 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 will be 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 will be replicated only once and will be divided among nine blocks each of nine plots.

PROGRESS

The Scientific Advisory Committee approved the trial in 1997 and the plots were marked out in December 1997. Pre-treatment yield recording will continue until the end of 1998 and fertiliser treatments will commence in 1999.

Trial 134 PALM POISONING TRIAL

PURPOSE

To provide recommendations for poisoning oil palms.

DESCRIPTION

Site: Kavui Section Block.

Palms: Dami commercial DxP crosses.
Planted in 1976 at 120 palms/ha.
Treatments started in June 1997.

DESIGN

There were 8 treatments, comprising two replications of the 8 treatments. Each treatment was applied to a row of palms in the block to be poisoned. Holes in each palm were drilled in each palm approximately 1 metre above ground level and the chemical applied in each hole. Chemicals used were as in Table 1.26. Rates for Touchdown, Gramoxone and Roundup were as recommended by the manufacturers.

Table 1.26 Chemicals used in Trial 134.

Chemical	No. Holes/Palm	Rate/Hole (mls)
Sodium Arsenite	2	60
MSMA	2	60
Touchdown	2	22.5
Touchdown	3	15
Gramoxone	2	60
Gramoxone	3	40
Roundup	2	22.5
Roundup	3	15

The palms were inspected after 2 weeks and 4 weeks and symptoms observed.

RESULTS

Sodium arsenite gave the fastest kill. Two weeks after application 70% of the fronds on the palms treated with sodium arsenite were completely desiccated and brown. After 1 month the crowns on all the palms treated with sodium arsenite had collapsed. 100% of fronds on MSMA treated palms were desiccated and brown after 2 weeks but the crowns had not collapsed until after 1 month.

The Gramoxone, Touchdown and Roundup treatments had not killed the palms 5 weeks after treatment and these palms had to be retreated with sodium arsenite to kill the palms so that the block could be replanted.

Sodium arsenite is dangerous to use (LD50 oral 10mg/kg) but will still be recommended for the poisoning of oil palm until such time as its import is banned. MSMA is an organo-arsenic with an LD50 (oral) of 900 mg/kg and is therefore much safer to handle. MSMA is the only effective replacement for sodium arsenite and should be kept in reserve should sodium arsenite imports be banned. The results of this trial show MSMA is an effective palm poison when injected at a rate of 90-120mls per palm in 2 or 3 holes around the base of the palm.

Trial 204 FACTORIAL FERTILISER TRIAL AT NAVO PLANTATION.

PURPOSE

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

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 120 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 1.27).

Table 1.27 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 average plot yield in this trial was 25.7 t/ha in 1997 compared to 31.8 t/ha in 1996. This reduction in yield was due the closure of the highway during the cyclone in early 1997. There was no harvesting of this trial for 2 months in March and April. As in previous years ammonium chloride application led to a significant increase in FFB yield from 21.7 t/ha to 27.2 t/ha (N1) and 28.1 t/ha (N2) (Table 1.28). This increase was due to significant increases in both the number of bunches produced and the single bunch weight.

No other fertiliser had any main effect on yield or the components of yield. However, there was a significant interaction between N and K in 1997 and this is given in Table 1.29. This interaction is not surprising, as potassium deficiency symptoms are quite apparent in those plots that are not receiving muriate of potash

Table 1.28 Main effects of N, P, K and Mg on yield and yield components in 1997 (Trial 204).

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha/yr)	21.7	27.2	28.1	***	0.811	11.0
Bunches/ha	1071	1218	1256	***	44.0	12.9
Bunch weight (kg)	20.6	22.7	22.7	***	0.495	7.8
	P0	P1	P2			
Yield (t/ha/yr)	25.6	25.1	26.3	ns	0.811	11.0
Bunches/ha	1175	1159	1211	ns	44.0	12.9
Bunch weight (kg)	22.1	22.0	22.0	ns	0.495	7.8
	K0	K1				
Yield (t/ha/yr)	25.7	25.6		ns	0.662	11.0
Bunches/ha	1183	1180		ns	36.0	12.9
Bunch weight (kg)	22.1	21.9		ns	0.404	7.8
	Mg0	Mg1				
Yield (t/ha/yr)	26.3	25.0		ns	0.662	11.0
Bunches/ha	1206	1157		ns	36.0	12.9
Bunch weight (kg)	22.2	21.9		ns	0.404	7.8

Table 1.29 Effect of N and K on yield in Trial 204 in 1997.

Rate of Fertiliser	K0	K1
N0	22.5	20.9
N1	27.8	26.5
N2	26.7	29.4

The cumulative data for the period 1995 to 1997 (Table 1.30) also shows a significant positive effect of ammonia chloride application on FFB yield, which was caused by an increase in both number of, bunches and bunch weight. Table 1.31 gives the yield and components of yield for each year from 1992 to 1997.

Analysis of the three-year cumulative yield data shows that the response to nitrogen is quadratic (Figure 1.4) and that maximum yield is achieved with an application of approximately 5kg of ammonium chloride (Table 1.32).

Table 1.30 Main effects of N, P, K and Mg on yield and yield components for 1995 to 1997. (Trial 204)

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha/yr)	23.8	30.5	31.9	***	0.698	8.4
Bunches/ha	1225	1362	1421	***	42.8	11.1
Bunch weight (kg)	19.6	22.6	22.5	***	0.438	7.0
	P0	P1	P2			
Yield (t/ha/yr)	28.6	28.2	29.3	ns	0.698	8.4
Bunches/ha	1319	1319	1370	ns	42.8	11.1
Bunch weight (kg)	21.8	21.5	21.5	ns	0.438	7.0
	K0	K1				
Yield (t/ha/yr)	28.7	28.7		ns	0.570	8.4
Bunches/ha	1341	1330		ns	34.9	11.1
Bunch weight (kg)	21.6	21.6		ns	0.358	7.0
	Mg0	Mg1				
Yield (t/ha/yr)	29.2	28.3		ns	0.570	8.4
Bunches/ha	1361	1311		ns	34.9	11.1
Bunch weight (kg)	21.6	21.6		ns	0.358	7.0

Table 1.31 Yield and components of yield for each year from 1992 to 1996 (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

Figure 1.4 Response to N in Trial 204 from 95-97

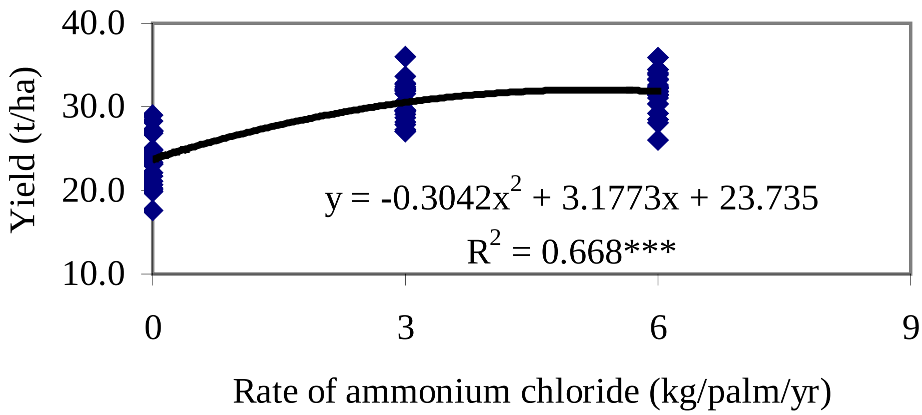


Table 1.32 Predicted yields (mean of 1995-97 yields) as determined by response curve in Figure 1.1.

Rate of AC (kg/palm/year)	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Yield (t/ha)	28.9	30.5	31.6	32.0	31.8	31.1	29.7

This shows that maximum yields are achieved at around 5kg per palm.

No samples were taken for tissue analysis in 1997 as many of the palms in the trial suffered damage to the crown during Cyclone Justin.

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 1.33). 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	Code	Progeny Number
A	9004093E	I	9009127E
B	9009030E	J	9103073E
C	9009149E	K	9103136E
D	9102109E	L	9010217E
E	9010040E	M	9010190E
F	4091	N	9009110E
G	9008022E	O	9101100E
H	5148	P	9007130E

Table 1.33 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

Where application of EFB and the inorganic fertilisers coincide, they are applied together.

RESULTS

1997 was the first full year of yield recording since fertiliser treatments were applied. The effect of fertiliser treatments on yield or the components of yield for the period Jan - Dec 1997 are given in Table 1.34). This shows that there was a significant response of yield to application of triple super phosphate due to an increase in single bunch weight. This is an extremely interesting response as P has long been recognised as a limiting factor at Hargy but this is the first time a response to P has been achieved on this soil type.

Table 1.34 Yield and the components of yield Jan - Dec 1997 (Trial 205).

Treatment	Yield (t/ha)	Number of Bunches/ha	Single Bunch Weight (kg)
EFB0	24.2	3711	6.61
EFB1	24.7	3699	6.75
Mg0	24.2	3678	6.68
Mg1	24.7	3732	6.68
TSP0	**24.0 ***	3698	**6.57 ****
TSP1	**24.9**	3712	**6.79**
Mean	24.5	3705	6.68
sed	0.431 (TSP)	ns	0.0745 (TSP)
cv%	6.1	6.1	3.9

There was a significant interaction between EFB and Mg that is shown in Table 1.35. The interaction of TSP and EFB was not significant.

Table 1.35 Effect of EFB and Mg on yield in 1997.

	Yield (t/ha)	
Treatment	Mg 0	Mg1
EFB 0	24.4	24.0
EFB 1	24.1	25.3

There were large highly significant differences between progenies for yield and the components of yield in 1997 (Table 1.36). There were no significant interactions between progeny and fertiliser treatment.

No samples were taken for tissue analysis in 1997.

Table 1.36. Yield and the components of yield for 16 selected progenies Jan - Dec 1997 (Trial 205).

Progeny	Yield (t/ha)	No. of bunches/ha	Single Bunch Wt. (kg)
1	29.0	3968	7.43
2	26.6	3524	7.58
3	25.1	4008	6.33
4	23.8	3586	6.70
5	21.8	3825	5.78
6	21.9	3555	6.22
7	23.7	3673	6.55
8	24.7	3600	6.90
9	27.6	4148	6.68
10	24.2	3575	6.95
11	25.2	3623	7.02
12	25.6	3856	6.69
13	23.6	3350	7.21
14	20.9	3229	6.45
15	25.0	3772	6.63
16	22.8	3991	5.74
Mean	24.5	3705	6.68
Sig.	***	***	***
sed	1.100	158.1	0.231
cv%	6.1	6.1	3.9

Trial 209 FACTORIAL FERTILISER TRIAL AT HARGY PLANTATION.

PURPOSE

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

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 to start 36 months after planting.

DESIGN

There will be 81 treatments comprising all factorial combinations of sulphate of ammonia, triple superphosphate, muriate of potash and kieserite each at three levels. There will be 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 will be replicated only once and will be divided among nine blocks each of nine plots (Table 1.37).

Table 1.37 Fertiliser 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 standard immature palm fertiliser input. Pre-treatment yield recording commenced in January 1997 and treatments will be applied in July 1998. Leaflet samples will be taken for analysis in May 1998.

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

PURPOSE

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

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 120 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 1.38).

Table 1.38 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 for 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 measured by drilling an auger hole beside each recorded palm until the auger struck limestone. Soil depth was used as a concomitant variable in an analysis of covariance of the yield data from 1997 as well as the pooled 1995-1997 data.

RESULTS

The data recording of these trials commenced in June 1992.

Mean yield in 1997 was 22.5 t/ha at Maramakas and 25.5 t/ha at Luburua. At Maramakas application of 2.5kg of MoP per palm led to a significant increase in yield as a result of an increase in both bunch number and bunch weight. There was no further increase with an application of 5kg of MoP per palm. Application of SoA, TSP and kieserite did not affect yield at Maramakas (Table 1.39). The response for the three-year cumulative period 1995-1997 at Maramakas was the same. Application of 2.5kg of MOP led to a significant increase in yield as a result of an increase in both bunch number and single bunch weight (Table 1.42).

Table 1.39 Main effects of N, P, K and Mg on yield and yield components for 1997 at Maramakas.

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha)	22.2	22.1	23.2	ns	1.39	15.1
Bunches/ha	1469	1486	1491	ns	62.8	10.4
Bunch weight (kg)	15.4	15.3	15.8	ns	0.494	7.8
	K0	K1	K2			
Yield (t/ha)	16.6	25.5	25.5	**	1.39	15.1
Bunches/ha	1278	1598	1570	*	62.8	10.4
Bunch weight (kg)	13.1	16.7	16.8	**	0.494	7.8
	P0	P1				
Yield (t/ha)	22.1	22.9		ns	1.13	15.1
Bunches/ha	1432	1532		ns	51.2	10.4
Bunch weight (kg)	15.7	15.3		ns	0.403	7.8
	Mg0	Mg1				
Yield (t/ha/yr)	22.4	22.7		ns	1.13	15.1
Bunches/ha	1445	1519		ns	51.2	10.4
Bunch weight (kg)	15.8	15.3		ns	0.403	7.8

The results at Luburua for 1997 show that there was a significant yield response to both nitrogen and potassium Table 1.40. This is the first time that a response to nitrogen has been recorded. Application of 2.5 kg of SoA led to an increase in yield from 22.6 t/ha to 27.1 t/ha due to a significant increase in bunch weight. There was no further increase in yield with 5.0 kg of SoA per palm. Potassium application led to a significant increase in yield due to a significant increase in bunch weight. Although not significant there was also an increase in bunch number with application of MoP.

Analysis of the cumulative data for 1995-1997 at Luburua shows that there was no significant increase in yield as a result of fertiliser application. Bunch weights increased with application of MoP, however the increase in yield from 19.2 at K0 to 20.8 at K1 and to 21.7 t/ha at K2 was not significant (Table 1.42).

Table 1.40 Main effects of N, P, K and Mg on yield and yield components for 1997 at Luburua.

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha)	22.6	27.1	26.8	*	1.064	10.2
Bunches/ha	1919	2112	2150	ns	91.0	10.8
Bunch weight (kg)	11.5	13.0	12.4	***	0.122	2.4
	K0	K1	K2			
Yield (t/ha)	21.2	27.0	28.3	**	1.064	10.2
Bunches/ha	1902	2105	2174	ns	91.0	10.8
Bunch weight (kg)	11.1	12.9	13.0	***	0.122	2.4
	P0	P1				
Yield (t/ha)	24.8	26.2		ns	0.869	10.2
Bunches/ha	2046	2075		ns	91.0	10.8
Bunch weight (kg)	12.0	12.6		**	0.099	2.4
	Mg0	Mg1				
Yield (t/ha/yr)	26.0	25.0		ns	0.869	10.2
Bunches/ha	2099	2021		ns	91.0	10.8
Bunch weight (kg)	12.3	12.3		ns	0.099	2.4

Table 1.41 Main effects of N, P, K and Mg on yield and yield components for January 1995 to December 1997 at Maramakas.

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha)	19.2	19.9	19.8	ns	0.71	8.9
Bunches/ha	1346	1398	1369	ns	32.7	5.8
Bunch weight (kg)	14.5	14.5	14.7	ns	0.31	5.2
	K0	K1	K2			
Yield (t/ha)	16.7	20.6	21.6	**	0.71	8.9
Bunches/ha	1300	1383	1430	*	32.7	5.8
Bunch weight (kg)	13.0	15.2	15.5	**	0.31	5.2
	P0	P1				
Yield (t/ha)	19.6	19.6		ns	0.58	8.9
Bunches/ha	1352	1390		ns	26.7	5.8
Bunch weight (kg)	14.7	14.4		ns	0.25	5.2
	Mg0	Mg1				
Yield (t/ha/yr)	19.4	19.8		ns	0.58	8.9
Bunches/ha	1362	1380		ns	26.7	5.8
Bunch weight (kg)	14.5	14.6		ns	0.25	5.2

Table 1.42 Main effects of N, P, K and Mg on yield and yield components for January 1995 to December 1997 at Luburua.

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha)	19.5	21.1	21.2	ns	1.29	15.4
Bunches/ha	1565	1644	1658	ns	85.2	12.9
Bunch weight (kg)	12.4	13.0	12.9	ns	0.16	3.1
	K0	K1	K2			
Yield (t/ha)	19.2	20.8	21.7	ns	1.29	15.4
Bunches/ha	1597	1617	1652	ns	85.2	12.9
Bunch weight (kg)	12.1	13.0	13.2	**	0.16	3.1
	P0	P1				
Yield (t/ha)	20.3	20.9		ns	1.05	15.4
Bunches/ha	1623	1621		ns	69.5	12.9
Bunch weight (kg)	12.6	12.9		ns	0.13	3.1
	Mg0	Mg1				
Yield (t/ha/yr)	20.9	20.3		ns	1.05	15.4
Bunches/ha	1640	1605		ns	69.5	12.9
Bunch weight (kg)	12.8	12.7		ns	0.13	3.1

There was a significant NxP interaction for yield recorded at Luburua (Table 1.43).

Table 1.43 Interaction of N and P at Luburua in 1997.

Treatment	P0	P1
N0	19.6	25.5
N1	26.3	27.9
N2	28.4	25.2

Mean yields for the combined data for the 2 sites for the six years from 1992 to 1997 are given in Table 1.44.

Table 1.44 Effect of K on FFB yield and yield components from 1992 to 1997 at Luburua and Maramakas.

Year (age from planting)	Yield (t/ha)			Bunches/ha			Bunch Weight (kg)		
	K0	K1	K2	K0	K1	K2	K0	K1	K2
1992 (3)	16.2	17.1	18.4	2577	2596	2768	6.3	6.6	6.6
1993 (4)	17.9	18.6	19.5	2216	2275	2341	8.1	8.2	8.3
1994 (5)	20.4	22.2	23.1	1996	2113	2116	10.2	10.5	10.9
1995 (6)	17.3	17.5	19.1	1534	1424	1529	11.3	12.2	12.4
1996 (7)	16.5	18.5	20.0	1218	1186	1266	13.7	15.7	15.9
1997 (8)	18.9	26.3	26.9	1590	1852	1872	12.1	14.8	14.9
Mean Yield	17.9	20.0	21.2						

In 1997 both leaflet and rachis samples were analysed and the results of these analyses are given in Table 1.45 and 1.47 for Maramakas and Table 1.46 and 1.48 for Luburua.

Table 1.45 Treatment main effects on leaflet nutrient concentrations in 1997 at Maramakas.

Element as % of dry matter	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Nitrogen	2.25	2.34	2.31	ns	0.068	7.2
Phosphorus	0.153	0.154	0.155	ns	0.002	3.8
Potassium	0.51	0.57	0.56	ns	0.028	12.7
Calcium	1.28	1.24	1.21	ns	0.035	6.9
Magnesium	0.36	0.34	0.35	ns	0.036	25.4
Chlorine	0.60	0.62	0.66	ns	0.033	12.9
	K0	K1	K2			
Nitrogen	2.14	2.34	2.41	*	0.068	7.2
Phosphorus	0.149	0.156	0.157	ns	0.002	3.8
Potassium	0.35	0.61	0.68	***	0.028	12.7
Calcium	1.29	1.19	1.24	ns	0.035	6.9
Magnesium	0.47	0.31	0.27	*	0.036	25.4
Chlorine	0.68	0.60	0.60	ns	0.033	12.9
	P0	P1				
Nitrogen	2.30	2.30		ns	0.056	7.2
Phosphorus	0.153	0.154		ns	0.002	3.8
Potassium	0.56	0.54		ns	0.023	12.7
Calcium	1.24	1.25		ns	0.029	6.9
Magnesium	0.34	0.36		ns	0.030	25.4
Chlorine	0.61	0.64		ns	0.027	12.9
	Mg0	Mg1				
Nitrogen	2.31	2.29		ns	0.056	7.2
Phosphorus	0.154	0.153		ns	0.002	3.8
Potassium	0.57	0.53		ns	0.023	12.7
Calcium	1.25	1.23		ns	0.029	6.9
Magnesium	0.32	0.37		ns	0.030	25.4
Chlorine	0.63	0.63		ns	0.027	12.9

Table 1.46 Treatment main effects on leaflet nutrient concentrations in 1997 at Luburua.

Element as % of dry matter	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Nitrogen	2.34	2.47	2.50	ns	0.071	7.2
Phosphorus	0.156	0.158	0.163	ns	0.003	4.7
Potassium	0.62	0.68	0.68	ns	0.010	3.7
Calcium	1.21	1.17	1.20	ns	0.031	6.4
Magnesium	0.34	0.29	0.29	ns	0.021	16.9
Chlorine	0.65	0.65	0.65	ns	0.039	14.6
	K0	K1	K2			
Nitrogen	2.37	2.46	2.47	ns	0.071	7.2
Phosphorus	0.157	0.159	0.161	ns	0.003	4.7
Potassium	0.47	0.73	0.77	***	0.010	3.7
Calcium	1.20	1.17	1.20	ns	0.031	6.4
Magnesium	0.41	0.26	0.24	**	0.021	16.9
Chlorine	0.65	0.65	0.65	ns	0.039	14.6
	P0	P1				
Nitrogen	2.39	2.48		ns	0.058	7.2
Phosphorus	0.156	0.162		ns	0.002	4.7
Potassium	0.65	0.67		*	0.008	3.7
Calcium	1.19	1.20		ns	0.026	6.4
Magnesium	0.32	0.29		ns	0.017	16.9
Chlorine	0.67	0.63		ns	0.032	14.6
	Mg0	Mg1				
Nitrogen	2.47	2.40		ns	0.058	7.2
Phosphorus	0.160	0.158		ns	0.002	4.7
Potassium	0.66	0.66		ns	0.008	3.7
Calcium	1.20	1.18		ns	0.026	6.4
Magnesium	0.28	0.33		*	0.017	16.9
Chlorine	0.64	0.66		ns	0.032	14.6

Table 1.47 Treatment main effects on rachis nutrient concentrations in 1997 at Maramakas.

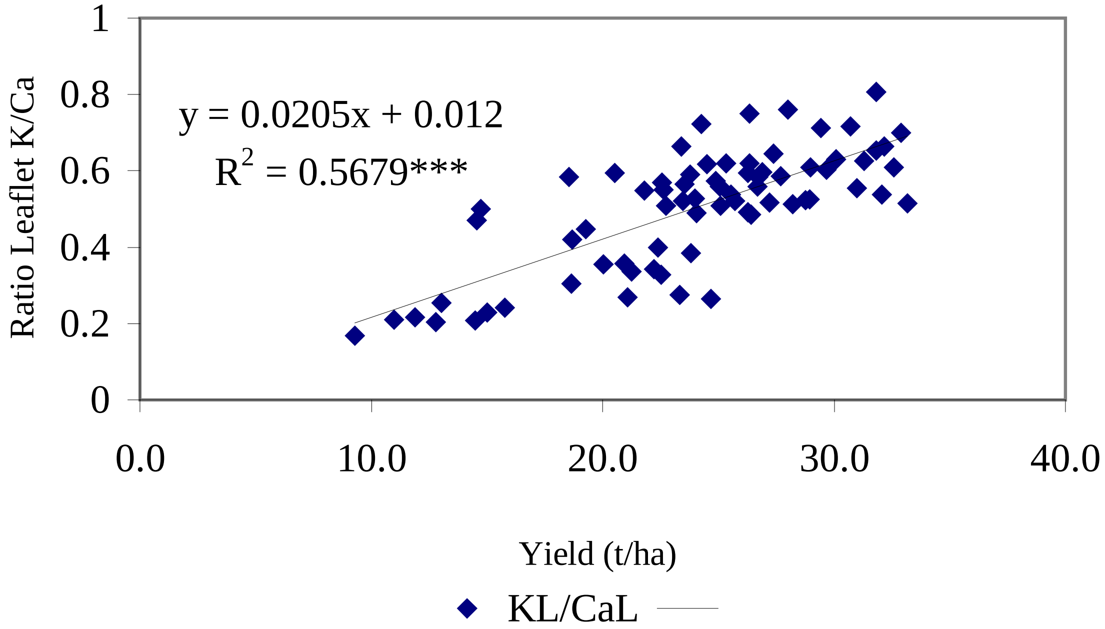
Element as % of dry matter	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Nitrogen	0.29	0.30	0.31	ns	0.006	4.9
Phosphorus	0.062	0.053	0.058	ns	0.004	15.1
Potassium	0.81	0.77	0.77	ns	0.021	6.6
Calcium	0.48	0.48	0.48	ns	0.023	11.8
Magnesium	0.12	0.12	0.12	ns	0.014	28.0
Chlorine	0.68	0.64	0.67	ns	0.027	10.0
	K0	K1	K2			
Nitrogen	0.32	0.29	0.29	*	0.006	4.9
Phosphorus	0.054	0.055	0.066	*	0.004	15.1
Potassium	0.13	0.89	1.35	***	0.021	6.6
Calcium	0.56	0.44	0.44	*	0.023	11.8
Magnesium	0.21	0.08	0.07	***	0.014	28.0
Chlorine	0.30	0.74	0.96	***	0.027	10.0
	P0	P1				
Nitrogen	0.29	0.31		*	0.005	4.9
Phosphorus	0.053	0.063		*	0.003	15.1
Potassium	0.78	0.79		ns	0.017	6.6
Calcium	0.48	0.48		ns	0.019	11.8
Magnesium	0.12	0.12		ns	0.011	28.0
Chlorine	0.66	0.67		ns	0.022	10.0
	Mg0	Mg1				
Nitrogen	0.29	0.31		*	0.005	4.9
Phosphorus	0.058	0.058		ns	0.003	15.1
Potassium	0.79	0.78		ns	0.017	6.6
Calcium	0.48	0.48		ns	0.019	11.8
Magnesium	0.11	0.14		ns	0.011	28.0
Chlorine	0.66	0.67		ns	0.022	10.0

Table 1.48 Treatment main effects on rachis nutrient concentrations in 1997 at Luburua.

Element as % of dry matter	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Nitrogen	0.29	0.28	0.28	ns	0.008	6.6
Phosphorus	0.072	0.060	0.064	ns	0.006	24.1
Potassium	0.82	0.87	0.83	ns	0.104	30.5
Calcium	0.49	0.49	0.49	ns	0.018	8.9
Magnesium	0.11	0.09	0.09	ns	0.012	30.3
Chlorine	0.64	0.70	0.63	ns	0.035	13.1
	K0	K1	K2			
Nitrogen	0.31	0.27	0.28	*	0.008	6.6
Phosphorus	0.056	0.062	0.078	ns	0.006	24.1
Potassium	0.17	0.97	1.37	***	0.104	30.5
Calcium	0.52	0.48	0.47	ns	0.018	8.9
Magnesium	0.15	0.07	0.06	**	0.012	30.3
Chlorine	0.30	0.74	0.93	***	0.035	13.1
	P0	P1				
Nitrogen	0.29	0.28		ns	0.006	6.6
Phosphorus	0.058	0.073		*	0.005	24.1
Potassium	0.82	0.86		ns	0.085	30.5
Calcium	0.49	0.49		ns	0.014	8.9
Magnesium	0.10	0.09		ns	0.009	30.3
Chlorine	0.64	0.67		ns	0.029	13.1
	Mg0	Mg1				
Nitrogen	0.28	0.29		ns	0.006	6.6
Phosphorus	0.067	0.064		ns	0.005	24.1
Potassium	0.83	0.85		ns	0.085	30.5
Calcium	0.49	0.49		ns	0.014	8.9
Magnesium	0.08	0.10		ns	0.009	30.3
Chlorine	0.64	0.68		ns	0.029	13.1

As in 1996 there continued to be a strong positive relationship (r^2=0.57***) between yield and the ratio of leaflet K:Ca (Fig 1.5).

Figure 1.5: Relationship between yield and lealfet K/Ca in 1997



Trial 401 FACTORIAL FERTILISER TRIAL AT KAUTU PLANTATION.

PURPOSE

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

DESCRIPTION

Site: Kapiura Estates, Kautu Plantation, Field 86T.

Soil: Young coarse textured freely draining soils formed on alluvially redeposited andesitic pumiceous sands and volcanic ash.

Palms: Dami commercial DxP crosses.

Planted in 1986 at 135 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 1.49).

Table 1.49 Rates of fertiliser used in trial 401.

	Level (kg/palm/year)		
	0	1	2
Ammonium chloride	0	3.0	6.0
Triple superphosphate	0	2.0	4.0
Muriate of potash	0	3.0	---
Kieserite	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. Plot isolation trenching was completed in August 1995.

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’ would be partially confounded with blocks. High order interactions provide the error term in the statistical analysis.

RESULTS

The average FFB yield in 1997 was 22.2 t/ha compared to 26.4 t/ha/ recorded in 1996. This is still considerably lower than the 1993 yield when 28.0 t/ha was recorded. There were no differences in yield recorded between treatments in this trial in 1997 (Table 1.50). The only response detected was an increase in bunch weight in both the 1997 and 1995-1997 cumulative data (Table 1.51) as a result of nitrogen application.

Detailed examination of the data from Trial 401 has indicated two problems:

a) there is a distinct possibility that N and K fertilisers are spreading form plot to plot despite trenching between the plot boundaries and

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 trial with this structure will not result in any changes to the patterns of response achieved so far.

Table 1.50 Main effects of N, P, K and Mg on yield and yield components in 1997 (Trial 401).

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha/yr)	21.8	22.5	22.3	ns	0.841	13.1
Bunches/ha	1102	1119	1092	ns	44.4	13.9
Bunch weight (kg)	20.0	20.5	20.8	*	0.311	5.3
	P0	P1	P2			
Yield (t/ha/yr)	22.5	22.5	21.5	ns	0.841	13.1
Bunches/ha	1109	1117	1087	ns	44.4	13.9
Bunch weight (kg)	20.6	20.5	20.1	ns	0.311	5.3
	K0	K1				
Yield (t/ha/yr)	22.0	22.4		ns	0.687	13.1
Bunches/ha	1101	1108		ns	36.3	13.9
Bunch weight (kg)	20.3	20.5		ns	0.254	5.3
	Mg0	Mg1				
Yield (t/ha/yr)	22.3	22.1		ns	0.687	13.1
Bunches/ha	1112	1097		ns	36.3	13.9
Bunch weight (kg)	20.4	20.4		ns	0.254	5.3

Table 1.51 Main effects of N, P, K and Mg on yield and yield components for 1994 to 1996 (Trial 401).

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha/yr)	22.5	23.3	23.4	ns	0.563	8.5
Bunches/ha	1080	1093	1074	ns	26.9	8.6
Bunch weight (kg)	20.9	21.4	22.0	**	0.305	4.9
	P0	P1	P2			
Yield (t/ha/yr)	23.0	23.3	22.9	ns	0.563	8.5
Bunches/ha	1063	1093	1089	ns	26.9	8.6
Bunch weight (kg)	21.8	21.4	21.2	ns	0.305	4.9
	K0	K1				
Yield (t/ha/yr)	23.1	23.0		ns	0.459	8.5
Bunches/ha	1080	1084		ns	22.0	8.6
Bunch weight (kg)	21.5	21.4		ns	0.249	4.9
	Mg0	Mg1				
Yield (t/ha/yr)	22.9	23.2		ns	0.459	8.5
Bunches/ha	1085	1079		ns	22.0	8.6
Bunch weight (kg)	21.3	21.6		ns	0.249	4.9

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 redeposited 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 1.52).

Table 1.52 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 average plot yield in 1997 was only 21.3 t/ha that is much lower than that recorded in previous years. This lack of response is very similar to that recorded in Trial 107 and Trial 401.

The only significant responses recorded in 1997 were an increase in bunch weight as a result on application of ammonium chloride, triple super phosphate and muriate of potash (Table 1.53). The 1995-1997 cumulative data (Table 1.54) shows that there was a significant yield response to application of EFB caused by a significant increase in bunch number. Bunch weight increased as a result of application of ammonium chloride.

Table 1.53 Main effects of N, P, K and Mg on yield and yield components in 1997 (Trial 402).

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha/yr)	21.3	21.7	20.9	ns	0.732	11.9
Bunches/ha	1169	1158	1119	ns	41.7	12.6
Bunch weight (kg)	20.8	21.5	21.3	**	0.208	3.4
	P0	P1	P2			
Yield (t/ha/yr)	20.8	22.1	21.0	ns	0.732	11.9
Bunches/ha	1135	1169	1143	ns	41.7	12.6
Bunch weight (kg)	21.0	21.7	21.0	**	0.208	3.4
	K0	K1				
Yield (t/ha/yr)	21.8	20.9		ns	0.597	11.9
Bunches/ha	1179	1118		ns	34.1	12.6
Bunch weight (kg)	21.0	21.4		*	0.170	3.4
	Mg0	Mg1				
Yield (t/ha/yr)	20.9	21.8		ns	0.597	11.9
Bunches/ha	1132	1165		ns	34.1	12.6
Bunch weight (kg)	21.2	21.3		ns	0.170	3.4
	EFB0	EFB1				
Yield (t/ha/yr)	20.9	21.7		ns	0.597	11.9
Bunches/ha	1132	1165		ns	34.1	12.6
Bunch weight (kg)	21.1	21.3		ns	0.170	3.4

As with Trial 107 and Trial 401 detailed examination of the data from Trial 402 has indicated two problems:

a) there is a distinct possibility that N and K fertilisers are spreading form plot to plot despite trenching between the plot boundaries and

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 trial with this structure will not result in any changes to the patterns of response achieved so far. However, the trial was trenched in 1997 and this may lead to a response. Application of EFB has led to a response in both 1996 and 1997.

Table 1.54 Main effects of N, P, K and Mg on yield and yield components from 1995 to 1997 (Trial 402).

	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Yield (t/ha/yr)	23.4	23.7	24.0	ns	0.427	6.3
Bunches/ha	1174	1152	1148	ns	22.4	6.7
Bunch weight (kg)	20.8	21.5	21.8	***	0.221	3.6
	P0	P1	P2			
Yield (t/ha/yr)	23.9	23.8	23.3	ns	0.427	6.3
Bunches/ha	1176	1151	1147	ns	22.4	6.7
Bunch weight (kg)	21.2	21.7	21.3	ns	0.221	3.6
	K0	K1				
Yield (t/ha/yr)	23.7	23.7		ns	0.349	6.3
Bunches/ha	1166	1150		ns	18.3	6.7
Bunch weight (kg)	21.2	21.5		ns	0.180	3.6
	Mg0	Mg1				
Yield (t/ha/yr)	23.6	23.8		ns	0.349	6.3
Bunches/ha	1160	1156		ns	18.3	6.7
Bunch weight (kg)	21.3	21.5		ns	0.180	3.6
	EFB0	EFB1				
Yield (t/ha/yr)	23.2	24.2		**	0.349	6.3
Bunches/ha	1137	1179		*	18.3	6.7
Bunch weight (kg)	21.3	21.5		ns	0.180	3.6

Table 1.55 shows the yield figures recorded from this trial since yield recording commenced in 1991. These figures show that in most years there has been a small increase due to nitrogen. In 1994 and 1995 EFB had almost no effect on yield. However, in 1996 and 1997 application of 50 t/ha of EFB resulted in a significant increase in yield.

Table 1.55 Effect of N and EFB on FFB yield from 1992 to 1996 in Trial 402.

Year (age from planting)	Yield (t/ha)			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

Application of ammonium chloride led to a significant increase in chlorine leaflet concentrations. Muriate of potash application led to an increase in leaflet chlorine whilst kieserite application led to an increase in leaflet magnesium. EFB led to an increase in leaflet nitrogen, potassium and chlorine but a decrease in leaflet magnesium (Table 1.56).

Table 1.56 Treatment main effects on leaflet nutrient concentrations in 1997 (Trial 402).

Element as % of dry matter	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Nitrogen	2.36	2.36	2.33	ns	0.020	2.9
Phosphorus	0.149	0.149	0.149	ns	0.001	3.0
Potassium	0.80	0.77	0.77	ns	0.018	7.8
Calcium	0.80	0.81	0.80	ns	0.022	9.5
Magnesium	0.13	0.13	0.13	ns	0.004	10.7
Chlorine	0.48	0.58	0.59	***	0.013	8.0
	P0	P1	P2			
Nitrogen	2.33	2.37	2.35	ns	0.020	2.9
Phosphorus	0.147	0.150	0.149	ns	0.001	3.0
Potassium	0.80	0.77	0.77	ns	0.018	7.8
Calcium	0.81	0.82	0.79	ns	0.022	9.5
Magnesium	0.13	0.13	0.12	ns	0.004	10.7
Chlorine	0.55	0.56	0.54	ns	0.013	8.0
	K0	K1				
Nitrogen	2.35	2.35		ns	0.016	2.9
Phosphorus	0.149	0.149		ns	0.001	3.0
Potassium	0.79	0.77		ns	0.014	7.8
Calcium	0.80	0.81		ns	0.018	9.5
Magnesium	0.13	0.12		ns	0.003	10.7
Chlorine	0.53	0.57		***	0.010	8.0
	Mg0	Mg1				
Nitrogen	2.36	2.35		ns	0.016	2.9
Phosphorus	0.149	0.149		ns	0.001	3.0
Potassium	0.78	0.78		ns	0.014	7.8
Calcium	0.82	0.79		ns	0.018	9.5
Magnesium	0.12	0.14		***	0.003	10.7
Chlorine	0.55	0.55		ns	0.010	8.0
	EFB0	EFB1				
Nitrogen	2.32	2.38		**	0.016	2.9
Phosphorus	0.148	0.150		ns	0.001	3.0
Potassium	0.76	0.80		**	0.014	7.8
Calcium	0.82	0.79		ns	0.018	9.5
Magnesium	0.13	0.12		*	0.003	10.7
Chlorine	0.53	0.57		***	0.010	8.0

Rachis chlorine levels increased with application of ammonium chloride and muriate of potash. EFB application led to a significant increase in rachis nitrogen, phosphorus, potassium and potassium (Table 1.57).

Table 1.57 Treatment main effects on rachis nutrient concentrations in 1997 (Trial 402).

Element as % of dry matter	Nutrient element and level			Statistics		
				sig	sed	cv%
	N0	N1	N2			
Nitrogen	0.25	0.26	0.27	*	0.007	8.8
Phosphorus	0.075	0.076	0.077	ns	0.005	24.2
Potassium	1.39	1.37	1.38	ns	0.057	14.2
Calcium	0.35	0.35	0.39	ns	0.016	15.0
Magnesium	0.04	0.04	0.04	ns	0.002	18.0
Chlorine	0.53	0.54	0.66	*	0.042	24.9
	P0	P1	P2			
Nitrogen	0.26	0.26	0.26	ns	0.007	8.8
Phosphorus	0.074	0.074	0.079	ns	0.005	24.2
Potassium	1.44	1.32	1.39	ns	0.057	14.2
Calcium	0.37	0.36	0.37	ns	0.016	15.0
Magnesium	0.04	0.04	0.04	ns	0.002	18.0
Chlorine	0.61	0.56	0.57	ns	0.042	24.9
	K0	K1				
Nitrogen	0.26	0.26		ns	0.005	8.8
Phosphorus	0.076	0.076		ns	0.004	24.2
Potassium	1.36	1.40		ns	0.046	14.2
Calcium	0.37	0.36		ns	0.013	15.0
Magnesium	0.04	0.04		ns	0.002	18.0
Chlorine	0.54	0.62		*	0.034	24.9
	Mg0	Mg1				
Nitrogen	0.26	0.26		ns	0.005	8.8
Phosphorus	0.074	0.078		ns	0.004	24.2
Potassium	1.38	1.38		ns	0.046	14.2
Calcium	0.37	0.36		ns	0.013	15.0
Magnesium	0.04	0.04		ns	0.002	18.0
Chlorine	0.59	0.57		ns	0.034	24.9
	EFB0	EFB1				
Nitrogen	0.25	0.27		*	0.005	8.8
Phosphorus	0.069	0.082		**	0.004	24.2
Potassium	1.33	1.44		*	0.046	14.2
Calcium	0.36	0.37		ns	0.013	15.0
Magnesium	0.04	0.04		ns	0.002	18.0
Chlorine	0.55	0.61		ns	0.034	24.9

2. MAINLAND REGION AGRONOMY

(A. Oliver, M. Banabas, J. Papah and P. Taramurrray)

2.1 INTRODUCTION

The mainland agronomy staff in 1997 was stable and this led to some improvements on the management of trials in general. There was a delay in tissue sampling that was due to the drying ovens not being serviceable. In house training for a number of staff were conducted at various times during the year. An additional computer from Dami sent to Higaturu and a computer room established and centralised. Planting of the grassland fertiliser trial was delayed due to a period of prolonged dry weather. Two new formal fertiliser trials were proposed for establishment, sites were selected but the palms were too young to initiate the trials immediately. Three smallholder demonstration blocks were set up during the year. Tissue sampling was completed for both Higaturu Oil Palms and Milne Bay Estates involving over 600 samples. Field days for plantation staff, OPIC Officers, and Oro smallholders were conducted during the year but only one field day was conducted in Milne Bay. PNGOPRA also participated at the Port Moresby agricultural show.

An automatic weather station was purchased for installation at the Higaturu Center. The Higaturu experienced major power problems towards the end of the year, and the station was running on a generator for the remainder of the year. This caused considerable damage to electrical equipment.

2.1.1 Staff

Mr. Murom Banabas was studying at Massey University, New Zealand studying towards a MSc in Soil Science. Mr. Allan Oliver and Mrs. Josephine Papah attended a biometrics workshop conducted by staff from IACR-Rothamsted, UK, in January & August. The Regional Agronomist attended the Coffee Research meeting in Aiyura, a Regional Consultation meeting organised by the FAO in Bangkok, and the CCRI meeting in Kerevat. In March Mr. Peter Taramurray attended a supervisory development course organised by Higaturu Oil Palms.

2.1.2 Trial Management

Analysis of the trial data for 1997 was completed in August 1998. All trials were managed in accordance planned work schedules. Dr Dick Morton, Biometrician, visited Higaturu, and discussed possible analysis methodology of the two anion trials, he also discussed possible trial designs for Mamba estate.

2.1.3 Leaf Sampling

Tissue sampling of PNGOPRA trials and plantation LSUs at Higaturu were delayed due to problems with the drying ovens. In Milne Bay all sampling and analysis was completed. In both Higaturu and Milne Bay training sessions on leaf sampling were conducted for field supervisors, Assistant Managers and Managers.

2.1.4 Smallholders

PNGOPRA participated in field days for smallholders at Higaturu and Milne Bay in conjunction with OPIC. The main topic covered was the need and benefits of fertiliser. The smallholder trials clearly indicated the need for applications of nitrogen fertiliser, which if not applied severely limits crop production. One field day was held in Milne Bay for OPIC staff. The PNGOPRA Regional Agronomist attended the OPIC Local Planning Committee meetings in Popondetta and Alotau.

A number of smallholder blocks in the Popondetta scheme are due for replanting, OPRA conducted a field day on palm poisoning for OPIC officers.

2.2 AGRONOMY TRIALS

Trial 305 FERTILISER TRIAL AT AREHE ESTATE

PURPOSE

To test the response to N, P, K, and Mg in factorial combination on Higaturu soil.

DESCRIPTION

Site: Arehe Estate, Block 78F

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

Palms: Dami commercial DxP crosses. Planted in 1978 at 130 palms/ha.

Trial started in 1981

DESIGN

There are 72 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 the core palms are surrounded by at least one guard row, which was trenched only in 1995.

The 72 plots are divided into two replicates of 36. In each replicate there are 36 treatment combinations, made up from all combinations of three levels each of N and K, and two levels each of P and Mg (Table 2.1).

Table 2.1 Types of fertiliser and amounts used in Trial 305.

		Amount of fertiliser (kg/palm/year)		
Elements	Type of Fertiliser	Level 0	Level 1	Level 2
N	Sulphate of ammonia	0.0	2.0	4.0
P	Triple Superphosphate	0.0	2.0	-
K	Muriate of potash	0.0	2.0	4.0
Mg	Kieserite	0.0	1.0	-

RESULTS

In 1997, the average plot yield of was 21.99 t FFB/ha/yr. There has been a continued major response to SOA. The increase in yield was made up from an increase in the number of bunches per hectare and single bunch weight. Muriate of Potash (MOP) did not have any major effects on yield, however there were significant increases in single bunch weights. Responses to TSP and Kieserite were absent in 1997 (Table 2.2).

Over the 10-year period, between 1987-1997, the trend is the same as seen in 1997 (Table 2.4). N and K treatment combinations are given in table 2.3 and 2.5. Though the interactions were not significant, the maximum yield of 29.0 t/ha in 1996 was obtained with an application of 4 kg of ammonium sulphate and 2 kg of muriate of potash per palm annually. The higher rate of sulphate of ammonia and the addition of muriate of potash provided further benefits of up to 7 tonnes/ha in 1997.

Table 2.2 Main effects of N, P, K, and Mg on yield and yield components in 1997 (Trial 305).

Nutrient element And level				Statistics sig.	cv%	sed
	N0	N1	N2			
Yield (t/ha/yr)	15.7	22.6	27.7	***	15.6	0.99
Bunches/ha	704	856	996	***	12.0	31
Bunch weight (kg)	21.6	26.5	28.0	***	12.8	0.93
	P0	P1				
Yield (t/ha/yr)	21.5	22.5		ns	15.6	0.81
Bunches/ha	838	866		ns	12.0	25
Bunch weight (kg)	25.0	25.6		ns	12.8	0.76
	K0	K1	K2			
Yield (t/ha/yr)	20.8	22.5	22.6	ns	15.6	0.99
Bunches/ha	871	825	860	ns	12.0	31
Bunch weight (kg)	23.1	26.9	26.0	***	12.8	0.93
	Mg0	Mg1				
Yield (t/ha/yr)	21.7	22.3		ns	15.6	0.81
Bunches/ha	851	853		ns	12.0	25
Bunch weight (kg)	**25.2**	**25.5**		**ns**	**12.8**	**0.76**

Table 2.3 The effect of N on yield at different levels of K in 1997 (Trial 305).

	Yield (t/ha/yr)		
	K0	K1	K2
N0	13.8	16.2	17.1
N1	22.3	22.3	23.1
N2	26.4	29.0	27.8
Grand mean	22.0	Standard Error	1.71

Table 2.4 Main effects of N, P, K, and Mg on yield and yield components in 1987-1997 (Trial 305).

	Nutrient element And level			sig	Statistics cv%	sed
	N0	N1	N2			
Yield (t/ha/yr)	18.5	23.8	26.3	***	17.1	1.13
Bunches/ha	814	899	968	***	11.8	30
Bunch weight (kg)	22.7	26.7	27.4	***	12. 8	0.94
	P0	P1				
Yield (t/ha/yr)	22.6	23.2		ns	17.1	0.92
Bunches/ha	888	899		ns	11.8	24
Bunch weight (kg)	25.4	25.7		ns	12.8	0.77
	K0	K1	K2			
Yield (t/ha/yr)	21.6	23.8	23.1	ns	17.1	1.13
Bunches/ha	923	889	869	ns	11.8	30
Bunch weight (kg)	23.4	26.8	26.5	***	12.8	0.94
	Mg0	Mg1				
Yield (t/ha/yr)	23.5	22.2		ns	17.1	0.92
Bunches/ha	917	870		ns	11.8	24
Bunch weight (kg)	25.6	25.6		ns	12.8	0.77

Table 2.5 The effects of N on yield at different levels of K in 1987-1997 (Trial 305).

	Yield (t/ha/yr)		
	K0	K1	K2
N0	20.1	24.0	23.8
N1	24.8	28.0	27.3
N2	25.3	28.6	28.2
Grand mean	25.6	Standard error	1.63

Leaflet and rachis tissue analysis sampled in 1997 is presented in Tables 2.6 and 2.7. Application of ammonium sulphate increased both leaflet N and P concentrations. There was also an increase in rachis N concentration but a reduction in rachis P. Triple super-phosphate increased the concentration of P in the leaflet and rachis tissue. Muriate of potash reduced the concentration of K in leaflet tissue, but significantly increased leaflet Ca, Cl and rachis K, P, Ca and Cl.

Kieserite application caused an increase in leaflet K concentration, but had no effect on Mg concentration.

Table 2.6 Main effects of N, P, K, and Mg on the concentrations of elements in the leaflet tissues in 1997 (Trial 305).

	Level of nutrient				Statistics	
	Element			sig	cv%	sed
	N0	N1	N2			
N%	1.82	1.96	2.09	***	4.6	0.03
P%	0.124	0.130	0.132	***	5.4	0.002
K%	0.71	0.68	0.69	ns	6.6	0.01
Ca%	0.63	0.64	0.62	ns	8.6	0.02
Mg%	0.17	0.16	0.15	ns	15.2	0.007
Cl%	0.33	0.32	0.30	(ns)	9.6	0.009
	P0	P1				
N%	1.94	1.98		(ns)	4.6	0.02
P%	0.125	0.132		***	5.4	0.002
K%	0.70	0.68		ns	6.6	0.01
Ca%	0.63	0.64		ns	8.6	0.013
Mg%	0.16	0.16		ns	15.2	0.006
Cl%	0.31	0.32		ns	9.6	0.007
	K0	K1	K2			
N%	1.96	1.98	1.93	ns	4.6	0.03
P%	0.130	0.130	0.127	ns	5.4	0.002
K%	0.70	0.70	0.67	*	6.6	0.01
Ca%	0.60	0.65	0.64	**	8.6	0.02
Mg%	0.16	0.16	0.16	ns	15.2	0.007
Cl%	0.09	0.41	0.46	***	9.6	0.009
	Mg0	Mg1				
N%	1.96	1.96		ns	4.6	0.02
P%	0.129	0.128		ns	5.4	0.002
K%	0.68	0.70		*	6.6	0.01
Ca%	0.64	0.62		ns	8.6	0.013
Mg%	0.16	0.16		ns	15.2	0.006
Cl%	0.32	0.32		ns	9.6	0.007

Table 2.7 Main effects of N, P, K, and Mg on the concentrations of elements in rachis tissue in 1997 (Trial 305).

	Level of nutrient			Statistics		
	Element			sig	cv%	sed
	N0	N1	N2			
N%	0.22	0.24	0.27	***	10.0	0.01
P%	0.198	0.143	0.121	***	28.0	0.012
K%	1.41	1.35	1.26	(ns)	11.9	0.05
Ca%	0.32	0.33	0.33	ns	12.7	0.01
Mg%	0.06	0.07	0.05	ns	69.2	0.01
Cl%	0.63	0.62	0.53	(ns)	27.0	0.05
	P0	P1				
N%	0.24	0.24		ns	10.0	0.006
P%	0.093	0.215		***	28.0	0.01
K%	1.32	1.37		ns	11.9	0.04
Ca%	0.32	0.33		ns	12.7	0.01
Mg%	0.06	0.06		ns	69.2	0.01
Cl%	0.58	0.60		ns	27.0	0.04
	K0	K1	K2			
N%	0.24	0.24	0.24	ns	10.0	0.01
P%	0.130	0.166	0.165	**	28.0	0.012
K%	0.99	1.44	1.60	***	11.9	0.05
Ca%	0.27	0.35	0.36	***	12.7	0.01
Mg%	0.07	0.06	0.06	ns	69.2	0.01
Cl%	0.08	0.76	0.94	***	27.0	0.05
	Mg0	Mg1				
N%	0.24	0.24		ns	10.0	0.006
P%	0.163	0.144		ns	28.0	0.01
K%	1.34	1.35		ns	11.9	0.04
Ca%	0.33	0.32		ns	12.7	0.01
Mg%	0.07	0.06		ns	69.2	0.01
Cl%	0.58	0.61		ns	27.0	0.04

Trial 306 FERTILISER TRIAL AT AMBOGO ESTATE

PURPOSE

To test the response to N, P, K, and Mg in factorial combination on Ambogo and Penderetta soils.

DESCRIPTION

Site: Ambogo Estate, Block 79B.

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

Palms: Dami commercial DxP crosses planted in 1979 at 143 palms/ha. Trial started in 1982.

DESIGN

There are 81 plots each containing 16-core palms. The numbers and weights of bunches for individual core palms are surrounded by at least one guard row, and a trench.

The 81 plots are a single replicate containing 81 treatments, made up from all combinations of three levels of N, P, K, and Mg (Table 2.8). The 81 treatments are divided into three blocks within the replicate, such that the effects of some high order interactions are confounded with block effects.

Table 2.8 Types and amount of fertiliser used in Trial 306.

		Amounts of fertiliser (kg/palm/year)		
Element	Type of fertiliser	Level 0	Level 1	Level 2
N	Sulphate of ammonia	0.0	3.0	6.0
P	Triple Superphosphate	0.0	0.5	1.0
K	Muriate of potash	0.0	2.5	5.0
Mg	Kieserite	0.0	0.75	1.5

Modifications: Until 1990 sulphate of ammonia rates were half those indicated.

RESULTS

The average plot yield in 1997 was 23.2 t FFB/ha/yr. There has been a continuing response to application of ammonium sulphate in 1997 (Table 2.9) and between 1987-1997 (Table 2.11). The increase in yield was made up from increases in bunch numbers per hectare and single bunch weight. Muriate of potash did not have a significant effect on yield, but there was a significant decrease in bunch numbers. There were no responses to Triple Superphosphate and Kieserite applications. This trend is similar for the cumulative data between 1987-1997.

N and K treatment combinations are shown in Tables 2.10 and 2.12.

In 1997, a maximum yield of 28.2 t/ha was obtained with 3 kg of sulphate of ammonia alone. Averaged over 10 years; the higher rate of sulphate of ammonia application produced the highest yield of 27.1 t/ha (Table 2.11).

Table 2.9 Main effects of N, P, K, and Mg on yield and yield components in 1997 (Trial 306).

	Nutrient element And level			sig	Statistics cv%	sed
	N0	N1	N2			
Yield (t/ha/yr)	19.0	25.2	25.6	***	18.4	1.16
Bunches/ha	819	940	929	**	15.3	37
Bunch weight (kg)	23.1	26.7	27.6	***	9.1	0.64
	P0	P1	P2			
Yield (t/ha/yr)	24.0	22.6	23.1	ns	18.4	1.16
Bunches/ha	916	889	883	ns	15.3	37
Bunch weight (kg)	26.0	25.4	26.0	ns	9.1	0.64
	K0	K1	K2			
Yield (t/ha/yr)	24.6	22.2	23.0	ns	18.4	1.16
Bunches/ha	965	849	874	**	15.3	37
Bunch weight (kg)	25.3	26.0	26.1	ns	9.1	0.64
	Mg0	Mg1	Mg2			
Yield (t/ha/yr)	23.0	24.0	22.8	ns	18.4	1.16
Bunches/ha	890	916	882	ns	15.3	37
Bunch weight (kg)	25.6	26.0	25.8	ns	9.1	0.64

Table 2.10 The effects of N on yield at different levels of K in 1997 (Trial 306).

	Yield (t/ha/yr)		
	K0	K1	K2
N0	20.0	18.5	18.5
N1	25.6	24.2	25.8
N2	28.2	24.0	24.5
Grand mean	23.2	Standard error	2.02

Table 2.11 Main effects of N, P, K and Mg on yield and yield components in 1987-1997 (Trial 306).

	Nutrient element And level			Statistics sig	cv%	sed
	N0	N1	N2			
Yield (t/ha/yr)	19.3	25.4	26.4	***	14.7	0.95
Bunches/ha	833	940	962	***	11.8	29
Bunch weight (kg)	23.1	27.0	27.6	***	7.6	0.54
	P0	P1	P2			
Yield (t/ha/yr)	24.4	23.0	23.9	ns	14.7	0.95
Bunches/ha	933	896	906	ns	11.8	29
Bunch weight (kg)	25.9	25.5	26.2	ns	7.6	0.54
	K0	K1	K2			
Yield (t/ha/yr)	24.4	23.2	23.6	ns	14.7	0.95
Bunches/ha	972	872	891	**	11.8	29
Bunch weight (kg)	25.0	26.4	26.3	*	7.6	0.54
	Mg0	Mg1	Mg2			
Yield (t/ha/yr)	23.1	24.4	23.7	ns	14.7	0.95
Bunches/ha	900	933	903	ns	11.8	29
Bunch weight (kg)	25.4	26.1	26.1	ns	7.7	0.54

Table 2.12 The effects of N on yield at different levels of K in 1987-1997

	Yield (t/ha/yr) K0	K1	K2
N0	20.1	18.9	19.0
N1	25.9	24.6	25.8
N2	27.1	26.0	26.1

Grand mean 23.7 Standard error 1.65

Leaflet and rachis tissue analysis for 1997, are presented in Tables 2.13 and 2.14. Sulphate of ammonia application increased leaflet N and P, and rachis N, but significantly decreased rachis P, K and Mg. Triple Superphosphate application increased tissue P concentrations. Muriate of potash application increased tissue Ca, Mg and Cl concentrations, whilst leaflet K were depressed.

Kieserite applications increased magnesium levels both in the leaf and rachis.

Table 2.13 Main effects of N, P, K and Mg on the concentrations of elements in the leaf tissue in 1997 (Trial 306).

Element	Level of nutrient			Statistics sig	cv%	sed
	N0	N1	N2			
N%	1.81	2.03	2.14	***	6.1	0.03
P%	0.118	0.125	0.127	***	4.4	0.001
K%	0.70	0.74	0.74	(ns)	8.8	0.02
Ca%	0.63	0.61	0.61	ns	10.3	0.02
Mg%	0.20	0.18	0.18	**	13.1	0.007
Cl%	0.34	0.36	0.34	ns	18.5	0.02
	P0	P1	P2			
N%	1.99	1.98	2.02	ns	6.1	0.03
P%	0.121	0.124	0.125	*	4.4	0.001
K%	0.73	0.73	0.72	ns	8.8	0.02
Ca%	0.60	0.63	0.62	ns	10.3	0.02
Mg%	0.19	0.19	0.19	ns	13.1	0.007
Cl%	0.34	0.34	0.36	ns	18.5	0.02
	K0	K1	K2			
N%	2.04	1.97	1.97	(ns)	6.1	0.03
P%	0.125	0.122	0.123	ns	4.4	0.001
K%	0.78	0.70	0.71	***	8.8	0.02
Ca%	0.58	0.64	0.64	***	10.3	0.02
Mg%	0.19	0.19	0.18	ns	13.1	0.007
Cl%	0.19	0.41	0.44	***	18.5	0.02
	Mg0	Mg1	Mg2			
N%	2.00	2.00	2.00	ns	6.1	0.03
P%	0.123	0.124	0.123	ns	4.4	0.001
K%	0.74	0.72	0.72	ns	8.8	0.02
Ca%	0.60	0.62	0.63	ns	10.3	0.02
Mg%	0.18	0.18	0.20	***	13.1	0.007
Cl%	0.33	0.37	0.34	ns	18.5	0.02

Table 2.14 Main effects of N, P, K and Mg on the concentrations of elements in the rachis in 1997 (Trial 306).

Element	Level of nutrient			Statistics sig	cv%	sed
	N0	N1	N2			
N%	0.22	0.25	0.28	***	10.9	0.008
P%	0.278	0.189	0.132	***	25.9	0.014
K%	1.65	1.58	1.50	**	10.7	0.05
Ca%	0.26	0.29	0.29	ns	12.8	0.01
Mg%	0.07	0.06	0.06	***	22.0	0.004
Cl%	0.69	0.68	0.63	ns	25.7	0.05
	P0	P1	P2			
N%	0.26	0.25	0.25	ns	10.9	0.008
P%	0.171	0.200	0.228	***	25.9	0.014
K%	1.54	1.58	1.60	ns	10.7	0.05
Ca%	0.28	0.28	0.28	ns	12.8	0.05
Mg%	0.06	0.06	0.07	ns	22.0	0.004
Cl%	0.64	0.65	0.70	ns	25.7	0.05
	K0	K1	K2			
N%	0.25	0.25	0.25	ns	10.9	0.008
P%	0.172	0.211	0.216	**	25.9	0.014
K%	1.28	1.66	1.79	***	10.7	0.05
Ca%	0.24	0.30	0.30	***	12.8	0.01
Mg%	0.06	0.07	0.07	*	22.0	0.004
Cl%	0.21	0.83	0.96	***	25.7	0.05
	Mg0	Mg1	Mg2			
N%	0.24	0.25	0.26	*	10.9	0.008
P%	0.202	0.189	0.208	ns	25.9	0.014
K%	1.57	1.56	1.60	ns	10.7	0.05
Ca%	0.27	0.29	0.29	*	12.8	0.01
Mg%	0.06	0.06	0.07	*	22.0	0.004
Cl%	0.64	0.68	0.68	ns	25.7	0.05

Trial 309 POTASSIUM, CHLORINE AND SULPHUR TRIAL AT AMBOGO ESTATE

PURPOSE

To test the response to potassium, chlorine and sulphur containing fertilisers.

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 weights of bunches for each individual core palms are recorded at intervals of 14 days. In each plot at least one guard row and a trench surround the core palms.

The 25 plots are divided into five replicate blocks each containing five treatments (Table 2.16). 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 section of table 2.16 illustrates the amount of each element that is applied with 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 treatment 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 comparisons with either 2 or 3 are used in order to test the effect of K.

Table 2.16 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/palm/yr)				Amount of element (kg/palm/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 data comparisons on the effects of N, S, K, and Cl for 1996 and 1997, are summarised in Table 2.17.

The treatment 4 application of muriate of potash and sulphate of ammonia in combination gave an FFB yield of 22 t/ha/year for the period 1991-1997. The control plots produced an average of 8.7 t/ha.

Overall, the treatment effects were significantly different in 1997 as compared to previous years (Table 2.17). The separation of the effects of different elements and their combinations over seven years are shown in Table 2.18. The application of sulphate of ammonia (effect of N and S), produced a yield increase of 10.6 tonnes/ha. The effects of K and S provided a significant yield increase of 6.6 t/ha/year.

In general the yields have been dropping over the years as illustrated in Table 2.19.

Table 2.17 Effects of N, S, K, and Cl in different combinations on yield and yield components in 1996 and 1997 (Trial 309).

Treatment	1996			1997		
	Yield (t/ha/yr)	Bunches (no/ha)	Bunch wt (kg)	Yield (t/ha/yr)	Bunches (no/ha)	Bunch wt (kg)
4 N S K Cl	18.7	769	24.1	21.2	1026	20.7
5 N S K	14.7	665	21.4	19.4	958	20.3
3 N S	15.1	722	20.7	18.7	913	20.5
2 N Cl	13.8	683	20.4	14.5	769	18.8
1 Nil	7.6	466	16.0	8.3	588	14.0
sig	ns	ns	***	***	***	***
sed	2.69	94	1.35	1.15	77	1.33

Table 2.18 Effects of N, S, K, and Cl, in different combinations on yield trends in 1991-1997 (Trial 309).

	Yield (t/ha/yr)						
	1991	1992	1993	1994	1995	1996	1997
Treatment	11	12	13	14	15	16	17
4 N S K Cl	31.3	32.5	28.4	27.7	18.6	18.7	21.2
5 N S K	28.6	30.9	28.7	26.4	19.7	14.7	19.4
3 N S	28.5	27.8	25.2	24.2	18.6	15.1	18.7
2 N Cl	24.5	21.7	19.4	18.7	14.4	13.8	14.5
1 Nil	16.4	13.6	9.8	7.1	6.4	7.6	8.3
Sig	**	***	***	***	***	ns	***
cv%	17.1	20.1	19.1	9.4	26.3	30.4	11.1

Table 2.19 Mean Yield for 1991-1997, and difference in yield for selected comparisons (Trial 309).

Mean Yield 91 – 97		Selected comparisons		
Treatment	Yield (t/ha/yr)	comparison	Difference (t/ha/yr)	sig
4 N S K Cl	22.2	4-2 (effect of K and S)	6.6	***
5 N S K	20.0	3-2 (substituting S for Cl)	3.7	***
3 N S	19.3	4-3 (effect of K and Cl)	2.9	***
2 N Cl	15.6	4-5 (effect of Cl)	2.2	**
1 Nil	8.7	5-3 (effect of K)	0.7	ns
		3-1 (effect of N and S)	10.6	***
		2-1 (effect of N and Cl)	6.9	***

cv%: 12.2, sed=1.33

The analysis of leaflet and rachis tissue sampled in 1997 is shown in Tables 2.20 and 2.21.

All treatments receiving N containing fertiliser increased the leaflet N concentration compared to the control but the concentrations were low. K concentrations in the leaflet tissue were all below 0.7%, even for bunch ash application. These are lower that the levels for the previous year. Significant differences between treatments were recorded for leaf Ca and Cl. For rachis tissue, only K, Ca and Cl were recorded.

Table 2.20 Effect of N, S, K, and Cl in different combinations, on the concentration of elements in leaf tissue of frond 17 in 1997 (Trial 309).

		Concentrations of elements (% of dry matter)					
Treatment		N	P	K	Ca	Mg	Cl
4	N S K Cl	1.66	0.120	0.51	0.76	0.19	0.41
5	N S K	1.69	0.111	0.67	0.67	0.19	0.29
3	N S	1.73	0.110	0.65	0.58	0.19	0.18
2	N Cl	1.71	0.116	0.57	0.70	0.21	0.43
1	Nil	1.62	0.110	0.63	0.63	0.24	0.25
	sig	ns	(ns)	(ns)	***	ns	***
	cv%	3.5	3.0	10.3	6.4	16.6	12.6
	sed	0.04	0.002	0.04	0.03	0.02	0.02

Table 2.21 Effect of N, S, K, and Cl in different combinations on the concentration of elements in the rachis of frond 17 in 1997 (Trial 309).

		Concentrations of elements (% of dry matter)					
Treatment		N	P	K	Ca	Mg	Cl
4	N S K Cl	0.24	0.140	1.71	0.37	0.07	1.14
5	N S K	0.21	0.152	1.49	0.27	0.07	0.52
3	N S	0.24	0.087	1.06	0.25	0.06	0.16
2	N Cl	0.27	0.156	1.44	0.30	0.08	0.92
1	Nil	0.23	0.143	1.24	0.23	0.09	0.36
	Sig	(ns)	(ns)	***	***	ns	***
	Cv%	11.0	21.7	10.8	10.7	30.3	34.3
	Sed	0.02	0.019	0.09	0.02	0.01	0.014

Trial 310 POTASSIUM, CHLORINE AND SULPHUR TRIAL AT AMBOGO ESTATE

PURPOSE

To test the response to potassium, chlorine and sulphur.

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 weights of bunches for each individual core palms are recorded at intervals of 14 days. In each plot at least one guard row and a trench surround the core palms.

The 35 plots are divided into five replicate blocks each containing seven treatments that are randomly located within the block (Table 2.23). The treatments comprise specific combinations of fertiliser material. The lower half of Table 2.23 shows the amount of each element that is applied with 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 2.23 Amount of each type of fertiliser, and each element, used for each treatment in Trial 310.

	Treatment number (kg of fertiliser/palm/year)						
Type of Fertiliser	1	2	3	4	5	6	7
Urea	1.8	-	-	-	-	-	-
SOA	-	4.0	-	4.0	-	4.0	2.0
AMC	-	-	3.2	-	3.2	-	1.6
BA	-	-	-	4.4	4.4	-	-
MOP	-	-	-	-	-	2.2	-
Element		(kg of element/palm/year)					
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

There were significant differences in FFB yield and single bunch weights caused by the experimental treatments in 1997 (Table 2.24).

Treatment 6 received N, K, Cl, and S, through applications of ammonium sulphate and muriate of potash. The effect of an element is found by comparing two treatments. In Table 2.25 Treatments, 7, 5 and 3 produce an increase in yield. These treatments were yielding more than treatment 6 that receives all elements. Applications of ammonium chloride with and without bunch ash produced a 2.6 tonne increase compared to treatment 6. All the treatment with chlorine yielded higher than treatment 6.

There were significant differences between treatments for FFB yield and single bunch in 1997 (Table 2.25). For the years 1991 to 1997, the cumulative FFB yield produced the same response. It would appear that the chlorine containing fertilisers were yielding higher than treatment 6.

Table 2.24 The effects of K, Cl and S on FFB yield in 1997 (Trial 310).

Treatment No.	Elements Supplied	Elements missing	Yield (t/ha/yr)	Differences from Treatment No. 6: t/ha/yr	Differences from Treatment No. 6: %
6	N, K, Cl, S	None	27.5	0.0	0.0
4	N, K, S	Cl	25.7	-1.8	-7.0
7	N, Cl, S	K	28.9	+1.4	+4.8
5	N, K, Cl	S	30.1	+2.6	+8.6
2	N, S	K, Cl	24.4	-3.1	-12.7
3	N, Cl	K, S	30.1	+2.6	+8.6
1	N (Urea)	K, Cl, S	26.9	-0.6	-2.2
		sig	*		
		cv%	11.1		
		sed	3.06		

Table 2.25 The effects of K, Cl, and S on single bunch weights in 1997 (Trial 310).

Treatment No.	Elements Supplied	Elements missing	Single bunch weight (kg)	Differences from Treatment No. 6 wt (kg)	Differences from Treatment No. 6 %
6	N, K, Cl, S	None	25.2	0.0	0.0
4	N, K, S	Cl	23.6	-1.6	-6.8
7	N, Cl, S	K	24.9	-0.3	-1.2
5	N, K, Cl	S	27.0	+1.8	+6.7
2	N, S	K, Cl	23.2	-2.0	-8.6
3	N, Cl	K, S	26.4	+1.2	+4.5
1	N (Urea)	K, Cl, S	23.3	-1.9	-8.2
		Sig	**		
		Cv%	7.2		
		Sed	1.78		

Table 2.26 The effects of K, Cl and S on FFB yield for the period 1991-1997 (Trial 310).

Treatment No.	Elements Supplied	Elements Missing	FFB Yield (t/ha/yr)	Differences from Treatment No. 6 t/ha/yr	Differences from Treatment No. 6 %
6	N, K, Cl, S	None	26.9	0.0	0.0
4	N, K, S	Cl	25.8	-1.1	-4.3
7	N, Cl, S	K	27.8	+0.9	+3.2
5	N, K, Cl	S	28.9	+2.0	+6.9
2	N, S	K, Cl	24.7	-2.2	-8.9
3	N, Cl	K, S	29.3	+2.4	+8.2
1	N (Urea)	K, Cl, S	25.8	-1.1	-4.3
		Sig	**		
		Cv%	7.3		
		Sed	1.97		

Table 2.27 The effects of N, S, K, and Cl in different combinations on the concentrations of elements in frond 17 leaflet tissue in 1997 (Trial 310).

		Concentration of elements (% dry matter)					
Treatment		N	P	K	Ca	Mg	Cl
6 N S K Cl		1.95	0.122	0.68	0.72	0.15	0.41
4 N S K		1.97	0.121	0.71	0.62	0.14	0.20
7 N S Cl		2.14	0.125	0.68	0.65	0.14	0.46
5 N K Cl		2.06	0.126	0.66	0.72	0.13	0.46
2 N S		2.02	0.122	0.73	0.60	0.14	0.10
3 N Cl		2.09	0.126	0.60	0.68	0.15	0.48
1 N (Urea)		2.08	0.125	0.73	0.63	0.13	0.11
	Sig	ns	ns	*	ns	ns	***
	Cv%	5.3	3.3	9.0	11.5	13.6	10.4
	Sed	0.07	0.003	0.04	0.05	0.01	0.02

Table 2.28 Effects of N, S, K and Cl in different combinations on the concentrations of elements in frond 17 rachis tissue in 1997 (Trial 310).

		Concentrations of elements (%dry matter)					
Treatment		N	P	K	Ca	Mg	Cl
6 N S K Cl		0.26	0.186	1.37	0.38	0.06	0.83
4 N S K		0.26	0.173	1.25	0.28	0.04	0.13
7 N S Cl		0.27	0.151	1.24	0.40	0.07	0.84
5 N K Cl		0.27	0.196	1.37	0.42	0.07	1.05
2 N S		0.26	0.137	0.91	0.27	0.04	0.04
3 N Cl		0.29	0.188	1.23	0.42	0.08	1.04
1 N (Urea)		0.27	0.150	0.96	0.29	0.04	0.06
	Sig	ns	ns	**	***	***	***
	Cv%	6.7	22.2	16.1	13.7	13.2	13.7
	Sed	0.01	0.02	0.12	0.03	0.005	0.05

The leaflet and rachis tissue analysis data are shown in Tables 2.27 and 2.28. Significant differences between treatments were recorded for leaflet and rachis K, Cl, Ca and Mg concentrations.

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 inputs.

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 at least one guard row and a trench surround the core palms.

The 32 plots comprise a single replicate of 32 treatments, made up of all combinations of four levels each of N and K, and two levels of EFB (Table 2.30). 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 given in Table 84 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 it was increased to 500 kg/palm and it is intended to apply this amount every two years.

Table 2.30 Amounts of fertiliser and EFB used in Trial 311.

Type of fertiliser	Amount (kg/palm/year)			
Or EFB	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 per palm per two 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 underwent plot isolation trenching in 1995.

RESULTS

Yield data for 1997 and the 7-year period, 1989 to 1997, are shown in Tables 2.31 and 2.32. In 1997, applications of sulphate of ammonia produced a statistically significant increase in FFB yield. The increase in yield was due to increases in bunch number and single bunch weight. There were no significant affects due to applications of muriate of potash. Empty fruit bunch increased FFB yield by 5.0 tonnes, which was caused by increases in bunch number and single bunch weight.

Table 2.33 shows the combined effects of N, K, and EFB application. The interactions were significant for the NxK interaction. An FFB yield of 34.9 t/ha/yr was obtained with 6 kg/palm of SoA and 2 kg/palm of MoP, this represents a 7.6 tonne increase compared to the mean yield of 27.3 tonnes.

The use of EFB in combination with SoA produced further benefits. A maximum FFB yield of 35.0 t/ha/yr was obtained with 6 kg/palm of SoA applied in the presence of EFB. Cumulative yields from 1989-1997 also showed the same combinations producing the same high yields as observed in the 1997 data (Table 2.34).

Table 2.31 Main effects of N, K, EFB on yield and yield components in 1997 (Trial 311).

	Level of nutrient element or EFB				Statistics		
					Sig	cv%	sed
	N0	N1	N2	N3			
Yield (t/ha/yr)	18.2	28.0	29.2	33.7	***	11.1	1.52
Bunches/ha	711	1002	959	1078	***	7.8	36
Bunch weight (kg)	25.3	27.7	30.6	31.3	***	6.9	0.99
	K0	K1	K2	K3			
Yield (t/ha/yr)	27.8	26.8	25.8	28.6	ns	11.1	1.52
Bunches/ha	962	910	885	993	(ns)	7.8	36
Bunch weight (kg)	28.4	28.8	29.0	28.8	ns	6.9	0.99
	EFB0	EFB1					
Yield (t/ha/yr)	24.5	30.0			***	11.1	1.07
Bunches/ha	873	1002			***	7.8	26
Bunch weight (kg)	27.5	30.0			**	6.9	0.70

Table 2.32 Effect of combinations of N and K, N and EFB, and K and EFB in 1997 (Trial 311).

	Yield (t/ha/yr)			
		Level of N		
Level of K	N0	N1	N2	N3
K0	19.0	26.6	31.6	34.2
K1	20.6	20.2	31.3	34.9
K2	13.8	31.8	24.2	33.4
K3	19.2	33.4	29.8	32.2
Level of EFB				
EFB 0	14.6	23.8	27.2	32.3
EFB 1	21.7	32.2	31.2	35.0
		Level of K		
Level of EFB	K0	K1	K2	K3
EFB 0	24.2	22.6	25.6	25.5
EFB 1	31.5	30.9	26.0	31.8

Grand mean: 27.3 Standard error: NxK=3.03, NxEFB & KxEFB=2.14

Table 2.33 Main effects of N, K, and EFB on yield and yield components for 1989 to 1997 (Trial 311).

	Level of nutrient Element or EFB				Statistics sig	cv%	sed
	N0	N1	N2	N3			
Yield (t/ha/yr)	21.8	28.6	30.0	33.6	***	11.1	1.59
Bunches/ha	824	1031	1007	1114	***	8.9	44
Bunch wt (kg)	26.1	27.5	29.9	30.3	**	6.2	0.89
	K0	K1	K2	K3			
Yield (t/ha/yr)	28.1	27.9	27.6	30.4	ns	11.1	1.59
Bunches/ha	994	968	956	1058	ns	8.9	44
Bunch wt (kg)	28.0	28.4	28.9	28.7	ns	6.2	0.89
	EFB0	EFB1					
Yield (t/ha/yr)	26.1	30.9			**	11.1	1.12
Bunches/ha	942	1046			**	8.9	31
Bunch wt (kg)	27.4	29.6			**	6.2	0.63

Table 2.34 Effect of combinations of N and K, N and EFB, and K and EFB, on yield from 1989 to 1997 (Trial 311).

	Yield (t/ha/yr)			
		Level of N		
Level of K	N0	N1	N2	N3
K0	21.0	27.2	31.4	33.0
K1	22.1	22.6	30.7	36.2
K2	20.2	31.6	26.4	32.2
K3	23.8	33.0	31.6	33.2
Level of EFB				
EFB 0	19.3	24.7	28.5	32.0
EFB 1	24.3	32.5	31.5	35.2
		Level of K		
Level of EFB	K0	K1	K2	K3
EFB 0	25.3	23.7	27.2	28.3
EFB 1	30.9	32.1	28.0	32.5

Grand mean: 28.5 Standard error: NxK=3.17, NxEFB & KxEFB=2.24

Table 2.35 Main effects of N, K, and EFB on concentrations of elements in leaflet tissue in 1997 (Trial 311).

	Level of nutrient Element or EFB				Statistics sig	cv%	sed
	N0	N1	N2	N3			
N%	1.82	2.00	2.10	2.21	***	4.4	0.04
P%	0.114	0.122	0.122	0.131	***	2.8	0.002
K%	0.62	0.64	0.66	0.69	(ns)	6.9	0.02
Ca%	0.67	0.66	0.62	0.61	(ns)	7.0	0.02
Mg%	0.15	0.15	0.12	0.13	(ns)	11.6	0.008
Cl%	0.35	0.38	0.39	0.42	*	9.1	0.02
	K0	K1	K2	K3			
N%	2.07	2.03	2.00	2.03	ns	4.4	0.04
P%	0.124	0.121	0.121	0.123	ns	2.8	0.002
K%	0.67	0.64	0.64	0.67	ns	6.9	0.02
Ca%	0.62	0.64	0.67	0.64	ns	7.0	0.02
Mg%	0.14	0.14	0.15	0.12	(ns)	11.6	0.008
Cl%	0.25	0.40	0.44	0.44	***	9.1	0.02
	EFB 0	EFB 1					
N%	1.96	2.10			**	4.4	0.03
P%	0.119	0.126			***	2.8	0.001
K%	0.63	0.68			**	6.9	0.02
Ca%	0.65	0.64			ns	7.0	0.02
Mg%	0.14	0.14			ns	11.6	0.006
Cl%	0.36	0.41			**	9.1	0.01

Sulphate of ammonia application significantly increased N, and P concentrations in the leaflet tissue (Table 2.35). Empty fruit bunch increased leaflet N, P, K and Cl concentrations. Muriate of potash increased the leaflet Cl concentration but had no significant effect on leaflet K.

Table 2.36 Main effects of N, K, and EFB on concentrations of elements in rachis in 1997 (Trial 311).

	Level of nutrient Element or EFB				Statistics sig	cv%	sed
	N0	N1	N2	N3			
N%	0.22	0.24	0.25	0.28	***	7.5	0.009
P%	0.086	0.078	0.058	0.072	ns	35.4	0.01
K%	1.34	1.42	1.35	1.38	ns	11.3	0.08
Ca%	0.38	0.39	0.36	0.35	ns	13.2	0.02
Mg%	0.06	0.05	0.04	0.04	***	10.1	0.002
Cl%	0.88	0.89	0.87	0.92	ns	13.0	0.06
	K0	K1	K2	K3			
N%	0.23	0.25	0.24	0.25	ns	7.5	0.009
P%	0.068	0.069	0.074	0.082	ns	35.4	0.01
K%	1.03	1.42	1.48	1.56	***	11.3	0.08
Ca%	0.33	0.38	0.38	0.38	ns	13.2	0.02
Mg%	0.04	0.05	0.06	0.05	***	10.1	0.002
Cl%	0.33	0.99	1.10	1.14	***	13.0	0.06
	EFB 0	EFB 1					
N%	0.23	0.26			**	7.5	0.006
P%	0.062	0.085			*	35.4	0.009
K%	1.29	1.46			(ns)	11.3	0.06
Ca%	0.36	0.37			ns	13.2	0.02
Mg%	0.05	0.04			**	10.1	0.002
Cl%	0.85	0.93			(ns)	13.0	0.04

Sulphate of ammonia application increased rachis N concentration, while Rachis Mg was significantly reduced (Table 2.36). Muriate of potash application increased rachis K and Cl concentrations. Empty fruit bunch applications increased the concentrations of N, P, K and Cl, but reduced Mg in the rachis.

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 inputs.

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 recorded palms. The number and weights of bunches from each individual core palm are recorded at intervals of 14 days. In each plot at least one guard row and a trench surround the core palms.

The 32 plots comprise a single replicate containing 32 treatments; these are made up of all combinations of four levels each of N and K, and two levels of EFB (Table 2.38). 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 mulch between palm circles. The weights of EFB in Table 91 are the fresh weights ex-mill. When EFB was applied for the first time in November 1988 the amount was 333 kg/palm every two years. In September 1990 this was increased to 500 kg/palm, and it is intended to give this amount every two years.

Table 2.38 Amounts of fertiliser and EFB used in 1997.

Type of fertiliser Or EFB	Level 0	Amount (kg/palm/year) 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/two 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 1997 and 1989-1997 are presented in Tables 2.39 and 2.40. Sulphate of ammonia significantly increased yields in 1997. This increase was due to increases in bunch number and single bunch weight. Muriate of potash did not have a significant effect on FFB yield. Empty fruit bunch applications significantly increased FFB yield and yield components in 1997.

The effects of combinations of N, K, and EFB on yield and yield components are shown in Table 2.41 and 95. The treatment interactions were not significant, but there are some interesting trends. The maximum FFB yield of 37 t/ha/yr was achieved with 6 kg/palm of SoA and 4 kg/palm of MoP. This combination and rates are also the same as indicated in Trial 311. SoA applied in combination with EFB provided a further increase in yield. EFB applied with MoP appeared to reduce FFB yield. Application of EFB increased yield when applied alone or with SoA. In the period 1989-1997 this trend was similar.

Table 2.39 Main effects of N, K, and EFB on yield and yield components in 1997 (Trial 312).

	Level of nutrient Elements or EFB				sig	Statistics cv%	sed
	N0	N1	N2	N3			
Yield (t/ha/yr)	24.1	29.1	31.6	34.3	**	15.5	2.31
Bunches/ha	1157	1235	1286	1393	*	12.0	76
Bunch weight (kg)	20.7	23.5	24.7	24.6	***	5.2	0.61
	K0	K1	K2	K3			
Yield (t/ha/yr)	29.3	31.1	30.2	28.6	ns	15.5	2.31
Bunches/ha	1223	1350	1288	1210	ns	12.0	76
Bunch weight (kg)	23.7	22.8	23.4	23.5	ns	5.2	0.61
	EFB 0	EFB 1					
Yield (t/ha/yr)	27.7	31.8			***	15.5	1.64
Bunches/ha	1230	1306			ns	12.0	53
Bunch weight (kg)	22.4	24.4			***	5.2	0.43

Table 2.40 Effect of combinations of N and K, N and EFB on yield in 1997 (Trial 312).

	Yield (t/ha/yr)			
		Level of N		
Level of N	N0	N1	N2	N3
K0	22.0	28.2	32.6	34.4
K1	26.2	30.4	33.9	34.0
K2	23.2	30.2	29.4	37.9
K3	25.0	27.8	30.6	30.9
Level of EFB				
EFB 0	19.8	26.6	30.1	34.4
EFB 1	28.4	31.7	33.2	34.1
		Level of K		
Level of EFB	K0	K1	K2	K3
EFB 0	26.6	28.2	29.4	26.8
EFB 1	32.0	34.0	31.0	30.4

Grand Mean: 29.8 Standard Error: NxK=4.63, NxEFB & KxEFB=3.28

The treatment interactions were not significant.

Table 2.41 Main effects of N, K, and EFB on yield and yield components in 1989 – 1997 (Trial 312).

	Level of nutrient Elements or EFB				Statistics sig	cv%	sed
	N0	N1	N2	N3			
Yield (t/ha/yr)	24.6	29.0	31.7	33.5	***	9.4	1.40
Bunches/ha	1177	1231	1314	1394	**	6.2	39
Bunch weight (kg)	20.8	23.5	24.1	24.1	***	5.1	0.59
	K0	K1	K2	K3			
Yield (t/ha/yr)	29.4	30.5	30.0	28.8	ns	9.4	1.40
Bunches/ha	1256	1333	1300	1228	ns	6.2	39
Bunch weight (kg)	23.2	22.8	23.1	23.4	ns	5.1	0.59
	EFB 0	EFB 1					
Yield (t/ha/yr)	27.7	31.6			**	9.4	0.99
Bunches/ha	1240	1319			*	6.2	27
Bunch weight (kg)	22.3	24.0			**	5.1	0.42

Table 2.42 Effects of treatment combinations of N and K, N and EFB and K and EFB on yield in 1989-1997 (Trial 312).

		Yield (t/ha/yr)		
		Level of N		
Level of K	N0	N1	N2	N3
K0	23.0	29.0	32.6	33.0
K1	25.2	29.8	33.5	33.6
K2	24.4	30.2	30.0	35.4
K3	25.6	27.0	30.5	32.0
Level of EFB				
EFB0	21.2	26.4	30.0	33.3
EFB1	27.8	31.6	33.3	33.7
		Level of K		
Level of EFB	K0	K1	K2	K3
EFB0	26.9	28.2	28.5	27.3
EFB1	31.9	32.8	31.5	30.2

Grand mean = 29.7 Standard error NxK=2.80, NxEFB & KxEFB=1.98

Treatment interactions were not significant.

Table 2.43 Main effects of N, K, and EFB on concentrations of elements in leaflet tissue of frond 17 in 1997, expressed as a % of dry matter (Trial 312).

	Level of nutrient Element or EFB				sig	Statistics cv%	sed
	N0	N1	N2	N3			
N%	1.98	2.06	2.21	2.24	**	5.6	0.06
P%	0.130	0.132	0.137	0.137	(ns)	4.4	0.003
K%	0.69	0.74	0.77	0.76	**	4.6	0.017
Ca%	0.75	0.68	0.65	0.63	**	6.3	0.02
Mg%	0.18	0.16	0.15	0.15	**	9.4	0.008
Cl%	0.44	0.44	0.45	0.45	ns	6.7	0.01
	K0	K1	K2	K3			
N%	2.09	2.13	2.15	2.12	ns	5.6	0.06
P%	0.134	0.135	0.133	0.135	ns	4.4	0.003
K%	0.76	0.73	0.71	0.75	ns	4.6	0.017
Ca%	0.63	0.69	0.69	0.71	*	6.3	0.02
Mg%	0.16	0.16	0.16	0.17	ns	9.4	0.008
Cl%	0.36	0.47	0.47	0.48	***	6.7	0.01
	EFB0	EFB1					
N%	2.10	2.20			**	5.6	0.06
P%	0.130	0.138			**	4.4	0.003
K%	0.70	0.77			***	4.6	0.017
Ca%	0.68	0.67			ns	6.3	0.02
Mg%	0.16	0.16			ns	9.4	0.008
Cl%	0.42	0.46			**	6.7	0.01

Application of sulphate of ammonia increased leaflet N, P and K concentrations, while Ca and Mg were decreased (Table 2.43). Muriate of potash increased both Ca and Cl concentrations. The effect of MoP on leaflet K was variable. Empty fruit bunches significantly increased leaflet N, P, K and Cl concentrations.

Table 2.44 Main effects of N, K, and EFB on concentrations of elements in the rachis in 1996 expressed as a % of dry matter (Trial312).

	Level of nutrient Element or EFB				sig	Statistics cv%	sed
	N0	N1	N2	N3			
N%	0.24	0.24	0.28	0.29	**	8.5	0.01
P%	0.212	0.162	0.128	0.111	***	12.9	0.01
K%	1.67	1.62	1.69	1.66	ns	8.1	0.07
Ca%	0.34	0.35	0.34	0.32	ns	10.3	0.01
Mg%	0.06	0.05	0.05	0.04	*	12.0	0.003
Cl%	0.86	0.88	0.95	1.03	*	9.7	0.04
	K0	K1	K2	K3			
N%	0.26	0.27	0.26	0.25	ns	8.5	0.01
P%	0.151	0.154	0.152	0.156	ns	12.9	0.01
K%	1.47	1.70	1.75	1.71	**	8.1	0.07
Ca%	0.30	0.35	0.38	0.33	**	10.3	0.01
Mg%	0.04	0.05	0.05	0.05	(ns)	12.0	0.003
Cl%	0.55	1.00	1.12	1.06	***	9.7	0.04
	EFB 0	EFB 1					
N%	0.25	0.28			**	8.5	0.01
P%	0.155	0.152			ns	12.9	0.01
K%	1.54	1.78			***	8.1	0.05
Ca%	0.35	0.32			*	10.3	0.01
Mg%	0.05	0.05			ns	12.0	0.003
Cl%	0.87	0.99			**	9.7	0.03

Sulphate of ammonia significantly reduced rachis P and Mg concentrations but increased rachis N and Cl (Table 2.44). Muriate of potash increased rachis K, Ca and Cl concentrations. Application of EFB increased N, K and Cl concentrations in the rachis.

Trial 317 FERTILISER TRIAL ON LOWER TERRACE, KOMO ESTATE, MAMBA

PURPOSE

To test the response to applications of N, P, K, and Mg in factorial combination on Mamba soils to obtain information that will assist in making fertiliser recommendations.

DESCRIPTION

Site: Komo Estate, Block 27.

Soil: Dark sandy loam, derived from air-fall ash.

Palms: Dami commercial DxP crosses planted in 1985 at 130 palms/ha. Trial started in May 1990.

DESIGN

There are 36 plots, each with a core of 10-recorded palms. The number and weights of bunches from each individual core palms are recorded at intervals of 14 days. Trenches to separate them from adjoining plots surround the core palms.

The 36 plots comprise a single replicate containing 36 treatments. The treatments are made up from all factorial combinations of three levels of N and K and two levels of P and Mg (Table 2.45).

Table 2.45 Types of fertiliser and amounts used in Trial 317

Element	Type of fertiliser	Amounts of fertiliser (kg/palm/yr) Level 0	Level 1	Level 2
N	Sulphate of ammonia	0.0	2.5	5.0
P	Triple Superphosphate	0.0	2.5	-
K	Muriate of potash	0.0	2.5	5.0
Mg	Kieserite	0.0	2.5	-

RESULTS

Yield data for 1997 and for the period 1991-1997 are presented in Tables 2.46 and 2.47.

There were no statistically significant responses to treatments in 1997. A response to Kieserite application is apparent and suggests a 3 ton increase in FFB yield. Kieserite applications also increased single bunch weight. For the period 1991-1997, cumulative data showed a significant increase in FFB yield and single bunch weight due to the application of Kieserite.

There were no responses to sulphate of ammonia, Triple Superphosphate and muriate of potash applications.

Table 2.46 Main effects of N, P, K, and Mg on yield and yield components in 1997 (Trial 317).

	Level of nutrient			Statistics		
	Element			sig	cv%	sed
	N0	N1	N2			
Yield (t/ha/yr)	25.2	27.9	22.7	ns	19.8	2.04
Bunches/ha	926	990	854	ns	15.3	57
Bunch weight (kg)	27.0	28.0	26.5	ns	12.1	1.34
	P0	P1				
Yield (t/ha/yr)	26.1	24.4		ns	19.8	1.67
Bunches/ha	956	891		ns	15.3	47
Bunch weight (kg)	27.1	27.3		ns	12.1	1.09
	K0	K1	K2			
Yield (t/ha/yr)	23.4	26.8	25.6	ns	19.8	2.04
Bunches/ha	902	927	940	ns	15.3	57
Bunch weight (kg)	25.7	28.7	27.1	ns	12.1	1.34
	Mg0	Mg1				
Yield (t/ha/yr)	23.7	26.8		ns	19.8	1.67
Bunches/ha	911	935		ns	15.3	47
Bunch weight (kg)	25.9	28.5		(ns)	12.1	1.09

Table 2.47 Main effects of N, P, K, and Mg on yield and yield components from 1991-1997 (Trial 317).

	Level of nutrient			Statistics		
Element				**sig**	**cv%**	**sed**
	N0	N1	N2			
Yield (t/ha/yr)	21.2	23.2	19.5	ns	15.0	1.31
Bunches/ha	824	877	780	ns	10.4	35
Bunch weight (kg)	**25.3**	**26.2**	**24.8**	**ns**	**10.2**	**1.05**
	P0	P1				
Yield (t/ha/yr)	21.6	21.0		ns	15.0	1.07
Bunches/ha	845	809		ns	10.4	28
Bunch weight (kg)	25.1	25.8		ns	10.2	0.86
	K0	K1	K2			
Yield (t/ha/yr)	19.8	22.0	22.1	ns	15.0	1.31
Bunches/ha	812	813	856	ns	10.4	35
Bunch weight (kg)	24.0	26.6	25.6	ns	10.2	1.05
	Mg0	Mg1				
Yield (t/ha/yr)	19.9	22.7		*	15.0	1.07
Bunches/ha	812	842		ns	10.4	28
Bunch weight (kg)	24.3	26.6		*	10.2	0.86

Trial 318 FERTILISER TRIAL ON RIVER TERRACE AT KOMO ESTATE, MAMBA

PURPOSE

To test the response to N, P, K, and Mg in factorial combination on the Mamba soil.

DESCRIPTION

Site: Komo Estate, Block 39.

Soil: Dark sandy loam.

Palms: Dami commercial DxP crosses planted in 1985 at 130 palms/ha. Trial started in March 1990.

DESIGN

There are 36 plots, each with a core of 9 recorded palms. The numbers and weights of bunches from each individual core palm are recorded at intervals of 14 days. Trenches to separate them from adjoining plots surround the core palms.

The 36 plots comprise a single replicate containing 36 treatments. The treatments are made up from all factorial combinations of three levels of N and K and two levels of P and Mg (Table 2.48).

Table 2.48 Types of fertiliser and amounts used in Trial 318

Element	Type of fertiliser	Amount of fertiliser Level 0	Level 1	Level 2
N	Sulphate of ammonia	0.0	2.5	5.0
P	Triple Superphosphate	0.0	2.5	-
K	Muriate of potash	0.0	2.5	5.0
Mg	Kieserite	0.0	2.5	-

RESULTS

Treatments did not have a statistically significant effect on yield. However data means suggest that the application of Kieserite had increased yield by 2 tons over the period 1991-1996 (Table 2.49).

Table 2.49 Main effects of N, P, K, and Mg on yield and yield components in 1997 (Trial 318).

	Level of nutrient Element			Statistics sig	cv%	sed
	N0	N1	N2			
Yield (t/ha/yr)	14.4	19.3	18.8	ns	47.8	3.42
Bunches/ha	624	737	761	ns	29.8	85
Bunch weight (kg)	22.6	25.8	24.3	ns	29.3	2.89
	P0	P1				
Yield (t/ha/yr)	18.2	16.8		ns	47.8	2.79
Bunches/ha	730	684		ns	29.8	70
Bunch weight (kg)	24.4	24.0		ns	29.3	2.36
	K0	K1	K2			
Yield (t/ha/yr)	16.3	18.3	17.9	ns	47.8	3.42
Bunches/ha	675	720	726	ns	29.8	85
Bunch weight (kg)	23.0	25.2	24.3	ns	29.3	2.89
	Mg0	Mg1				
Yield (t/ha/yr)	16.2	18.8		ns	47.8	2.79
Bunches/ha	669	745		ns	29.8	70
Bunch weight (kg)	23.5	24.8		ns	29.3	2.36

Table 2.50 Main effects of N, P, K, and Mg on yield and yield components in 1991-1997 (Trial 318).

	Level of nutrient Element			Statistics sig	cv%	sed
	N0	N1	N2			
Yield (t/ha/yr)	14.2	17.3	16.9	ns	43.6	2.88
Bunches/ha	652	706	726	ns	27.1	76
Bunch weight (kg)	21.4	24.1	22.8	ns	27.2	2.53
	P0	P1				
Yield (t/ha/yr)	16.7	15.6		ns	43.6	2.35
Bunches/ha	710	679		ns	27.1	62
Bunch weight (kg)	23.1	22.4		ns	27.2	2.06
	K0	K1	K2			
Yield (t/ha/yr)	14.5	17.1	16.8	ns	43.6	2.88
Bunches/ha	647	716	721	ns	27.1	76
Bunch weight (kg)	21.6	23.7	23.0	ns	27.2	2.53
	Mg0	Mg1				
Yield (t/ha/yr)	14.9	17.3		ns	43.6	2.35
Bunches/ha	652	737		ns	27.1	62
Bunch weight (kg)	22.3	23.2		ns	27.2	2.06

Trial 502B FERTILISER TRIAL AT WAIGANI ESTATE

PURPOSE

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

DESCRIPTION

Site: Waigani Estate, Field 6503 and 6504.

Soil: Plantation family, which of recent alluvial origin.

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

DESIGN

Trial 502B relocation comprises a single replicate of 64 treatments split into four blocks. Treatments comprise of all factorial combinations of N and K at 4 levels and P and EFB at 2 levels. There are 64 plots each containing 16 core recorded 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 trench surround the core palms. EFB is applied by hand as mulch between palm circles.

Table 2.51 Amounts of fertiliser and EFB used in 1997.

Type of fertiliser Or EFB	Level 0	Amounts (kg/palm/year) 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		
	Kg/palm/year			
EFB	0.0	300		

Plot isolation 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

The average plot yield in 1997 was 26.5 t/ha/year, an increase from 22.6 t/ha in 1996. The trial has just begun to show responses to ammonium sulphate and muriate of potash applications (Table 2.52).

Sulphate of ammonia increased single bunch weight (p=0.025) and bunch numbers though the later was not statistically significant. This resulted in an increase in FFB yield.

Muriate of potash increased the number of bunches (p=0.011) which also caused an increase in FFB yield (p=0.005).

There was no yield response to Triple Superphosphate and empty fruit bunch treatments. Empty fruit bunch increased single bunch weight (p=0.036) but this increase was not large enough to cause an increase in FFB yield.

Table 2.53 shows the two-way table for N and K. Maximum yield of 29.6 t/ha/yr was achieved with 4 kg of ammonium sulphate and 5 kg of muriate of potash.

Table 2.52 Main effects of N, P, K, and EFB on yield and yield components in 1997 (Trial 502b).

	Level of nutrient Element or EFB				sig	Statistics cv%	sed
	N0	N1	N2	N3			
Yield (t/ha/yr)	24.5	26.4	28.2	26.7	ns	11.5	1.07
Bunches/ha	1251	1242	1321	1232	ns	12.5	55
Bunch weight (kg)	20.1	21.4	21.4	21.7	***	5.5	0.41
	K0	K1	K2	K3			
Yield (t/ha/yr)	24.6	25.2	26.6	29.4	***	11.5	1.07
Bunches/ha	1186	1204	1257	1366	(ns)	12.5	55
Bunch weight (kg)	20.8	21.0	21.2	21.2	ns	5.5	0.41
	P0	P1					
Yield (t/ha/yr)	26.7	26.2			ns	11.5	0.76
Bunches/ha	1251	1255			ns	12.5	39
Bunch weight (kg)	21.4	20.9			ns	5.5	0.29
	EFB0	EFB1					
Yield (t/ha/yr)	26.4	26.6			ns	11.5	0.76
Bunches/ha	1271	1235			ns	12.5	39
Bunch weight (kg)	20.7	21.5			**	5.5	0.29

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

		Level of N		
Level of K	N0	N1	N2	N3
K0	22.4	24.7	27.6	23.9
K1	23.8	25.8	24.6	26.5
K2	23.6	24.6	**29.6**	27.3
K3	28.1	26.5	27.3	29.3

Mean 26.5 Standard error 2.06

Table 2.54 Main effects of N, P, K and EFB on yield and yield components in 1995-1997 (Trial 502b).

	Level of nutrient Element or EFB				Statistics sig	cv%	sed.
	N0	N1	N2	N3			
Yield (t/ha/yr)	22.6	23.6	24.3	23.8	*	6.1	0.51
Bunches/ha	1103	1098	1132	1097	ns	6.3	25
Bunch weight (kg)	20.5	21.6	21.6	21.8	*	4.8	0.36
	K0	K1	K2	K3			
Yield (t/ha/yr)	22.7	22.9	23.7	25.0	**	6.1	0.51
Bunches/ha	1074	1086	1110	1160	*	6.3	25
Bunch weight (kg)	21.6	21.4	21.7	21.6	ns	4.8	0.36
	P0	P1					
Yield (t/ha/yr)	23.8	23.3			ns	6.1	0.36
Bunches/ha	1110	1105			ns	6.3	18
Bunch weight (kg)	21.5	21.2			ns	4.8	0.26
	EFB0	EFB1					
Yield (t/ha/yr)	23.6	23.6			ns	6.1	0.36
Bunches/ha	1118	1096			ns	6.3	18
Bunch weight (kg)	21.2	21.5			ns	4.8	0.26

Leaflet tissue analysis results are presented in Table 2.55. Generally there was no response to fertiliser treatments with the exceptions of muriate of potash causing an increase in Cl ($p=<0.001$) and empty fruit bunch increasing K ($p=<0.001$) levels. The effects of drought in 1997 seem to have had an overriding effect on the responses to fertiliser treatments.

Mean leaflet nutrient concentrations for N, P and Ca were lower in 1997 than in 1996 whilst the opposite was the case with K and Cl concentrations (Table 2.56). There was no change in mean Mg concentration between the 2 years. The drought in 1997 probably was a major contributing factor to the differences in the mean nutrient concentrations.

Rachis P concentration was suppressed with the application of sulphate of ammonia ($p=<0.001$) (Table 110). Muriate of potash increased rachis K and Cl ($p=<0.001$) but lowered Ca ($p=0.01$) and Mg ($p=<0.001$) concentrations. There was no response to Triple Superphosphate application. Empty fruit bunch significantly increased tissue K concentrations but also suppressed Ca and Mg ($p=<0.001$). K released from the breakdown of empty fruit bunch is probably readily available for plant uptake. The suppression of Ca and Mg is probably due to the antagonistic effect of K.

Table 2.55 Main effects of N, P, K, and EFB on the concentrations of nutrients in leaflet tissue of frond 17 in 1997 expressed as % dry matter (Trial 502b).

	Nutrient Element and Level				Statistics sig	cv%	sed.
	N0	N1	N2	N3			
N%	2.23	2.23	2.35	2.34	ns	8.0	0.06
P%	0.145	0.147	0.149	0.146	ns	2.6	0.001
K%	0.72	0.73	0.73	0.73	ns	6.2	0.02
Ca%	0.69	0.65	0.64	0.66	ns	7.3	0.02
Mg%	0.33	0.31	0.30	0.31	ns	13.1	0.03
Cl%	0.54	0.55	0.53	0.54	ns	6.8	0.013
B(ppm)	9.93	9.59	9.53	9.53	ns	14.3	0.49
	K0	K1	K2	K3			
N%	2.29	2.25	2.25	2.35	ns	8.0	0.06
P%	0.145	0.147	0.146	0.147	ns	2.6	0.001
K%	0.73	0.73	0.72	0.73	ns	6.2	0.02
Ca%	0.65	0.67	0.66	0.66	ns	7.3	0.02
Mg%	0.32	0.31	0.32	0.31	ns	13.1	0.03
Cl%	0.49	0.54	0.56	0.57	***	6.8	0.013
B(ppm)	9.93	9.47	9.80	9.38	ns	14.3	0.49
	P0	P1					
N%	2.27	2.30			ns	8.0	0.05
P%	0.145	0.147			ns	2.6	0.001
K%	0.72	0.72			ns	6.2	0.01
Ca%	0.66	0.66			ns	7.3	0.02
Mg%	0.31	0.31			ns	13.1	0.02
Cl%	0.54	0.54			ns	6.8	0.009
B(ppm)	9.62	9.67			ns	14.3	0.35
	EFB0	EFB1					
N%	2.28	2.30			ns	8.0	0.05
P%	0.146	0.147			ns	2.6	0.001
K%	0.70	0.75			***	6.2	0.01
Ca%	0.67	0.65			ns	7.3	0.012
Mg%	0.32	0.31			ns	13.1	0.02
Cl%	0.55	0.54			ns	6.8	0.009
B(ppm)	10.0	9.86			ns	14.3	0.35

Table 2.56 Mean leaflet tissue nutrient concentrations for 1996 and 1997 (Trial 502b).

Nutrient Element	1996	1997
N%	2.49	2.29
P%	0.151	0.146
K%	0.68	0.72
Ca%	0.75	0.66
Mg%	0.31	0.31
Cl%	0.45	0.54

Table 2.57 Main effects of N, P, K, and EFB on the concentration of elements in the rachis of frond 17 in 1997 expressed as % dry matter (Trial 502b).

	Nutrient Element and Level				Statistics		
					sig.	cv%	sed.
	N0	N1	N2	N3			
N%	0.27	0.27	0.29	0.30	ns	6.3	0.006
P%	0.100	0.080	0.070	0.063	***	18.9	0.005
K%	1.24	1.16	1.11	1.16	ns	13.1	0.05
Ca%	0.31	0.30	0.31	0.32	*	5.5	0.006
Mg%	0.13	0.12	0.12	0.12	*	10	0.004
Cl%	0.71	0.67	0.63	0.66	ns	14	0.03
B(ppm)	5.11	5.04	5.23	5.10	ns	11.6	0.21
	K0	K1	K2	K3			
N%	0.29	0.27	0.29	0.29	ns	6.3	0.006
P%	0.071	0.078	0.076	0.087	ns	18.9	0.005
K%	0.84	1.10	1.27	1.46	***	13.1	0.05
Ca%	0.31	0.32	0.30	0.30	**	5.5	0.006
Mg%	0.14	0.13	0.12	0.11	***	10	0.004
Cl%	0.45	0.63	0.73	0.85	***	14	0.03
B(ppm)	5.31	5.01	5.10	5.06	ns	11.6	0.21
	P0	P1					
N%	0.28	0.29			ns	6.3	0.005
P%	0.075	0.018			ns	18.9	0.004
K%	1.18	1.15			ns	13.1	0.04
Ca%	0.31	0.31			ns	5.5	0.004
Mg%	0.12	0.13			ns	10	0.003
Cl%	0.67	0.66			ns	14	0.023
B(ppm)	5.08	5.17			ns	11.6	0.15
	EFB0	EFB1					
N%	0.29	0.28			ns	6.3	0.005
P%	0.072	0.084			ns	18.9	0.004
K%	1.01	1.32			***	13.1	0.04
Ca%	0.33	0.29			***	5.5	0.004
Mg%	0.14	0.11			***	10	0.003
Cl%	0.65	0.68			ns	14	0.023
B(ppm)	5.20	5.04			ns	11.6	0.15

Trial 504 MATURE PHASE FERTILISER TRIAL AT SAGARAI ESTATE

PURPOSE

To test the response to N and K and an allowance made for one additional treatment in Sagarai Estate.

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.

Palms: Special Dami DxP crosses of 16 progenies that were randomised within each plot. The palms were planted in January 1991 at 127 palms/ha. The trial was initiated in 1994.

DESIGN

There are 64 plots, each with a core of 16 recorded 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 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 factorial combinations of four levels each of N and K, and two levels of an additional treatment, which is currently vacant (Table 2.58).

Table 2.58 Type of fertiliser and amounts used in Trial 504.

Element	Type of fertiliser	Amounts and levels of fertiliser Level 0	Level 1	Level 2	Level 3
N	Sulphate of ammonia	0.0	2.0	4.0	6.0
K	Muriate of potash	0.0	2.5	5.0	7.0
?	?	?	?	?	?

RESULTS

In 1997 and in the period 1995-1997 there was no significant responses to application of sulphate of ammonia (Table 2.59). A response to muriate of potash application by single bunch weight (p=0.024) was beginning to appear but this was not large enough to affect the FFB yield. Yields were high even in the control plots and the mean FFB yield was 32.5 t/ha/yr, an increase from 28.3 t/ha/yr in 1996. The trend is the same for the period 1995-1997 (Table 2.60).

Table 2.59 Main effects of N and K on yield and yield components in 1997 (Trial 504).

	Level of nutrient Element				sig	Statistics cv%	sed
	N0	N1	N2	N3			
Yield (t/ha/yr)	32.0	32.8	32.4	32.9	ns	7.3	0.84
Bunches/ha	2587	2544	2541	2597	ns	9.3	84
Bunch weight (kg)	12.4	13.0	12.8	12.7	ns	7.5	0.34
	K0	K1	K2	K3			
Yield (t/ha/yr)	32.1	32.4	33.5	32.1	ns	7.3	0.84
Bunches/ha	2623	2605	2530	2510	ns	9.3	84
Bunch weight (kg)	12.3	12.5	13.3	12.8	(ns)	7.5	0.34

Table 2.60 Main effects of N and K on yield and yield components in 1995-1997 (Trial 504).

	Level of nutrient Element				sig.	Statistics cv%	sed.
	N0	N1	N2	N3			
Yield (t/ha/yr)	28.5	29.0	28.8	29.0	ns	6.2	0.63
Bunches/ha	2438	2399	2407	2412	ns	8.1	69
Bunch weight (kg)	11.6	12.1	11.9	12.0	ns	5.6	0.23
	K0	K1	K2	K3			
Yield (t/ha/yr)	28.5	29.1	29.4	28.2	ns	6.2	0.63
Bunches/ha	2433	2449	2409	2366	ns	8.1	69
Bunch weight (kg)	11.7	11.9	12.2	11.9	ns	5.6	0.23

Leaf and rachis analysis results are presented in Tables 2.61 and 2.62. Only leaflet N was beginning to respond to application of sulphate of ammonia (p=0.026). Muriate of potash did not affect leaflet K concentration but increased Ca (p=0.013) and Cl (p=<0.001) concentrations.

In the rachis, sulphate of ammonia significantly reduced P concentration (p=<0.001) whilst muriate of potash application increased P (<0.001), K (<0.001), Ca (p=0.002) and Cl (p=<0.001) concentrations. The significant treatment effects on the rachis nutrient concentrations are not reflected in the yields but may show up in later years.

Table 2.61 Main effects of N and K on the concentration of elements in leaflet tissue of frond 17 expressed as % of dry matter in 1997 (Trial 504).

	Nutrient element and level				sig.	cv%	Statistics sed.
	N0	N1	N2	N3			
N%	2.28	2.39	2.36	2.37	*	4.5	0.04
P%	0.149	0.151	0.150	0.149	ns	3.4	0.002
K%	0.76	0.76	0.73	0.75	ns	8.5	0.02
Ca%	0.70	0.70	0.68	0.70	ns	5.3	0.01
Mg%	0.33	0.32	0.32	0.32	ns	7.2	0.008
Cl%	0.55	0.55	0.55	0.56	ns	5.4	0.01
B(ppm)	8.77	8.79	8.79	8.61	ns	5.9	0.18
	K0	K1	K2	K3			
N%	2.29	2.39	2.38	2.34	(ns)	4.5	0.04
P%	0.148	0.151	0.149	0.150	ns	3.4	0.002
K%	0.75	0.74	0.74	0.76	ns	8.5	0.02
Ca%	0.68	0.72	0.69	0.70	*	5.3	0.01
Mg%	0.33	0.33	0.32	0.32	ns	7.2	0.008
Cl%	0.47	0.56	0.60	0.59	***	7.0	0.01
B(ppm)	8.86	8.79	8.63	8.67	ns	5.9	0.18

Table 2.62 Main effects of N and K on the concentrations of elements in the rachis of frond 17 in 1997 expressed as % of dry matter (Trial 504).

	Nutrient element and levels				sig.	cv%	Statistics sed.
	N0	N1	N2	N3			
N%	0.29	0.29	0.29	0.29	ns	10.8	0.11
P%	0.138	0.121	0.106	0.102	***	14.8	0.006
K%	1.14	1.17	1.10	1.06	(ns)	9.9	0.04
Ca%	0.31	0.32	0.33	0.33	ns	6.0	0.01
Mg%	0.13	0.12	0.13	0.13	ns	14.4	0.006
Cl%	0.61	0.60	0.63	0.62	ns	11.5	0.03
B (ppm)	4.77	4.77	4.79	4.78	ns	6.8	0.11
	K0	K1	K2	K3			
N%	0.29	0.29	0.29	0.29	ns	10.8	0.11
P%	0.107	0.112	0.121	0.128	***	14.8	0.006
K%	0.86	1.14	1.17	1.28	***	9.9	0.04
Ca%	0.31	0.33	0.33	0.32	**	6.0	0.01
Mg%	0.12	0.13	0.13	0.12	ns	14.4	0.006
Cl%	0.36	0.66	0.69	0.75	***	11.5	0.03
B(ppm)	4.76	4.68	4.96	4.71	ns	6.8	0.11

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

PURPOSE

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

DESCRIPTIONS

Site: Waigani estate, Field 8501 and 8502

Soil: Hagita soil 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 predominantly poorly drained. Although these soils are predominantly 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 crests 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 recorded palms. The numbers and weights of bunches for each individual core palm are recorded at intervals of 14 days. In each plot a guard row and a trench surround the core palms.

The 64 plots comprise a single replicate split into four blocks. The trial contains 63 treatments comprising all factorial combinations of N and K at 4 levels, and P and EFB at 2 levels (Table 2.62). EFB is applied by hand as mulch between palm circles.

Table 2.62 Amounts of fertiliser and EFB used in Trial 511.

Type of fertiliser	Amounts of fertiliser (kg/palm/ha)			
or EFB	Level 0	Level 1	Level 2	Level3
Sulphate of ammonia	0.0	2.0	4.0	6.0
Muriate of potash	0.0	2.5	5.0	7.5
Triple Superphosphate	0.0	2.0		
		kg/palm/year		
EFB	0.0	315		

RESULTS

Yield data for 1997 and the period 1995-1997 are presented in Tables 2.63 and 2.64. There were significant FFB yield responses to sulphate of ammonia application (p=<0.001). This was due to increases in number of bunches (p=0.012) and single bunch weight (p=<0.001). Triple Superphosphate significantly increased single bunch weight (p=0.016) and FFB yield (p=0.003). Responses to empty fruit bunch application were beginning to appear with increases in single bunch weight (p=0.025) and FFB yield (p=0.018). There was no response to muriate of potash application.

Table 2.63 Main effects of N, P, K, and EFB on yield and yield components in 1997 (Trial 511).

	Nutrient element and level				Statistics		
					sig	sed	cv%
	N0	N1	N2	N3			
Yield (t/ha/yr)	12.6	16.7	20.4	22.0	***	1.04	16.3
Bunches/ha	866	997	1114	11182	*	77	21.0
Bunch weight (kg)	14.6	16.9	18.3	18.7	***	0.56	9.3
	P0	P1					
Yield (t/ha/yr)	16.5	19.4			**	0.73	16.3
Bunches/ha	990	1090			ns	54.0	21.0
Bunch weight (kg)	16.6	17.7			*	0.40	9.3
	K0	K1	K2	K3			
Yield (t/ha/yr)	16.5	18.3	19.0	18.0	ns	1.04	16.3
Bunches/ha	943	1101	1093	1023	ns	77	21.0
Bunch weight (kg)	17.3	16.5	17.3	17.3	ns	0.56	9.3
	EFB0	EFB1					
Yield (t/ha/yr)	16.9	19.0			*	0.73	16.3
Bunches/ha	1008	1071			ns	54.0	21.0
Bunch weight (kg)	16.6	17.7			*	0.40	10.0

Table 2.64 Main effects on N, P, K, and EFB on yield and yield components in 1995-1997 (Trial 511).

	Nutrient element and level				Statistics		
					sig	sed	cv%
	N0	N1	N2	N3			
Yield (t/ha/yr)	16.9	19.5	21.8	23.1	***	0.69	9.6
Bunches/ha	1179	1237	1302	1392	*	52.0	11.6
Bunch weight (kg)	14.4	16.0	17.0	16.9	***	0.45	7.8
	P0	P1					
Yield (t/ha/yr)	19.4	21.2			**	0.49	9.6
Bunches/ha	1248	1307			ns	37.0	11.6
Bunch weight (kg)	15.7	16.5			*	0.32	7.8
	K0	K1	K2	K3			
Yield (t/ha/yr)	19.4	20.3	21.1	20.5	ns	0.69	9.6
Bunches/ha	1196	1313	1335	1268	ns	52.0	11.6
Bunch weight (kg)	16.3	15.6	16.0	16.3	ns	0.45	7.8
	EFB0	EFB1					
Yield (t/ha/yr)	19.8	20.9			*	0.49	9.6
Bunches/ha	1253	1302			ns	37.0	11.6
Bunch weight (kg)	15.9	16.3			ns	0.32	7.8

Results of leaflet and rachis analysis are presented in Tables 2.65 and 2.66. Sulphate of ammonia application increased leaflet N, P, and K concentrations but reduced leaf Ca and Mg concentrations. Muriate of potash only increased leaflet Cl. Triple Superphosphate application increased leaflet P and empty fruit bunch increased leaflet P and K concentrations.

In the rachis, concentrations of P, Mg and Cl were reduced when sulphate of ammonia was applied. Muriate of potash application increased rachis K and Cl concentrations. Triple Superphosphate application increased rachis P concentration and reduced Cl concentration. EFB application increased P and K, but lowered Ca and Cl concentrations.

Table 2.65 Main effects of N, P, K, and EFB on the concentrations of elements in leaflet tissue of frond 17 in 1997 (Trial 511).

	Level of nutrient Element or EFB				Statistics sig.	cv%	sed.
	N0	N1	N2	N3			
N%	2.05	2.13	2.23	2.28	*	9.2	0.07
P%	0.132	0.134	0.137	0.139	*	4.3	0.002
K%	0.81	0.84	0.92	0.94	**	8.3	0.03
Ca%	0.75	0.73	0.68	0.67	*	9.5	0.02
Mg%	0.36	0.34	0.30	0.30	*	16.6	0.02
Cl%	0.60	0.59	0.61	0.62	ns	9.3	0.02
B(ppm)	8.98	8.73	8.43	8.49	ns	14.4	0.44
	K0	K1	K2	K3			
N%	2.18	2.15	2.15	2.22	ns	9.2	0.07
P%	0.136	0.136	0.134	0.136	ns	4.3	0.002
K%	0.88	0.88	0.86	0.89	ns	8.3	0.03
Ca%	0.69	0.72	0.72	0.71	ns	9.5	0.02
Mg%	0.33	0.33	0.33	0.31	ns	16.6	0.02
Cl%	0.54	0.61	0.62	0.64	**	9.3	0.02
B(ppm)	8.69	8.81	8.78	8.34	ns	14.4	0.44
	P0	P1					
N%	2.16	2.19			ns	9.2	0.05
P%	0.133	0.138			**	4.3	0.001
K%	0.89	0.87			ns	8.3	0.02
Ca%	0.69	0.72			ns	9.5	0.02
Mg%	0.32	0.33			ns	16.6	0.01
Cl%	0.59	0.61			ns	9.3	0.01
B(ppm)	8.58	8.73			ns	14.4	0.31
	EFB0	EFB1					
N%	2.14	2.21			ns	9.2	0.05
P%	0.134	0.137			*	4.3	0.001
K%	0.84	0.91			**	8.3	0.02
Ca%	0.73	0.69			ns	9.5	0.02
Mg%	0.33	0.32			ns	16.6	0.01
Cl%	0.60	0.61			ns	9.3	0.01
B(ppm)	8.77	8.54			ns	14.4	0.31

Table 2.66 Main effects of N, P, K, and EFB on the concentration of elements in the rachis of frond 17 in 1997 (Trial 511).

	Level of nutrient Element or EFB				sig.	cv%	Statistics sed.
	N0	N1	N2	N3			
N%	0.24	0.24	0.24	0.25	ns	8.1	0.007
P%	0.078	0.058	0.049	0.047	***	13.3	0.002
K%	1.55	1.52	1.44	1.45	ns	8.5	0.04
Ca%	0.29	0.28	0.26	0.26	ns	11.7	0.01
Mg%	0.11	0.09	0.08	0.08	***	14.3	0.005
Cl%	1.02	0.86	0.67	0.76	***	6.5	0.02
B(ppm)	4.63	4.71	4.63	4.75	ns	11.1	0.18
	K0	K1	K2	K3			
N%	0.25	0.24	0.24	0.24	ns	8.1	0.007
P%	0.057	0.057	0.057	0.060	ns	13.3	0.002
K%	1.29	1.50	1.56	1.62	***	8.5	0.04
Ca%	0.26	0.28	0.27	0.28	ns	11.7	0.01
Mg%	0.09	0.10	0.09	0.09	ns	14.3	0.005
Cl%	0.62	0.87	0.86	0.96	***	6.5	0.02
B(ppm)	4.79	4.56	4.68	4.71	ns	11.1	0.18
	P0	P1					
N%	0.24	0.24			ns	8.1	0.005
P%	0.042	0.074			***	13.3	0.002
K%	1.53	1.45			ns	8.5	0.03
Ca%	0.27	0.27			ns	11.7	0.01
Mg%	0.09	0.09			ns	14.3	0.003
Cl%	0.88	0.78			***	6.5	0.01
B(ppm)	4.77	4.60			ns	11.1	0.13
	EFB0	EFB1					
N%	0.24	0.24			ns	8.1	0.005
P%	0.051	0.065			***	13.3	0.002
K%	1.44	1.54			**	8.5	0.03
Ca%	0.28	0.26			*	11.7	0.01
Mg%	0.10	0.09			ns	14.3	0.003
Cl%	0.86	0.79			**	6.5	0.01
B(ppm)	4.66	4.70			ns	11.1	0.13

3. SOLOMON ISLANDS AGRONOMY

(A. Oliver)

3.1 INTRODUCTION

Following a successful application for PNGOPRA Membership by the Solomon Islands Plantations Limited (SIPL), PNGOPRA assumed responsibility for research and specified agricultural technical services work for SIPL in August of 1998. In this report two Agronomy trials that commenced recording in 1996, are presented for the first time. The trials were inherited from the previous Technical Services Department within the Field Division of SIPL. It is therefore not possible to report on field activities in 1997.

A major part of the previous Technical Services Department was to carry out regular six monthly *Ganoderma* surveys in the plantation. This will continue under OPRA, and specific fields with high incidence of *Ganoderma* will be surveyed every three months, followed by the implementation of the field control strategy.

3.1.1 Staff

A total staff of 13 will be seconded to OPRA. These consisting of 11 Recorders, 1 Senior Field Supervisor, Mr Paul Awaikera and 1 Office Supervisor, Mrs. Helen Kasile.

3.1.2 Trial Management

Analyses of the fertiliser trials were completed in September 1998. Both trials were managed well under SIPL.

3.1.3 Leaf Sampling

Tissue sampling of the plantation leaf-sampling units (LSUs) was completed in April 1997. The fertiliser trials were sampled from selected plots only. It is our intention to sample all plots commencing 1999.

3.2 AGRONOMY TRIALS

Trial 701 NITROGEN AND POTASSIUM FACTORIAL TRIAL AT NGALIMBIU DIVISION.

PURPOSE

To investigate the response of oil palm to application of nitrogen and potassium fertilisers.

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 1996.

DESIGN

There are 48 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.

The 48 plots are divided into three replicates each containing 16 treatments made up from all factorial 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 in Trial 701 in 1997

Type of fertiliser	Amount (kg/palm/year)			
	Level 0	Level 1	Level 2	Level 3
Sulphate of ammonia	0.0	2.0	4.0	6.0
Muriate of potash	0.0	2.0	4.0	6.0

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

RESULTS

Yield data for 1997 and 1996-1997 are presented in Tables 3.2 and 3.3.

There were no responses to either sulphate of ammonia or muriate of potash application. Yields in the trial were high in 1997, mostly above 30t/ha.

Table 3.2 Main effects of N and K on FFB yield and yield components in 1997 (Trial 701).

		Level of nutrient Elements					sig	Statistics cv%	sed
		N0	N1	N2	N3				
Yield (t/ha/yr)	30.9	32.9	31.9	31.0		ns	12.5	1.62	
Bunches/ha	1525	1484	1512	1513		ns	12.6	77	
Bunch weight (kg)	20.4	22.5	21.1	20.6		ns	11.4	0.98	
		K0	K1	K2	K3				
Yield (t/ha/yr)	31.6	31.9	32.0	31.2		ns	12.5	1.62	
Bunches/ha	1458	1529	1563	1485		ns	12.6	77	
Bunch weight (kg)	22.0	21.0	20.5	21.0		ns	11.4	0.98	

Table 3.3 Effect of combinations of N and K on FFB yield in 1997 (Trial 701).

	FFB Yield (t/ha/yr) Level of N			
Level of K	N0	N1	N2	N3
K0	32.0	31.9	31.2	31.3
K1	31.8	33.2	32.3	30.4
K2	31.3	33.0	32.0	31.8
K3	28.6	33.6	32.1	30.4

Grand Mean: 31.7 Standard Error: NxK=3.24

Treatment interactions were not statistically significant.

Table 3.4 Main effects of N and K on FFB yield and yield components in 1996 – 1997 (Trial 701).

		Level of nutrient Elements					Statistics sig	cv%	sed
		N0	N1	N2	N3				
Yield (t/ha/yr)	20.8	21.1	21.0	20.9		ns	8.5	0.73	
Bunches/ha	1080	1019	1035	1070		ns	8.2	35	
Bunch weight (kg)	19.3	21.0	20.3	19.6		ns	9.1	0.74	
		K0	K1	K2	K3				
Yield (t/ha/yr)	20.6	20.8	21.4	21.0		ns	8.5	0.73	
Bunches/ha	1007	1056	1087	1054		ns	8.2	35	
Bunch weight (kg)	20.7	19.8	19.8	20.0		ns	9.1	0.74	

Table 3.5 Effects of combinations of N and K on FFB yield in 1996-1997 (Trial 701).

	FFB Yield (t/ha/yr)			
		Level of N		
Level of K	N0	N1	N2	N3
K0	20.5	19.9	20.9	21.2
K1	21.7	21.3	20.1	20.0
K2	21.3	22.1	21.0	21.2
K3	19.5	21.3	22.1	21.1

Grand mean = 21.0 Standard error NxK=1.46

Treatment interactions were not statistically significant.

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

PURPOSE

To investigate the response of oil palm to N, P and K fertiliser application.

DESCRIPTION

Site: Mbalasuna Division, Block 70.

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

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

DESIGN

There are 54 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.

The 54 plots are divided into two replicates each containing 27 treatments made up from all factorial combinations of three levels each of N, P and K (Table 3.6). Sulphate of ammonia (SoA) is the source of N, Triple Superphosphate (TSP) is the source of P and muriate of potash (MoP) is the source of K.

Table 3.6 Amounts of fertiliser applied in Trial 702 in 1997.

Type of fertiliser	Amount (kg/palm/year)		
	Level 0	Level 1	Level 2
Sulphate of ammonia	0.0	2.0	4.0
Triple Superphosphate	0.0	2.0	4.0
Muriate of potash	0.0	2.0	4.0

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

RESULTS

Yield data for 1997 and 1996-1997 are presented in Tables 3.7 and 3.8.

There were significant yield responses to sulphate of ammonia application, which increase FFB yield and single bunch weight.

A maximum FFB yield of 19 tons is obtained with 4 kg of SoA and 2 kg of MoP.

Table 3.7 Main effects of N, P and K on FFB yield and yield components in 1997 (Trial 702).

		Level of nutrient Elements				Statistics sig	cv%	sed
		N0	N1	N2				
Yield (t/ha/yr)	14.5	18.1	18.0		*	27.9	1.56	
Bunches/ha	1089	1299	1258		ns	25.7	104	
Bunch weight (kg)	13.1	14.0	14.6		*	12.9	0.60	
		P0	P1	P2				
Yield (t/ha/yr)	16.6	16.4	17.6		ns	27.9	1.56	
Bunches/ha	1247	1193	1205		ns	25.7	104	
Bunch weight (kg)	13.2	14.0	14.5		(ns)	12.9	0.60	
		K0	K1	K2				
Yield (t/ha/yr)	16.2	17.2	17.1		ns	27.9	1.56	
Bunches/ha	1175	1225	1247		ns	25.7	104	
Bunch weight (kg)	13.8	13.9	13.9		ns	12.9	0.60	

Table 3.8 Effect of combinations of N and K on FFB yield in 1997 (Trial 702).

FFB Yield (t/ha/yr)

Level of K	N0	Level of N N1	N2
K0	14.4	17.9	16.5
K1	13.5	18.0	19.9
K2	15.4	18.4	17.5

Grand Mean: 16.8 Standard Error: NxK=2.71

Treatment interactions were not statistically significant.

Table 3.9 Main effects of N, P and K on FFB yield and yield components in 1996 – 1997 (Trial 702).

		Level of nutrient Elements				Statistics sig	cv%	sed
		N0	N1	N2				
Yield (t/ha/yr)	10.2	11.9	12.2		*	21.4	0.82	
Bunches/ha	873	968	974		ns	16.5	51	
Bunch weight (kg)	19.3	21.0	20.3		ns	9.1	0.74	
		P0	P1	P2				
Yield (t/ha/yr)	11.0	11.3	12.0		ns	21.4	0.82	
Bunches/ha	926	939	951		ns	16.5	51	
Bunch weight (kg)	19.3	21.0	20.3		ns	9.1	0.74	
		K0	K1	K2				
Yield (t/ha/yr)	11.1	11.6	11.6		ns	21.4	0.82	
Bunches/ha	913	937	965		ns	16.5	51	
Bunch weight (kg)	20.7	19.8	19.8		ns	9.1	0.74	

Table 3.10 Effects of combinations of N, P and K on FFB yield in 1996-1997 (Trial 702).

FFB Yield (t/ha/yr)

Level of K	N0	Level of N N1	N2
K0	10.5	11.8	11.2
K1	9.6	11.9	13.1
K2	10.6	12.1	12.2

Grand mean = 11.4 Standard error NxK=1.42

Treatment Interactions were not statistically significant.

4. SMALLHOLDER DEMONSTRATION TRIALS.

PNG ISLANDS REGION

(G. King, J. Yambun, D. Piskot)

Trial 128 BENCHMARK/DEMONSTRATION OF RECOMMENDED MANAGEMENT AND FERTILISER APPLICATION ON OIL PALM SMALLHOLDINGS IN THE HOSKINS SCHEME.

PURPOSE

To determine if there is a requirement for fertiliser input and if so determine the type of fertiliser required. To demonstrate that good agronomic management and correct use of fertilisers can increase or maintain relatively high levels of FFB production.

DESCRIPTION

Site Experiment 128 is located on OPIC=s Hoskins Smallholder Oil Palm. The 28 blocks selected in pairs are located at Sarakolok, Tamba, Kapore, Kavui, Buvussi, Mai, Kwalakesi, Gule and Kavutu. At Kavui and Buvusi there are 2 and 3 pairs respectively. Details of each block are given in Table 58.

Palms Dami commercial DxP planting material.

Planted in various dates between 1972 and 1990 at 120 palms/ha.

Treatments started in July 1994.

DESIGN

Each of the 2 paired smallholder blocks provides a single replicate. There are three treatments (Table 4.1). With the first pair, half of the block will receive no fertiliser at all (control - RED) and the remaining receives half the recommended (demonstration - YELLOW) type and amount of fertiliser for the smallholder. With the second pair, half of the block will again receive no fertiliser at all (control - RED), and the remaining half will receive a generous amount (2kg) of all main types (N, P, K, MG - WHITE) of fertiliser.

Table 4.1 Treatments used in Trial 128.

	Type of Fertiliser (kg/palm/year)			
Treatment Colour Code	Ammonium Chloride	Triple Superphosphate	Muriate of Potash	Kieserite
Red	0	0	0	0
Yellow	2	0	0	0
White	2	2	2	2

Fertiliser is applied twice a year in May and November. The whole block is harvested in the normal way by the block owner but the bunches from each treatment are put in separate nets and the weight of the nets from each colour code are recorded on the docket at the time of pick up. The OPRA recorders count the number of bunch stalks cut from each treatment. Trenches are dug between the two-fertiliser treatments to minimise fertiliser poaching by palms in the untreated blocks. Frond 17 leaflet and rachis samples were taken for analysis in 1997.

Table 4.2 Details of 28 smallholder demonstration blocks in the Hoskins Smallholder Oil Palm Project areas of West New Britain Province in 1995.

Division	Sect	Owner	Block Number	Number of Palms		
				Red	Yellow	White
Kapore	3	H.T. Towakaken	010306	226	227	
Kapore	3	Joseph Pochei	010307	97		93
Tamba	2	A.T.T. Taul	20413	206	365	
Tamba	2	Hambakman	20414	250		240
Tamba	9	Usini Embi	20555	235		197
Tamba	9	Esther Sakius	20556	199	308	
Sarakolok	5	Gima Bagera	30922	268	153	
Sarakolok	5	M. Hendry	30923	268		273
Buvussi	6	Gumagoi Dogoba	41160	250		227
Buvussi	6	Dombul Dekemba	41161	233	345	
Buvussi	5	Wamenvok Holbini	41193	376	332	
Buvussi	5	Vincent Kalaivi	41194	414		326
Buvussi	1	Simon Oleiuba	41399	341	353	
Buvussi	1	Wai Aure	41418	238		566
Kavui	5	K. Tobubu	61682	221		257
Kavui	5	T. Tamaia	61681	188	192	
Kavui	8	Madau Tonatonok	61701	343	382	
Kavui	8	T. Todaungu	61702	358		344
Kwalakesi	VOP	Uba Kilu	130002	234	185	
Kwalakesi	VOP	Dominica Kaipu	130012	121		100
Mai	VOP	Kulu Kuba	140019	120	112	
Mai	VOP	Kenda Tavaperry	140091	130		106
Kavutu	VOP	Peter Magiap	330012	120		111
Kavutu	VOP	Misibil Irima	330037	109	122	
Gule	VOP	Timothy Tobubu	020007	135	86	
Gule	VOP	Mesunam Malalia	020008	118		123

The yield recording system for the trial blocks collapsed during 1997. All of the block owners decided to apply their own fertiliser and consequently lost interest in separating bunches from the two halves of the trial. Also the system where fruit truck drivers recorded colour codes on the field dockets could not be enforced. Reported yields given in the following table are much lower than actual yields as for most of the latter part of the year the yield recording system was not functioning.

RESULTS

Table 4.3 Yield results for Trial 128 in 1997.

Division	Sect	Block No.	No months harvesting recorded	Recorded Yield (t/ha/yr)		
				Control	N only	NPKMg
Kapore	3	10306	10	10.8	12.1	
Kapore	3	10307	9	16.9		18.6
Tamba	2	20413	6	17.4	12.1	
Tamba	2	20414	7	10.7		13.9
Tamba	5	20555	8	7.2		6.4
Tamba	5	20556	9	8.5	10.1	
Sarakolok	5	30922	0			
Sarakolok	5	30923	8	7.6		12.4
Buvussi	5	41193	7	4.5	16.4	
Buvussi	5	41194		8.3		10.6
Buvussi	1	41399		8.1	10.5	
Buvussi	1	41418	3	7.6		13.5
Buvussi	6	41160	0			
Buvussi	6	41161	8	9.5	15.3	
Kavui	5	61681		25.6	12.4	
Kavui	5	61682		20.8		43.3
Kavui	8	61701		7.3	8.9	
Kavui	8	61702		9.4		10.5
Mai	VOP	140019	7	13.2		12.6
Mai	VOP	140091	5	12.5	12.9	
Kwalakesi	VOP	130002		5.4		17.3
Kwalakesi	VOP	130012		8.3	6.2	
Kavutu	VOP	330012		4.3		10.4
Kavutu	VOP	330037		18.5	20.9	
Gule	VOP	020007	0			
Gule	VOP	020008	0			
			Mean			
			Maximum			
			Minimum			
			s.e.			

The results of this trial have shown that there is a positive response to fertiliser and that the trials have been excellent demonstrations of the effect of fertiliser. However, they have not proven to be particularly useful for the development of more appropriate fertiliser recommendations. The results suggest that the NPKMg treatment is better than the N only treatment. However, it is not possible to determine which of the other nutrients is contributing to the increase in yield.

Leaf and rachis samples were taken from all the trial blocks in 1997. The summary statistics of this analysis are given in Table 4.4. This summary shows that although leaflet N has increased with the addition of fertiliser levels are still well below optimum. Even the highest leaflet N level recorded is below optimum. Leaflet P increased with the addition of ammonium chloride but leaflet K and Mg decreased. Leaflet chlorine levels increased dramatically as a result of chloride containing fertiliser. Rachis K decreased with ammonium chloride application but increased in the complete treatment. The minimum rachis K levels are very low suggesting that K is limiting at some sites.

Table 4.4 Descriptive statistics of leaflet and rachis nutrient concentrations (% on dry matter) from Trial 128 in 1996.

Nutrient	Treatment	Mean	Minimum	Maximum	Std Error
Leaflet N	Control	1.94	1.63	2.26	0.042
	N only	2.04	1.73	2.20	0.05
	N,P,K,Mg	2.08	1.71	2.35	0.061
Leaflet P	Control	0.129	0.116	0.141	0.0017
	N only	0.133	0.123	0.139	0.0019
	N,P,K,Mg	0.138	0.131	0.144	0.0012
Leaflet K	Control	0.77	0.67	0.93	0.017
	N only	0.70	0.59	0.81	0.024
	N,P,K,Mg	0.70	0.59	0.83	0.024
Leaflet Ca	Control	0.82	0.66	0.95	0.021
	N only	0.94	0.73	1.06	0.036
	N,P,K,Mg	0.91	0.72	1.08	0.033
Leaflet Mg	Control	0.18	0.14	0.25	0.007
	N only	0.15	0.09	0.23	0.016
	N,P,K,Mg	0.16	0.13	0.21	0.009
Leaflet Cl	Control	0.30	0.14	0.55	0.025
	N only	0.51	0.33	0.72	0.036
	N,P,K,Mg	0.54	0.44	0.75	0.032
Rachis N	Control	0.22	0.19	0.27	0.004
	N only	0.22	0.20	0.27	0.007
	N,P,K,Mg	0.22	0.19	0.25	0.006
Rachis P	Control	0.078	0.032	0.139	0.008
	N only	0.061	0.036	0.116	0.010
	N,P,K,Mg	0.074	0.036	0.140	0.009
Rachis K	Control	1.37	0.95	1.67	0.050
	N only	1.27	1.07	1.57	0.054
	N,P,K,Mg	1.45	0.93	1.98	0.102
Rachis Ca	Control	0.36	0.29	0.64	0.018
	N only	0.48	0.35	0.59	0.028
	N,P,K,Mg	0.43	0.28	0.51	0.023
Rachis Mg	Control	0.04	0.03	0.06	0.002
	N only	0.04	0.03	0.06	0.003
	N,P,K,Mg	0.04	0.03	0.05	0.002
Rachis Cl	Control	0.24	0.04	0.81	0.048
	N only	0.50	0.27	0.91	0.059
	N,P,K,Mg	0.54	0.08	0.81	0.067

Trial 210 BENCHMARK/DEMONSTRATION OF RECOMMENDED MANAGEMENT AND FERTILISER APPLICATION ON OIL PALM SMALLHOLDINGS IN THE BIALLA SCHEME

PURPOSE

To determine if there is a requirement for fertiliser input and if so determine the type of fertiliser required. To demonstrate that good agronomic management and correct use of fertilisers can increase or maintain relatively high levels of FFB production.

DESCRIPTION

Site. Experiment 210 is located on OPIC=s Bialla Smallholder Oil Palm Project covering areas between Bereme and NBPOL's Kapiura Plantations Pty Ltd in the west to Noau and Hargy's Navo Plantation east of Bialla township. Details of the 23 selected blocks are given in Table 63.

Palms. Dami commercial DxP planting material.

Planted in various dates the between 1984 and 1991 at 120 palms/ha.

Treatments started in July 1994.

DESIGN

Each of the 2 paired smallholder blocks provide a single replicate. There are three treatments (Table 4.5). With the first pair, half of the block will receive no fertiliser at all (control - RED) and the remaining half receive the recommended (demonstration - YELLOW) type and amount of fertiliser for the smallholder. With the second pair, half of the block will again receive no fertiliser at all (control - RED), and the remaining half will receive generous amounts (2kg) of all main types (N, P, K, MG - WHITE) of fertiliser.

Table 4.5 Treatments used in Trial 210.

	Type of Fertiliser (kg/palm/year)			
Treatment Colour Code	Ammonium Chloride	Triple Superphosphate	Muriate of Potash	Kieserite
Red	0	0	0	0
Yellow	2	0	0	0
White	2	2	2	2

Fertiliser is applied twice a year in May and November. The whole block is harvested in the normal way for a smallholder block and the weight of the fruit recorded by the transport company in each project at the time of pick up. Trenches are dug between the two-fertiliser treatments to minimise fertiliser poaching by palms in the untreated blocks. Frond 17 leaflet and rachis samples were taken for analysis in 1997.

New demonstration blocks were established at Lalopo, Kiava and Balima in 1996 and fertiliser was first applied in 1997. No yield data is reported for 1997, as yield data collection did not commence until after the fertiliser was applied.

The second block in Soi was abandoned as a trial block in 1997 due to poor harvesting standards.

Table 4.6 Details of 28 smallholder demonstration blocks in the Bialla Smallholder Oil Palm Project areas of West New Britain Province in 1995.

Division	Sect	Owner	Block Number	Number of Palms		
				Red	Yellow	White
Bereme	VOP	Leo Lusi	254-04	79		96
Bereme	VOP	Mathais Avu	254-09	126	94	
Lavege	VOP	Emmanuel Moli	251-33	119		85
Lavege	VOP	Albert Vua	251-30	117	114	
Mamota	LSS	Maria Soima	240-0912-8	214		247
Mamota	LSS	Thomas Tingairo	240-0921-8	220	256	
Tarobi	VOP	Francis Lowa	257-023	110		146
Tarobi	VOP	Alphonse Tovili	257-07	108	121	
Lalopo	LSS	Anna Joram	1129			
Lalopo	LSS	Peni Lagoa	1108			
Kiava	VOP	Monais Taba	1122	116		133
Kiava	VOP	Laili Taga	1123	131	132	
Balima	LSS	Benedict Ikinaka	1273	241		262
Balima	LSS	Augustus Eremas	1274	259	247	
Noau	VOP	Enoch Volele	0723	108		129
Noau	VOP	P. Malila	0714	116	116	
Soi	10	Raphael Moute	1653	125		126
Matililiu	VOP	Raiman Vilale	1705	266		267
Matililiu	VOP	Mauli Vilale	1707	114	115	
		Bialla High School	13	99	120	120

RESULTS

1997 yield results for Trial 210 are given in Table 4.7.

Table 4.7 Yield results for Trial 210 in 1997.

Division	Sect	Block No.	No months harvesting recorded	Calculated Yield (t/ha/yr)		
				Control	N only	NPKMg
Bereme	VOP	254-04	4	5.7		3.5
Bereme	VOP	254-09	3	4.8	8.8	
Lavege	VOP	251-33	5	28.0		42.4
Lavege	VOP	251-30	4	14.9	6.5	
Mamota	LSS	240-0912-8	6	16.7		21.1
Mamota	LSS	240-0921-8	6	21.2	21.6	
Tarobi	VOP	257-023	7	23.9		25.7
Tarobi	VOP	257-07	7	15.3	13.3	
Noau	VOP	0723	12	18.7		16.9
Noau	VOP	0714	12	12.5	14.5	
Soi	10	1653	3	15.8		19.5
Matililiu	VOP	1705	11	18.1	20.9	
Matililiu	VOP	1707	11	25.3		28.5
Bialla H.S.		13	10	11.3	30.2	16.1
			Mean	16.6	16.5	21.7
			Maximum	28.0	30.2	42.4
			Minimum	4.8	6.5	3.5
			s.e.	1.81	3.11	3.97

As with Trial 128 it has proven to be very difficult to ensure that the fruit truck drivers record the colour coding of the nets on the delivery docket. The calculated yield figures given above should therefore be treated with some caution. They do however, show that yields increase with addition of nitrogen as well as phosphorus, potassium and magnesium.

Tissue sampling was completed in October 1997 and the results are given in the Table 4.8. These results show that leaflet N increased with application of ammonium chloride but levels are still well below optimum. Leaflet P increased with the addition of TSP. Leaflet K and Mg decreased with the addition of ammonium chloride. Leaflet chlorine increased with the addition of chloride.

Rachis K increased with the addition of ammonium chloride and with muriate of potash. Rachis chlorine increased with the addition of chloride.

Table 4.8 Descriptive statistics of leaflet and rachis nutrient concentrations (% on dry matter) from Trial 210 in 1996.

Nutrient	Treatment	Mean	Minimum	Maximum	Std Error
Leaflet N	Control	2.13	1.64	2.45	0.072
	N only	2.23	2.03	2.39	0.060
	N,P,K,Mg	2.24	1.97	2.42	0.080
Leaflet P	Control	0.143	0.127	0.163	0.003
	N only	0.147	0.132	0.165	0.006
	N,P,K,Mg	0.152	0.136	0.163	0.005
Leaflet K	Control	0.87	0.57	1.12	0.041
	N only	0.78	0.59	0.87	0.044
	N,P,K,Mg	0.79	0.67	0.95	0.045
Leaflet Ca	Control	0.99	0.71	1.23	0.039
	N only	1.08	1.01	1.17	0.024
	N,P,K,Mg	1.04	0.91	1.16	0.036
Leaflet Mg	Control	0.21	0.13	0.30	0.018
	N only	0.19	0.15	0.28	0.019
	N,P,K,Mg	0.20	0.14	0.27	0.019
Leaflet Cl	Control	0.37	0.12	0.69	0.061
	N only	0.62	0.50	0.74	0.039
	N,P,K,Mg	0.66	0.55	0.83	0.043
Rachis N	Control	0.24	0.21	0.31	0.009
	N only	0.24	0.20	0.29	0.013
	N,P,K,Mg	0.26	0.23	0.30	0.010
Rachis P	Control	0.048	0.029	0.096	0.006
	N only	0.058	0.031	0.115	0.015
	N,P,K,Mg	0.063	0.040	0.082	0.006
Rachis K	Control	1.14	0.67	1.57	0.076
	N only	1.24	0.81	1.67	0.136
	N,P,K,Mg	1.36	0.99	1.77	0.108
Rachis Ca	Control	0.40	0.24	0.67	0.033
	N only	0.47	0.36	0.59	0.033
	N,P,K,Mg	0.47	0.40	0.64	0.036
Rachis Mg	Control	0.05	0.03	0.13	0.009
	N only	0.06	0.04	0.14	0.015
	N,P,K,Mg	0.06	0.04	0.08	0.007
Rachis Cl	Control	0.21	0.04	0.76	0.061
	N only	0.50	0.07	1.07	0.149
	N,P,K,Mg	0.66	0.36	0.80	0.073

Trial 253: BENCHMARK/DEMONSTRATION OF RECOMMENDED MANAGEMENT AND FERTILISER PRACTICES ON OIL PALM SMALLHOLDINGS IN THE NEW IRELAND SCHEME.

PURPOSE

To carry out basic investigations into requirement for fertiliser input in smallholdings and if so determine the type of fertiliser required. This is a missing element trial on village oil palm.

DESCRIPTION

Sites: Experiment 253 is located on OPIC=s New Ireland Smallholder Oil Palm The two blocks in which the trials have been established are located at Lossu at South village oil palm (VOP), and Paruai in the North VOP area. Both these blocks are on the east coast of New Ireland.

Palms: Dami commercial DxP crosses.

Planted in 1992/93.

DESIGN

Each smallholder block provides a single replicate consisting of 2 hectares. Within this 2 ha there are 6 different treatments in 6 plots (Table 4.9). The fertiliser types and rates used are given in Table 4.10.

Table 4.9 Fertiliser types used in Trial 253.

Fertiliser type	Plot No	Treatment
AS + TSP + MOP + KIE	1	Complete: N+P+K+Mg
TSP + MOP + KIE	2	Complete minus N
AS + MOP + KIE	3	Complete minus P
AS + TSP + KIE	4	Complete minus K
AS + TSP + MOP	5	Complete minus Mg
NIL	6	NIL

AS = ammonium sulphate,
TSP = triple superphosphate,
MOP = muriate of potash,
KIE = kieserite

Table 4.10 Rates of fertiliser applied in Trial 253.

Treatment	Amount of fertiliser (kg/palm/yr)			
	Ammonium Sulphate	Triple Superphosphate	Muriate of Potash	Kieserite
1	2	2	2	2
2	0	2	2	2
3	2	0	2	2
4	2	2	0	2
5	2	2	2	0
6	0	0	0	0

Fertiliser application currently follows plantation (Poliamba Pty Ltd) practice. The whole block is harvested in the normal way for a smallholder block and the weight of the fruit is recorded by OPRA. Leaflets and rachis of frond 17 were not sampled in 1997 due to the effect of the drought and fire.

RESULTS

The palms at Lossu started bearing fruit in 1996 and 1997 was the first full year of yield recording. The grower at Lossu harvested his fruit regularly throughout 1997. The block at Paruai was not harvested regularly and yields have not been recorded.

The drought in 1997 severely effected both blocks particularly at Paruai. Fire damage was severe at Paruai and this block has been abandoned as a trial. The Lossu block was partially burnt but recovered well following rain in December 1997.

Yield results from the block at Lossu are given in Table 4.11 below showing that the highest yield was recorded in the plot receiving nitrogen, phosphorus and potassium. It appears that the addition of magnesium is adversely effecting yield.

Table 4.11 Yield results at Lossu in 1997

Treatment	Yield (t/ha)	Bunch No/Ha	Bunch Wt (kg)
Complete	11.0	2010	5.46
Minus N	11.4	1686	6.75
Minus P	7.9	1470	5.39
Minus K	6.8	1644	4.16
Minus Mg	12.6	2592	4.88
Nil	3.3	630	5.16

Due to the effect of the drought and fire leaf and rachis samples were not taken for analysis in 1997.

5. ENTOMOLOGY RESEARCH

(R.W. Caudwell and T. Solulu)

ISLANDS PEST REPORT

1. Sexava (Orthoptera: Tettigonniidae)

Segestes decoratus Redtenbacher and *Segestidea defoliaria* Uvarov are the principal insect pests of oil palm in West New Britain Province. Control of these insects currently involves the use of trunk-injected monocrotophos and the release of hymenopteran egg parasitoids.

The areas of West New Britain that required chemical treatment for economically significant levels of Sexava damage during 1997 are shown in Table 5.1. From the table it can be seen that there were 6 outbreaks spread throughout the year, and that the total area treated was approximately 215 ha. This represents about 0.50% of the total oil palm growing area in West New Britain Province. The insecticide costs for the treatment were approximately 13, 819 Kina. During 1996 approximately 910 ha were treated for Sexava damage at a cost of 42, 330 Kina.

It is apparent that the Sexava situation in West New Britain was very quiet during 1997. This relatively low level of damage was probably due to: (1) the very low rainfall during the year, and pronounced dry spell from April to November; (2) the timely release of egg parasitoids; and (3) a robust and efficient monitoring system for the pest. We have an on-going training programme in entomology for plantation workers, OPIC extension officers and smallholder growers. This has resulted in an improved awareness of insect pests, and consequently Sexava outbreaks are now being reported well before they reach economic levels.

The mass rearing and release of Sexava egg parasitoids (*Leefmansia bicolor* and *Doirania leefmansia*) continued at Dami and Hargy throughout 1997. Table 5.2 gives details of the number of parasitoids reared for biocontrol and the areas where they were released. From the table it can be seen that we released a total of 8110 parasitized eggs in West New Britain during 1997. From these eggs we would expect approximately 701,300 parasitoids to emerge. During 1996 we released a total of approximately 1, 969,260 parasitoids. The low rainfall during 1997 meant that we found it difficult to find sufficient Sexava for our breeding cultures. This made breeding the parasitoids very difficult, hence the relatively low numbers that were reared and released. The releases into coconut areas in Cape Gloucester were done at the request of the Provincial D.A.L. in Kimbe.

Our EU-funded Sexava research programme continued throughout 1997. Our progress during the year is documented in the research reports.

Our integrated pest management system for Sexava is illustrated in Figure 5.1.

Figure 5.1. Strategies for Sexava IPM .

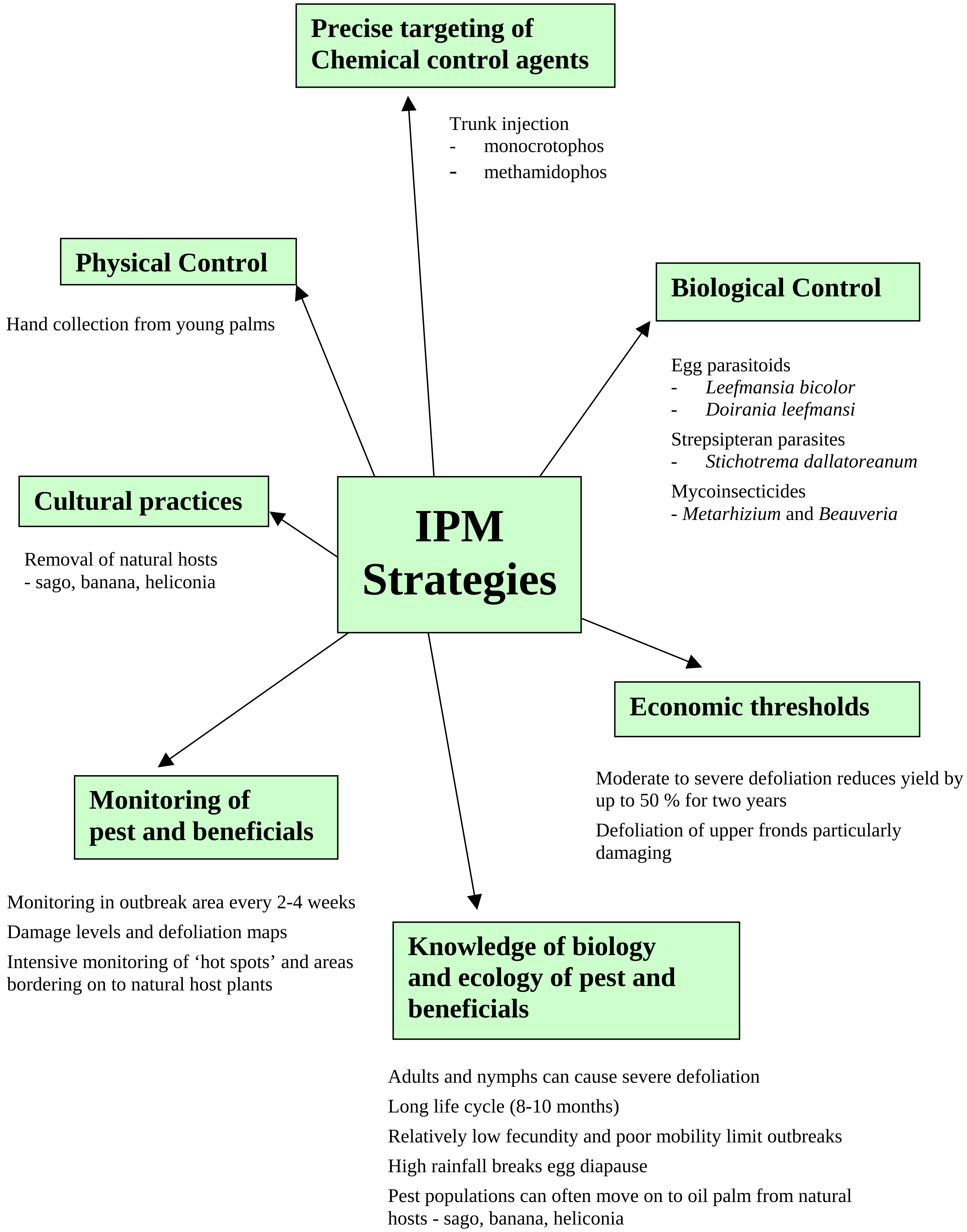


Table 5.1 The oil palm growing areas in West New Britain that required chemical treatment for economically significant levels of Sexava damage in 1997.

Date	Plantation/ Smallholders	Site	Approx Area (ha)	Volume of formulation (l)
7-Mar	Hargy Oil Palms	Area 12	120	300
18-Apr	Hoskins Smallholders	Karapi VOP	24	60
11-Jul	NBPOL Kapiura	Bilomi	45	112.5
3-Sep	Salalubu Smallholders	Silanga	12	30
30-Sep	Salalubu Smallholders	Uasilau	4	10
25-Nov	NBPOL Kapiura	Kautu	10	25
		TOTAL	215	537.5
% WNBP oil palm growing area treated				0.50%
Insecticide costs - Nuvacron/Azodrin K25.71/l				13,819 Kina

Table 5.2 The Oil palm growing areas in West New Britain in which Sexava egg parasitoids were released during 1997.

	Number of parasitised eggs		**Number of adult parasitoids**	
Location	***L. bicolor***	***D. leefmansia***	***L. bicolor***	***D. leefmansia***
Bebere Plantation	550	440	11,000	88,000
Dami Research Station	1,320	550	26,400	110,000
Kumbango Plantation	450	330	9,000	66,000
Bilomi Plantation	340	-	6,800	-
Kapore sub-division	440	440	8,800	88,000
Sarakolok sub-division	350	220	7,000	44,000
Banaule VOP	905	785	18,100	157,000
Dire VOP	120	-	2,400	-
Silanga	120	-	2,400	-
Kavutu	120	-	2,400	-
Cape Gloucester	400	230	8,000	46,000
Total	**5,115**	**2,995**	**102,300**	**599,000**

2. Bagworms (Lepidoptera: Psychidae)

Economically significant levels of Bagworm damage occurred at Kautu and Kaurausu plantations during the early part of 1997. Rapidly increasing populations of 1st and 2nd instar caterpillars were widespread in these areas, and immediate chemical treatment was required. This was done by a single application of trunk-injected monocrotophos.

Table 5.3 gives the oil palm growing areas in West New Britain that required chemical treatment for economically significant levels of Bagworm damage during 1997. From the table it can be seen that approximately 340 hectares at Kautu and Kaurausu required chemical treatment. This compares with approximately 210 during the previous year.

Table 5.3 The oil palm growing areas in West New Britain that required chemical treatment for economically significant levels of Bagworm damage in 1997.

Date	Plantation/ Smallholders	Site	Approx area (ha)	Volume of Formulation (I)
11-Feb	NBPOL Kapiura	Kautu	220	275
17-Feb	NBPOL Kapiura	Kaurausu	120	150
		TOTAL	340	425
% WNBP oil palm growing area treated				0.85%
Insecticide costs - Nuvacron/Azodrin K25.71/l				10,926 Kina

The relatively high levels of Bagworm damage during 1997 was probably due to the low rainfall experienced during the year, and consequent lack of population regulation by naturally occurring biological control agents. We continued surveying in these areas throughout 1997, and found no evidence of renewed population growth.

A section of our research reports describe trials that we undertook during 1997 to determine the effect of plantation management practices on general levels of biodiversity, and on the population levels of Bagworm natural enemies.

Our integrated pest management system for Bagworms is illustrated in Figure 5.2.

Figure 5.2 Strategies for Bagworm IPM

3. Rhinoceros beetles (Coleoptera: Scarabaeidae)

There were no new outbreaks of *Oryctes rhinoceros* or *Scapanes australis* reported during 1997.

Our mass trapping and release programme for *Oryctes rhinoceros* at Numundo plantation continued for the early part of 1997. This involved the use of pheromone traps to catch adult beetles, followed by the infection of trapped adults with baculovirus, and release back into the field.

The results and a full account of this work are given in last year's annual report. Our programme seems to have been very successful, there are high levels of baculovirus in the field, and the population of *O. rhinoceros* is under good control at Numundo plantation.

We continued surveying throughout 1997, and found no evidence of renewed population growth at Numundo, and no evidence of the spreading of the beetle population into other areas.

Our integrated pest management system for *Oryctes rhinoceros* is illustrated in Figure 5.3.

4. Weevils (Coleoptera: Curculionoidea)

Two species of weevil were reported to be causing defoliation to young plantings at Haella Plantation during 1997. The damage levels were however light and very localised, and no chemical treatment was recommended. The outbreak was probably caused by a temporary breakdown in natural control following the clearing of food gardens for oil palm development. Good cover crop was established within a couple of months of the outbreak, and there were no further problems with the weevils.

The weevils were sent to the International Institute of Entomology for identification:

1. *Lophothetes pencilliger* (Heller) (Coleoptera: Curculionidae)
2. *Rhinoscapha schmeltzi* (Fairmaire) (Coleoptera: Curculionidae)

5. Taro Beetle (Coleoptera: Scarabaedae)

Taro beetles (*Papuana huebneri* Fairmaire) were reported to be causing damage to seedlings at Garu nursery during 1997. Adult beetles were found to be boring into the base of seedlings and feeding from soft tissue just below soil level. Damage levels were however very light, with less than 1% of the seedlings showing symptoms.

Hand collection of beetles was recommended, and this was done throughout the nursery at fortnightly intervals. After two rounds of hand collection a layer of mill fibre was fitted around the base of each seedling to prevent access by the Taro beetles. The outbreak was probably caused by a temporary breakdown in natural control following the clearing of forest areas around the perimeter of the nursery, with felled logs providing breeding sites for the beetle. Hand collection was continued for 2-3 months, after which time the breeding sites were overgrown with cover crop and natural vegetation, and the Taro beetle population reduced to very low levels.

6. Screwworm (Diptera: Calliphoridae)

Wound myiasis due to screwworm strikes on cattle was reported at Numondo plantation during 1997. Adult and larval stages of the screwworm were taken to the Natural History Museum in London, UK for identification. The specimens were identified as the Old World Screwworm, *Chrysomya bezziana*. This species is native to Papua New Guinea, and is an obligate parasite in its larval stages. Female flies deposit their eggs at sites of wounding or body orifices and the emerging larvae immediately begin to feed on the host's living tissues causing myiasis, a serious condition that can be fatal if not treated.

Control of myiasis due to Old World Screwworm is possible at three levels: eradication, prevention and cure. Eradication is only possible in practise by the use of the sterile insect technique. Prevention and curative treatments rely on the application of insecticides to the sites of wounds or the use of systemics. In addition, prevention can be aided by active quarantine programmes and good husbandry practices, including regular inspection of livestock for wounds and their subsequent protection or treatment.

At Numondo control of myiasis was done using a combination of regular inspection of livestock with the application of pirimiphos-methyl (Screwworm Smear) to the sites of wounds. Workers were given basic training in the biology of the pest and its detection, and over a four month trial period we were able to reduce the number of strikes from more than 10 per 500 cows each week to less than 1 per 500 cows per week.

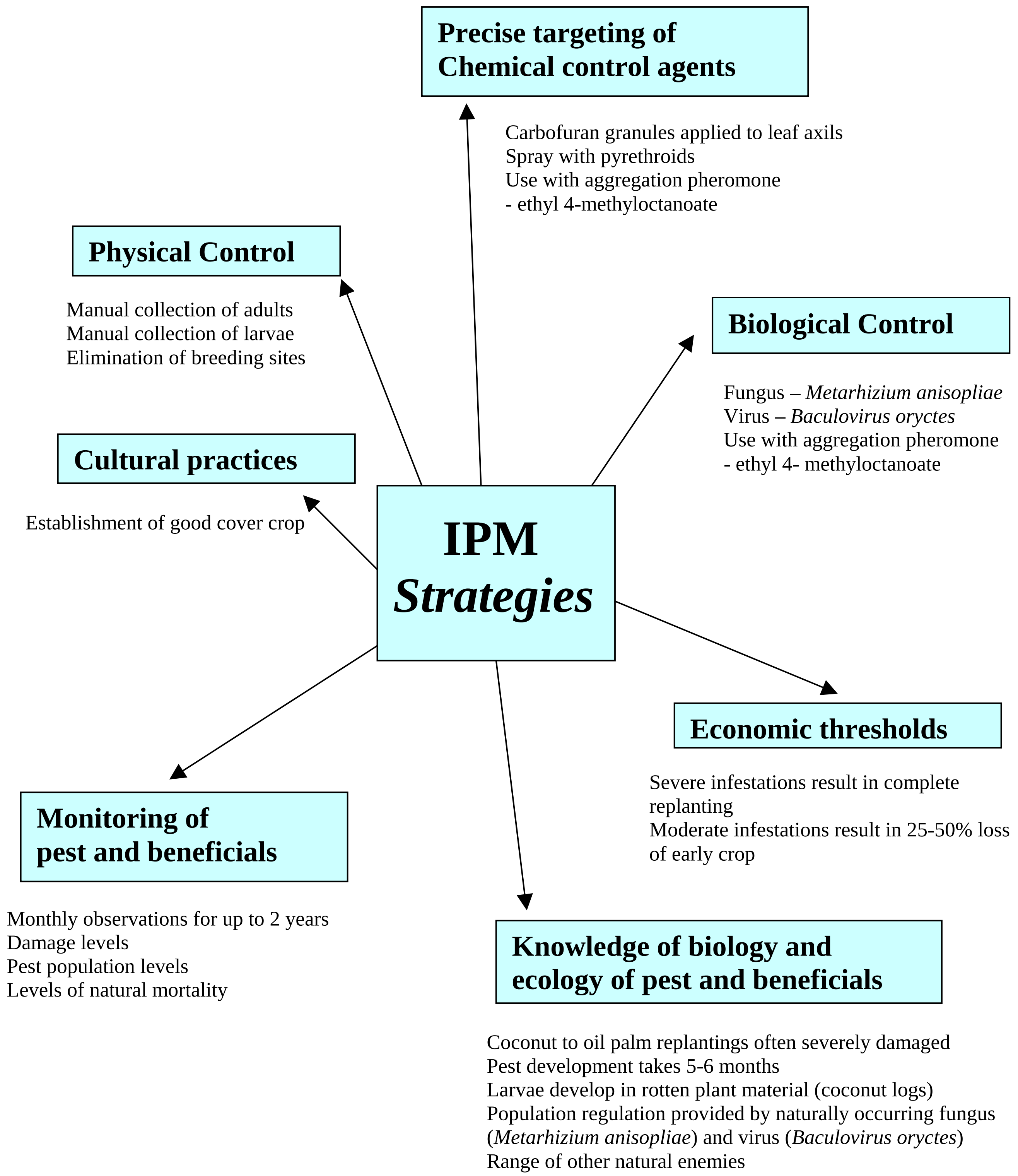
7. Leafhoppers (Hemiptera: Cicadelloidea)

Finschafen disease, caused by a small brown leahopper *Zophiuma lobulata* Ghauri, continued to spread within West New Britain Province during 1997. The disease is now present on hybrid coconuts throughout the Kimbe area, and up the Bialla highway as far as Sege and Kae.

Treatment is by targeting the leafhopper vector of the disease, using trunk-injected monocrotophos. For a number of reasons we are reluctant to recommend such treatments for subsistence coconut growing. The spread of the disease to oil palm has so far been very slow and localised, with affected palms showing very weak symptoms.

We have observed a high prevalence of naturally occurring fungal pathogens in field populations of the leafhoppers (*Metarhizium* and *Beauveria* sp). We have also been able to isolate and rear populations of hymenopteran egg parasitoids, the identity of which are yet to be established. These two biocontrol agents could form the basis of an integrated pest management system in the future should the need arise

Figure 5.3 Strategies for Rhinoceros Beetle IPM



Mainland Pest Report

1. Sexava (Orthoptera: Tettigoniidae)

Segestidea novaeguineae Brancsik is the largest species of Sexava found in PNG. It is a potential pest of oil palm in Oro Province, but has not caused any economic damage since 1983. There were no economic outbreaks of *S. novaeguineae* in Oro Province during 1997. Adequate population regulation is provide by a number of naturally occurring biological control agents, including the strepsipteran, *Stichotrema dallatorreanum*; and the dipteran, *Exorista notabilis*; as well as various predators (ants, ground beetles, centipedes) and fungal agents.

There is no record of Sexava attacking oil palm in Milne Bay Province.

2. 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.

During 1997 economic damage caused by stick insects was reported at a total of 8 smallholder blocks at Awala/Koropata subdivisions. Of these 4 blocks with moderate to severe levels of defoliation were recommended for chemical treatment, by trunk injection with monocrotophos (Nuvacron or Azodrin). The other 4 blocks had light to moderate levels of damage, and improved block hygiene was recommended for these areas.

There is no record of stick insects attacking oil palm in Milne Bay Province.

3. 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 1997, in both Milne Bay and Oro Provinces. The occurrence of field populations was sporadic and isolated, with light damage of no economic significance.

4. *Acria* moth (Xyloryctidae)

Acria moth is widespread throughout Milne Bay Estates from Giligili to Hagita, Waigani and Sagarai. During 1997 significant 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. These include a number of species of parasitic wasp, as well as several pathogens of both the larvae and pupa. Population outbreaks seem to occur during the dry season, when regulation by natural enemies seems to break down. A severe drought was experienced during 1997, and it is expected that a return to normal rain patterns will improve the population regulation of this pest. No chemical control was recommended, but regular population monitoring should be undertaken.

There is no record of *Acria* moth attacking oil palm in Oro Province.

5. Rhinoceros beetles (Coleoptera: Scarabaeidae)

The common rhinoceros beetle, *Scapanes australis*, is the only species that attacks oil palm in Milne Bay and Oro Provinces. During 1997 damage by this beetle was sporadic and infrequent, and of no economic significance.

There is no record of *Oryctes rhinoceros* attacking oil palm in Milne Bay and Oro Provinces.

6. Sugarcane weevil (Coleoptera: Curculonidae)

The sugarcane weevil, *Rhabdocelis obscurus* is widespread in PNG, and is well known to attack other crops, notably sugarcane. In oil palm it is usually associated with freshly pruned fronds, damaged areas, and rotten bunches. Recently however the weevil has been reported to be causing damage to developing oil palm bunches.

During 1997 the sugarcane weevil was reported to be damaging black bunches at Mamba Estate (Higaturu Oil Palms). The weevil larvae were found to be tunneling into both the bunch stalk and spikelets. The relatively high incidence of rotten bunches during that period (possibly due to bunch failure and/or poor pollination) probably attracted large numbers of sugarcane weevils and increased overall population levels.

7. Chafer beetles (Coleoptera: Melonothinae)

Chafer beetles are widespread throughout the oil palm growing areas of Oro Province. Population levels are usually very low, and damage levels light.

Light to moderate levels of Chafer beetle damage occurred at Embi Plantation during 1997. 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. We continue a programme of monthly population and damage monitoring.

8. Longicorn beetles (Coleoptera: Cerambycidae)

Longicorn beetles (*Mulciber* sp) were found at Embi Plantation during 1997. Damage levels were light during the year, with no treatment recommended. We are however conducting monthly monitoring of this insect.

9. Rats

Damage to oil palm by rats was reported in Milne Bay and Oro Province during 1997. Rats cause damage to seedlings in nurseries by chewing through frond bases. In mature palms they feed on fruit bunches (ripe and black bunches) and also damage male inflorescences whilst searching for larvae of the pollinating weevil.

Damage levels due to rats were very light during 1997 in both Milne Bay and Oro Provinces.

10. Giant African Snails

The introduced Giant African Snail, *Achatina fulica* feeds on leguminous covercrops in the oil palm agroecosystem.

Damage levels were however very light during 1997 in both Milne Bay and Oro Provinces.

11. Giant Sensitive Plant (GSP)

Mimosa invisa Mart, commonly known as the Giant Sensitive Plant (GSP) is widespread throughout the oil palm agroecosystem in Papua New Guinea. It is a serious weed that can hinder field operations, particularly in young plantings (3-5 years old).

During 1997 we obtained a batch of the psyllid, *Heteropsylla spinulosa* (Homoptera: Psyllidae) from Ramu Sugar Limited. This insect has been demonstrated to give good field control of GSP. It is a sap-sucking bug (2-3mm long) introduced into PNG in 1992 from Queensland, Australia. The psyllid is known to be effective in controlling *Mimosa invisa* in areas where it has been released, especially in sugarcane fields at Ramu. The adults and nymphs of the bug suck sap from leaflets, leaf stems and growing tips of the weed, thus causing distortion and deformed growth of GSP. Flowering and seed production can also be adversely effected by the feeding behaviour of the psyllid, with a reduction of 98% GSP seed production demonstrated at Ramu Sugar Limited.

We released the first batch of psyllids into clumps of GSP at Higaturu Oil Palms in 1997. Further collections and releases are planned for 1998.

Research Report 1

A study of Dipteran and Hymenopteran biodiversity associated with the oil palm agroecosystem in Papua New Guinea

Introduction

A great deal of agriculture and plantation forestry is based on the concept that ecosytems 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 reestablish the 'natural balance' of plantation ecosytems by the conservation, augmentation and introduction of natural enemies and beneficial organisms (Mariau 1991; 1993).

The role of biodiversity 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 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. 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 Bagworm natural enemies. The objective of this work was to study this in a rigorous and analytical manner, and particularly to:

1. Determine the Dipteran and Hymenopteran biodiversity associated with the oil palm agroecosystem in areas that have experienced persistent outbreaks of Bagworms.
2. Assess the impact of management practices on Dipteran and Hymenopteran biodiversity, with specific 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. This plantation was planted in 1985 from low-lying Sago swamp, and has 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 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 plots were used for the study. Each trial plot was 30 hectares in area, and each of the four separated from its nearest neighbour by at least 1km. All four of the plots had low-level bagworm populations, with light defoliation to the oil palms contained within them. None of the plots had received chemical treatment during the previous two years.

All four plots were epiphyte sprayed using Gramoxone in January 1996. Only two of the plots were subsequently epiphyte sprayed in January 1997, with 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.

Malaise traps were used to sample the Dipteran and Hymenopteran biodiversity associated with the four experimental plots over a three-month period from August to November 1997. 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 plot. 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 given in Table 5.4 and summarized in Table 5.5. Brief details of the Dipteran and Hymenopteran families that were represented in the surveys are given Table 5.7.

Table 5.5 Summary of trap-catch data for 1997.

Plot	Diptera		Hymenoptera	
	No families	No individuals	No families	No individuals
1 – sprayed	16	245	8	31
2 – not sprayed	18	256	8	25
3 – not sprayed	15	262	4	6
4 – sprayed	12	217	5	18
Total sprayed	28	462	13	49
Total not sprayed	33	518	12	31
Chi-square	0.41		0.04	
Probability	$P<0.5^{NS}$		$P<0.75^{NS}$	

Of these families the Ichneumonoidea, Braconidae, and Tachinidae are known to contain species that are Bagworm natural enemies. Table 5.6 summarizes the number of individuals from each of these families caught at plots 1-4 during the survey period.

Table 5.6 The number of individuals from the families Ichneumonoidea, Braconidae and Tachinidae caught at plots 1-4 during the survey period.

	Number of individuals from families of Bagworm natural enemies		
Plot	Ichneumonoidea	Braconidae	Tachinidae
1 – sprayed	3	12	0
2 – not sprayed	6	4	1
3 – not spayed	0	3	2
4 – sprayed	0	10	0
Total sprayed	3	22	0
Total not sprayed	6	7	3
Chi-square	1.00	7.76	3.00
Probability	$P<0.25^{NS}$	P>0.01**	$P<0.05^{NS}$

Table 5.4 Trap catch data for 1997 biodiversity trials.

Plot One (sprayed)

Diptera Family	No Individuals	Hymenoptera Family	No Individuals
Cecidomyiidae	25	Apidae	1
Ceratopogonidae	1	Chrysididae	1
Chironomidae	4	Dryinidae	1
Chironomidae	3	Braconidae	12
Dolichopodidae	99	Ichneumonidae	3
Drosphilidae	4	Sphecidae	1
Calliphoridae	1	Vespoidea	2
Muscidae	5	Formicidae	10
Mycetophilidae	15		
Micropezidae	1		
Phoridea	45		
Psychodidae	2		
Sciaridae	12		
Stratiomyidae	21		
Tipulidae	7		
Total No families	16	Total No families	8
Total No individuals	245	Total No individuals	31

Plot two (not sprayed)

Diptera Family	No Individuals	Hymenoptera Family	No Individuals
Cecidomyiidae	24	Dryinidae	2
Ceratopogonidae	3	Braconidae	4
Chironomidae	1	Ichneumonidae	6
Dolichopodidae	79	Scelionidae	1
Empididae	2	Diapriidae	1
Drosphilidae	35	Sphecidae	1
Sphaeroceridae	1	Vespoidea	3
Calliphoridae	1	Formicidae	7
Muscidae	18		
Tachinidae	1		
Mycetophilidae	6		
Micropezidae	6		
Phoridae	11		
Psychodidae	1		
Sciaridae	36		
Mycetophilidae	1		
Stratiomyidae	18		
Tipulidae	12		
Total No families	18	Total No families	8
Total No individuals	256	Total No individuals	25

Table 5.4 (cont.). Trap catch data for 1997 biodiversity trials.

Plot Three (not sprayed)

Diptera Family	No Individuals	Hymenoptera Family	No Individuals
Cecidomyiidae	34	Apidae	1
Ceratopogonidae	1	Dryinidae	1
Chironomidae	1	Braconidae	3
Dolichopodidae	109	Formicidae	1
Drosphilidae	12		
Ephydridae	5		
Muscidae	3		
Tachinidae	2		
Mycetophilidae	14		
Micropezidae	1		
Phoridea	6		
Psychodidae	5		
Sciaridae	36		
Stratiomyidae	19		
Tipulidae	14		
Total No families	15	Total No families	4
Total No individuals	262	Total No individuals	6

Plot Four (sprayed)

Diptera Family	No Individuals	Hymenoptera Family	No Individuals
Cecidomyiidae	24	Braconidae	10
Culicidae	2	Proctotrupidae	1
Phoridae	9	Sphecidae	1
Dolichopodidae	76	Vespoidea	3
Drosphilidae	2	Formicidae	3
Muscidae	1		
Mycetophilidae	9		
Phoridea	22		
Psychodidae	15		
Sciaridae	7		
Stratiomyidae	43		
Tipulidae	7		
Total No families	12	Total No families	5
Total No individuals	217	Total No individuals	18

Table 5.7 Brief details of the Dipteran and Hymenopteran families represented in the biodiversity trials for 1997.

Diptera

Asilidae	A very large family of predatory flies. Adults live mainly in open forest country and are aggessive predators. Feed on Dipterans and Hymenopterans, attack almost all insects. Eggs laid in soil or attached to leaves or bark of plants
Calliphoridae	Blowfies and bluebottles. A large, cosmopolitan family of flies, mostly stoutly built and of moderate size; almost all have antennal arista plumose. Adults are ubiquitous, flying mainly by day. Feed on nectar, honeydew and other sweet liquids, and on liquid products of organic decomposition. Reproduction is oviparous, and many species breed in carrion.
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. Some feed on fungi introduced by ovipositing female. Others are scavengers in decomposing organic matter and some are paedogenetic.
Ceratopogonidae	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, many are notable pests of vertebrates.
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 seem to be 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 a mesopleural bristle. The larvae of most species are fungivorous, some eating yeasts in decaying fruit, others have been recorded as predators/parasitoids of Hemiptera
Empididae	A large family of flies, of moderate to minute size. In most the proboscis is elongate and adapted for piercing, some have chewing labella. Most adults are predacious on smaller arthropods. They frequent moist places. Most larvae are also predacious.
Ephydridae	Larvea are mainly aquatic. Adults are terrestrial, feeding mainly from plants
Lauxaniidae	Largest and commonest of acalyptrates with a wide range of 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. Adult are mainly crepuscular or nocturnal. Larvea are mostly peripneustic, and usually found associated with fungi
Micropezidae	Larvae live in decaying wood and other vegetable material. Adults have elongated legs
Phoridae	Family of small to minute flies, with a characteristic hunchbacked appearance. Larval habits vary greatly. Many are scavengers in carrion and other decomposing organic matter, others are probably endoparasites.

Psychodidae	Moth flies. A cosmopolitan family of small flies. Adults frequent moist, shady places. Most are short lived and do not feed. 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 with pale body and shiny black head-capsule, tend to be gregarious and are found in rotting vegetable matter or highly organic soils
Sphaeroceridae	Small to very minute flies with distinct vibrisae often found on animal dung or other organic matter in which the larvae live.
Stratiomyidae	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 widespread 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 bristled, and drab in colouration. Adults are ubiquitous, larvea are all endoparastic in other arthropods, 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
Apidae	Family of long-tongued bees in which pollen is carried in the corbiculae
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.
Chrysididae	Small to large (2.5-22mm). Terminal metasomal segements forming a telescopic tube which is usually concealed by the preceding 6 of fewer terga. Biologically diverse. Parasitise nests of Sphecidae and Eumeninae (Vespidae).
Diapriidae	Small (1-6mm). Most are endoparasitic on prepupae or pupae of Diptera. Adults are most common on low vegetation in moist, shaded habitats, in areas of high rainfall. Often wings are reduced or absent, especially in females.
Dryinidae	Small (1.5-10mm). Parasites of adults and nymphs of leafhoppers. Females use their chelae to catch and hold hosts which they sting into temporary paralysis. Many are ant mimics and are found with ants that attend leafhoppers for honeydew.
Elasmidae	Minute insects (1-3mm long). Mostly ectoparasites 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
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 early morning. Eggs attached externally to host cuticle or within host's body.

	Pupation occurs in host's own pupation chamber or feeding recess.
Pompilidae	small insects (0.5-6mm). Ectoparasites or endoparasites of Lepidoptera and Diptera in leaf mines
Proctotrupidae	Mostly small (3-15mm). Most are solitary or gregarious endoparasites of larvae of Coleoptera. Pupation occurs outside host remains. Adults found in low vegetation in forest habitats.
Scelionidae	Minute to small (0.5-7.5mm) parasites of eggs of insects and spiders. Usually occur in all terrestrial and fresh water habitats. Most parasitise eggs of Orthoptera and Heteroptera
Sphecidae	Small to large (1.5-39mm). Adults feed on nectar or honeydew, or all extrafloral nectaries. Females hunt spiders or various hexapods for larval food. Predatory or cleptoparasitic. Predominantly solitary: some species nesting communally, with varying degrees of social behaviour
Vespoidea	Mostly large (5-32mm). Are solitary or eusocial. Nest in soil or pre-exisiting cavities, or in free mud nests. Some provision their larval cells with pollen and nectar.

Discussion

Our results show that during the 1997 trials there were no significant differences in the number of Dipteran or Hymenopteran families represented in the treated and untreated plots.

Of the families represented in the trials the Ichneumonoidea, Braconidae, and Tachinidae are known to contain species that are Bagworm natural enemies. Our results show that for the 1997 trials there were no significant differences in the number of Ichneumonoidea or Tachinidae represented in the treated and untreated plots. It is also apparent that for 1997 there were significantly more Braconidae from the treated than the untreated plots.

We plan to identify all the specimens from these three families down to species level. It will then be possible to determine exactly which species from which families are natural enemies of Bagworms, and to test whether there are significant differences in the population levels of these species between the treated and untreated plots.

There was a severe drought throughout PNG during 1997, with West New Britain having little or no rainfall from April onwards. These very dry conditions had a pronounced effect on vegetation growth, consequently there was little or no discernable differences in general levels of ground cover between the treated and untreated plots. Furthermore this lack of rainfall meant that there was little epiphyte growth, even in the untreated plots, and therefore no significant differences in the level of epiphyte growth on palms in the two treatments.

There has been a more normal rainfall pattern during 1998. We are currently doing a second year of sampling in the four trial plots, and the higher rainfall has resulted in a definite difference in the levels of epiphyte growth between the treated and untreated plots. We will identify the specimens caught during these trials, then analyse the data in the same manner as in 1997. The results of this trial will be presented in next year’s annual report.

In the future we would like to keep the control plots untreated for several years in order to reestablish good epiphyte growth, adequate levels of ground cover, and high populations of beneficial weeds. We would then sample Dipteran and Hymenopteran biodiversity as well as population levels of known natural enemies of Bagworms, to test whether there are significant differences between the controls and treated plots. It would then be possible to determine the role, if any, of a number of plantation management practices on the regulation of pest populations by natural enemies and on general levels of biodiversity.

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Research Report 2

Research into the biological control of Sexava – Strepsipteran parasites

Experiment 1 - Life history studies

Objectives

1. To investigate the biology of *Segestidea novaeguineae*
2. To determine the possible effects of infection by *Stichotrema dallatorreanum* on the life history and development of its host, *S. novaeguineae*.

Materials and methods

A total of 45 first and second instar *S. novaeguineae* were collected from the oil palm agro-ecosystem in Oro Province, and reared at OPRA Higaturu. The test insects were colour coded, using a permanent marker, then placed in large walk-in cages. These cages were 1.83m x 1.86m x 1.83m in size, with 32 x 32 Lumite mesh screen. Each cage was partitioned into two sections, and five test insects housed in each section. Nursery seedlings were provided as a food source for the test insects (3 seedlings per section).

Growth rates, moulting increment and the inter-moult period were recorded for each of the 45 test insects. Observations were also undertaken to assess unusual or abnormal behaviour. The test insects in this part of the study were field collected, and could therefore have been either healthy or infected by *S. dallatorreanum*. Therefore during the study each test insect was examined daily for evidence of infection, particularly for signs of protrusion of the cephalothorax of the parasite through the abdomen of the host.

A total of 14 first instar *S. novaeguineae* were reared from field-collected eggs, and kept in walk-in cages as described. Growth rates, moulting increments and the inter-moult period were also recorded for these test insects. These test insects were lab-reared, and obviously not infected by *S. dallatorreanum.*

Results

Of the 45 first and second instar field collected *S. novaeguineae* reared in the walk-in cages only fourteen successfully developed into adults, the others either died or went missing during the study period. A total of nine of these test insects were observed to have developing larvae of *S. dallatorreanum* inside them. Between one and five parasites were found inside these infected insects.

The field collected *S. novaeguineae* eggs took between 97-105 days to hatch, and the hatching of these eggs was not synchronous. Male nymphs took between 118-146 days to reach the adult stage after hatching. Females took between 132 -159 days. There were 6 - 7 instars recorded in males, while females usually attained 7 before reaching the adult stage. The body length of nymphs from first to seventh instar ranged from 15 - 49mm and 13 - 51mm in male and females respectively. Whilst adult body length, measured and recorded one day after moulting, was 54mm and 57mm respectively in male and females. Adult longevity in captivity ranged from 103 - 204 days in males and 69 - 100 days in females. Thus the possible life span of *S. novaeguineae* could be some 350 days from hatching to death for males and 259 days for females.

There was no apparent difference in the moulting increment at each developmental stage (1^{st} - 7^{th} instar) between the sexes of healthy lab-reared and field-collected test insects. Furthermore there was no difference observed within or between sexes of healthy and infected hosts (see Table 5.8). However adult female *S. novaeguineae* appeared to have a slightly longer body length as compared to males.

Female *S. novaeguineae* appear to take longer to develop from 1^{st} instar into adults, taking some 146 days, compared to 136 days for males. With the exception of the 1^{st} and 7^{th} instar, no difference was seen in the number of days required between successive moults, both within and between the sexes of lab-reared and field-collected test insects (Table 5.9).

Table 5.8 The mean length (mm) attained at each nymphal instar by *S. novaeguineae.*

Instar	Males			Females		
	Lab reared	Field Collected		Lab reared	Field Collected	
		Healthy	Infected		Healthy	Infected
1st	15			13		
2nd	18	19		18	22	
3rd	20	25	25	26	26	25
4th	30	30	31	28	30	29
5th	35	36	38	35	36	37
6th	42	43	45	42	43	44
7th	49	51	48	51	52	55
Adult	54	53	54	57	59	59

Table 5.9 The mean number of days between successive moults of *S. novaeguineae.*

Instar	Males			Females		
	Lab reared	Field Collected		Lab reared	Field Collected	
		Healthy	Infected		Healthy	Infected
1st – 2nd	25			18		14
2nd – 3rd	18	18	19	18	18	21
3rd - 4th	15	19	22	15	18	16
4th – 5th	18	17	17	18	17	17
5th - 6th	20	21	20	20	21	21
6th - Adult	22	24	25			
6th - 7th	17		20	25	23	21
7th - Adult	23			32	26	33

Discussion

Host-seeking triungulins (free-living first instar larvae of *S. dallatorreanum*) enter the early stages of *S. novaeguineae*, and then develop with the host until the adult stage is reached. Host entry can be as early as the 1st instar, as observed in *S. novaeguineae* where 7 field-collected first instar nymphs were confirmed to have developing *S. dallatorreanum*. Developmental time for *S. dallatorreanum* from entry to maturity (i.e. from host penetration to protrusion of cephalothorax from host cuticle) appears to be slightly longer than the development time of the host (i.e. from hatching to adult stage). This was evident in field-collected nymphs of *S. novaeguineae,* where there was no evidence of infection during the 7 larval instars. Furthermore, in the field most external evidence of infection is found in adult hosts. Therefore for successful development in the host it is imperative that parasite-induced physiological alterations are minimalised, so that the host can undergo its full development cycle. This could explain the lack of differences in the moult increment and instar duration between healthy and infected *S. novaeguineae.*

Experiment 2 - Infectivity trials

Objectives

1) To infect *Segestidea defoliaria* and *Segestes decoratus* with *S. dallatorreanum*

2) To observe the development of the parasite, and determine the effect that it has on the development of its host.

Materials and methods

Field collected eggs of *S. defoliaria* and *S. decoratus* were sent from Dami Research Station to OPRA Higaturu in March 1997. These eggs were kept in the laboratory until hatching. Upon hatching each test insect was measured and colour coded with a permanent marker. Five test insects were placed in one cage ($0.6m^3$), and this defined as one experimental replicate.

The 5 test insects were then infected with triungulins (free-living, first instar larvae of *S. dallatorreanum*). This was done by the introduction of an infected *S. novaeguineae,* with emerging 1st instar larvae, into the cage containing the test insects. Fresh oil palm leaflets and moisture were provided daily for both the test insects and the infected host in each cage.

The test insects were exposed to emerging triungulins throughout all stages of development. Moult increment and inter-moult period were determined for each test insect as previously described.

Three replicates were undertaken during 1997, with ten treated and ten control replicates planned for the study. No further replicates were undertaken during the year due to the lack of *S. defoliaria* and *S. decoratus eggs*.

Results

All 15 test insects were confirmed as *S. decoratus.* The moult increment for these test insects is given in Table 151 and the inter-moult period in Table 152. Female *S. decoratus* were found to have 7 instars, with a total development time of 107 days.

Of the 15 test insects, 4 successfully developed to adults while 11 died before reaching adulthood. Triungulin penetration and development was observed in 5 test insects, i.e. 33% infection. Of these, 2 developed into adults and 3 died before becoming adults. The two test insects that developed into adults did so abnormally, having deformed and twisted bodies. These test insects subsequently died before the parasite was able to complete its development. In the infected test insects, the number of developing parasites observed after dissecting each dead carcass was 3 - 13 per individual. These were subsequently sent to Oxford University for ultrastructural studies.

Two 4th/5th instar of *S. defoliaria* were exposed to triungulins of *S. dallatorreanum* in the same manner. The male specimen died in captivity before developing to adulthood. The female successfully developed into an adult, but subsequently died (76 days after exposure to triungulins). Upon dissection a total of 6 evenly developing larvae of the parasite was found inside the test insect.

It is therefore apparent that we have been able to successfully infect both *S. decoratus* and *S. defoliaria* with *S. dallatorreanum.* We are however yet to demonstrate complete development of the parasite within these novel hosts.

There was no apparent difference in the moulting increment at 1st - 6th instar between healthy and infected *S. decoratus*. However, a slight difference in body length was apparent at the 7th instar and adult stage, where the infected test insects were 4-6mm longer than the healthy ones (Table 5.10). Infected *S. decoratus* appeared to take longer than healthy ones to develop from 1st instar to adulthood. It is apparent from Table 5.11 that infected *S. decoratus* took 121 days to develop into adults, whereas healthy ones took 107 days. About 2-3 extra days were required by infected test insects to complete each developmental stage, indicating a possible effect of the parasite on host development.

Table 5.10 The mean length (mm) attained at each nymphal instar by *S. decoratus*.

Instar Females	1st	2nd	3rd	4th	5th	6th	7th	Adult
Healthy	13	17	21	28	35	41	47	53
Infected		17	23	27	35	43	51	59

Table 5.11 The mean number of days between successive moults in *S. decoratus*.

Instar Females	1st–2nd	2nd-3rd	3rd-4th	4th-5th	5th-6th	6th-7th	7th-Adult
Healthy	14	13	13	14	15	16	22
Infected	16	11	12	17	18	20	27

Discussion

Our preliminary results from the infectivity trials demonstrates that *S. dallatorreanum* will infect both *S. decoratus* and *S. defoliaria* from West New Britain. We have shown that triungulins will successfully infect and develop within these two hosts. However full development of the parasite (ie protrusion of its cephalothorax from the host cuticle) has not so far been achieved with either species, because all the test insects have dead before reaching adulthood. The deaths may have been due to parasite-induced physiological effects and/or superparasitism, i.e. a very high number of parasites infecting a single host.

Experiment 3. Field studies

Objectives

1. To monitor the levels of stylopization in the oil palm agroecosystem in Oro Province.
2. To survey for the free- living stages of male *S. dallatorreanum.*

<u>Materials and methods</u>

Monitoring of the level of stylopization in *S. novaeguineae* by *S. dallatorreanum* was undertaken every two weeks at a smallholder oil palm block at Dobuduru, Oro Province. Monitoring was done at the same time each fortnight (between 0700h and 100h), and sighted individuals were caught and observed for evidence of infection (i.e. the cephalothorax of the parasite protruding from the host cuticle). Captured individuals were also examined for evidence of parasitism by the tachinid fly, *Exorista notabilis.* The captured individuals were then released back into the field.

During 1997 malaise and light traps were used to survey for the free-living stages of male *S.dallatorreanum* in Oro Province and at Dami Research Station, West New Britain Province.

Results

For the year there was an average of 30% parasitism by *S. dallatorreanum* and 38% by *E.. notabilis* (see Table 5.12).

In Oro Province a total of four male strepsipterans were caught in the light traps, and none were caught in the malaise traps. These specimens, plus a number of others were sent Dr. Kathirithamby at Oxford University for identification.

Table 5.12 Rate of infection of *S. novaeguineae* by *S. dallatorreanum* and *E. notabilis* and the number of male *S. dallatorreanum* caught in light traps in Oro Province during 1997.

Month	% Infection		No. of male S. dallatorreanum caught in light traps
	S. dallatorreanum	*E. notabilis*	
Jan	39	41	0
Feb	46	46	0
Mar	55	41	1
Apr	36	34	no trapping
may	17	28	no trapping
Jun	23	42	no trapping
Jul	14	36	no trapping
Aug	15	38	1
Sep	25	37	0
Oct	Fire	Fire	1
Nov	Fire	Fire	0
Dec	Fire	Fire	1

Taxonomy of male strepsiptera caught during the study

Identified by Dr Kathirithamby, Department of Zoology, Oxford University, UK.

Family **Elenchidae**

Elenchidae Perkins, 1905, p. 98.
Elenchoidae Pierce, 1908, p. 76.
Elenchinae Ulrich, 1930, p. 7; Riek, 1970, p. 634.

Subfamily **Elenchinae** Perkins

Elenchinae Perkins, 1905, p. 106.
Deinelenchinae Kinzelbach, 1971b, p. 9, syn. nov.
Subfamily Elenchinae has four genera: *Elenchus* Curtis, *Deinelenchus* Perkins, *Protelenchus* Kinzelbach and Elencholax Kinzelbach. Kathirithamby (1989).

Genus **Deinelenchus** Perkins
Deinelenchus Perkins, 1905, p. 107.
Elenchus Bohart, 1941, p. 125.
Type species: *Deinelenchus australensis* Perkins

Deinelenchus deviatus Kinzelbach

Deinelenchus deviatus Kinzelbach, 1971, p. 155.- Kifune & Hirashima, 1989, p. 25.
Type specimen: male, 8Y 9, Fischhafen, New Guinea.
Material examined: 1 male, Dami Research Station, Kimbe,West New Britain, light trap, 23.i.1995, (PNGOPRA).
Host and female: unknown.
Distribution: New Guinea (Papua and Irian Jaya).

Deinelenchus hamifer Kinzelbach

Deinelenchus hamifer Kinzelbach, 1971, p. 155.- Kifune & Hirashima, 1989, p. 26.
Type specimen: male, 59G 73L', 83W (male), Fischhafen, New Guinea.
Material examined: 1 male, Dami Research Station, Kimbe, West New Britain, light trap, 23.i.1995, (PNGOPRA).
Distribution: New Guinea (Irian Jaya, Papua).

Family **Corioxenidae** Kinzelbach

Mengeidae pro part Pierce, 1908, p. 75.
Callipharixenidae Blair, 1936, p. 116.
Corioxenidae Kinzelbach, 1970.- Miyamoto and Kifune, (1984) (new synonym), p. 143; Kathirithamby, (1989), p. 71.- Kathirithamby, 1990, p. 471.- Kathirithamby, 1994, p. 127.

Subfamily **Corioxeninae**

Corioxeninae Kinzelbach, 1970, p. 106.
Corioxeninae, Kathirithamby, (1989), p. 71.
Blissoxeninae, Miyamoto & Kifune, 1984, p. 142 (sym.).

Genus **Triozocera** Pierce

Triozocera Pierce, p. 89.
Type species: Triozocera mexicana Pierce

Triozocera papuana Kogan & Oliveira 1964

Triozocera papuana Kogan & Oliveira, 1964, p. 456; Kinzelbach, 1971, p. 150; Kifune & Hirashima, 1989, p. 13.
Type specimen: Gurakor, Wampit R. Valley, Morobe Dist., Papua New Guinea.
Material examined: Dami Research Station, Kimbe, West New Britain, light trap: 1 male, 23.i.1995; 6 males, 29.i.1995; 5 males, 29.i.1995; 2 males, 30.i.1995; 2 males, 3.ii.1995; 2 males, 14.ii.1995; 8 males, 11.ii.1995; 35 males, 12.iii.1995; 2 males, 17.iv.1995; malaise trap: 12.ix.97 (ref. 01-MS-97); 3 males, ix.1997 (ref. 07/1997), (PNGOPRA).
Popendetta: 1 male, light, 27.viii.97 (PNGOPRA).
Host and female: unknown.
Distribution: Solomon Is. (Bougainville, Santa Ysabel, Gundalcanal); New Guinea (Papua and Irian Jaya).

Family **Myrmecolacidae** Saunders

Myrmecolacidea Saunders, 1872, p. 20.
Myrmecolacidae Pierce, 1908, p. 76.
Stichotrematoidea Hofeneder, 1910, p. 49.
Stichotrematidae Hofeneder, 1910, p. 49.

Genus **Lychnocolax** Bohart

Lychnocolax Bohart, 1951, p. 95.
Type species: *Lychnocolax mindoro* Bohart, 1951.

Lychnocolax ovatus Bohart

Lychnocolax ovatus Bohart, 1951, p. 101.- Kifune & Hirashima, 1989, p. 28.- Kathirithamby, 1993a, p. 192.- Kathirithamby, 1993b, p. 865.
Type specimen: Male Maco, Tagum, Davano, Mindanao, Philippines, at light, sea level, 17, ix. 1946, H. Hoogstraal (CMNH).
Material examined: 1 male, Nagada Harbour, near Medang, PNG, water trap, 18.iii.1990, 6.30-9.30, (I Lansbury) (OUM); 1 male, Dobudon, Oro Province, light trap, 12.ii.1996 (PNGOPRA); 1 male, Mainland Research Station,, at light, 1.ix.1997 (PNGOPRA); 1 male, Dobvduru, Oro Province, PNG, light (uv), 19.30-22.00, 20.xii. 1995, (PNGOPRA).
Host and female: unknown.
Distribution: Philippines (Mindanao), Malaysia (Sabah), Indonesia, (Sulawesi),Australia (Northern Territory); New Guinea (Papua).

Lychnocolax mindanao Bohart

Lychnocolax mindanao Bohart 1951, p. 98.- Kinzelbach, 1971, p. 157.- Kifune and Hirashima, 1989, p. 28.- Kathirithamby, 1993 p. 191.
Type specimen: male, San Jose, Mindord, Philippines, at light, April 1945, (E.S. Ross) (CAS).
Material examined: male, Dami Research Station, Kimbe, West New Britain, Papua New Guinea, Light trap,11.iii.1995 (PNGOPRA); Dubuduru, Oro Province, uv light, 12.ix.1995 (PNGOPRA)..
Host and female: unknown.
Distribution: Philippines, (Mindanao), Bismarck Islands (New Ireland); New Guinea (Irian and Papua); Papal Islands (Koror); Malaysia (Sabah).

Myrmecolax Westwood

Myrmecolax Westwood, 1861: 418.
Parastylops de Meijere 1908: 185.
Afrostylops Fox & Fox 1964: 754.
Type species: Myrmecolax nietneri Westwood, 1861, by monotypy.

Myrmecolax rossi Bohart

Myrmecolax rossi Bohart: 1951, p. 91.- Kinzelbach 1971: p. 158.- Kifune, 1981, p. 330.- Kathirithamby 1993: p. 868.
Type specimen: male, San Jose, Mindoro, Philippines, April 1945, at light, E. S. Ross. (CAS).
Material examined: male, Dami Research Station, Kimbe, PNG, light, 31.iii.1995, (PNGOPRA)
Host and female: unknown.
Distribution, Philippines (Mindoro, Mindanao), Malaysia (Ipoh), Australia (Queensland, Northern Territory, Western Australia), New Guinea (Papua).

Myrmecolax longipalpis Kogan and Oliveira

Myrmecolax longipalpis Kogan and Oliveira 1964.
Type specimen: male, Waikaiuna, Normandy Island, 0-50m, Papua New Guinea, 5th Archibold Expedition, 28.iv.1950 (L. J. Bass coll.).
Material examined: male, Dami Research Station, Kimbe, PNG, light, 31.iii.1995, (PNGOPRA); No. 12 Kassam, on Lea-Goroka Rd., Kratke Mts., Eastern Highlands, 11.xi.1959, (Sixth Archibold Expedition to Papua New Guinea) (AMNH).
Distribution: Papua New Guinea.

Genus ***Stichotrem***a Hofeneder

Stichotrema Hofeneder, 1910, p. 47.
Caenocholax Pierce, 1909, p. 88, pro part
Mantidoxenos Ogloblin, 1939, p. 1277.
Rhipidocolax Bohart, 1951, p. 94.
Type species: *Stichotrema dallatorreanum* Hofeneder

Stichotrema retrorsum (Bohart)

Rhipidocolax retrorsus, Bohart, 1951:p. 94.-
Stichotrema retrorsum (Bohart, 1951): 94.- Kinzelbach, 1971: 159.- Kifune, 1981: 220.- Kifune and Hirashima, 1989: 40.- Kathirithamby, 1993: 195.
Type specimen: Maco, Tagum, Davano, Mindanao, Philippines,
Material examined: male, Higaturu, Oro Province, PNG, 17.iii.1996, (PNGOPRA); male, Dobuduru, Oro Province, PNG, 10.iii.1997. (PNGOPRA).
Host and female: unknown.
Distribution: Philippines (Mindanao), Malaysia (W. Malaysia, Sabah), New Guinea, (Papua).

Stichotrema dallatorreanum Hofeneder

Type specimen: Pak and Admiralty Islands, Pacific.
Material examined: Popondetta: several females (PNGOPRA).
Male: unknown
Host: ***Segestidea novaeguineae*** (Brancsik)
Distribution: Papua New Guinea

Stichotrema acutipenis Kogan & Oliveira

Caenocholax (Rhipidocolax) acutipennis Kogan & Oliveira, 1964, p. 467. *Stichotrema acutipennis* (Kogan & Oliveira, 1964): Kinzelbach 1971 p. 158. *acutipenis*.(Kogan & Oliveira, 1964): Kifune & Hirashima, 1983, p. 161; 1989, p. 40.- Kathirithamby, 1993, p. 869.
Stichotrema dallatorreanum Hofeneder, 1910.- Luna de Carvalho, 1972, p. 1.
Type: Male, New Guinea, Gurakor, (n. 3), Wampit R. Valley, 45 miles from Lae, 670m, Morobe District, 5-8.v.1959, I. J. Brass collection (sixth Archibold Expedition to Papua New Guinea) (AMNH).
Material examined: male, Dami Research Station, Kimbe, West New Britain, light trap, 11.iii.1995, PNG, (PNGOPRA).
Host and female: unknown.
Distribution: New Guinea (Papua, Irian Jaya); Borneo (Sabah); Sri Lanka; Australia.

Stichotrema davano (Bohart)

Caenocholax davano Bohart, 1951: p. 92.- Stichotrema davano Kinzelbach 1971: p; 1993, p. 194.
Type specimen: Maco, Tagum, Davano, Mindanao, near sea level, at light, Octover17 .1946, (H. Hoostraal) (CMNH).
Material examined: male, Dami Research Station, Kimbe, West New Britain, 11.iii.1995 (PNGOPRA).
Host and female: unknown.
Distribution: Philippines (Mindanao), Malaysia (Sabah), New Guinea (Papua).
Male: unknown.

- In addition to these 8 new species of Strepsiptera have been identified so far.

Consultant's Report

By Dr Kathirithamby, Department of Zoology, Oxford University, UK

I put together 2 joint papers (Solulu, Simpson & Kathirithamby, 1998; and Kathirithamby *et al.* 1998) which are now in press (see references), and I co-ordinated with a member of the Conventions and Policy Section, The Royal Botanic Gardens, Kew, a paper on benefit-sharing case study titled '*Biological Crop Protection in Papua New Guinea. The Papua New Guinea Oil Palm Research Association and the Department of Zoology, Oxford University'*. There are so few collaborative projects on Biodiversity that have yielded good results such as the present one and the Biodiversity Co-ordinating group was interested to present this project as a case study. This paper was presented at the Biodiversity Convention at Bratislava in May and apparently it was well received.

I have been concentrated on two important aspects of *Stichotrema* - feeding and reproduction. These features have not been studied in Strepsiptera before and it is crucial to do so in this species so that I can compare it with the specimens from the infectivity trials. While I have been conducting an in-depth study on these two aspects I have found novel features that have not been seen in insects before.

Feeding:

IInd to IVth instar female larva of Stichotrema has a mouth that leads to the gut but when the female extrudes the anterior region (cephalothorax) through the host cuticle there is no mouth opening. As it is important for the female to continue feeding the developing viviparous larvae a region analogous to the peritropic matrix is formed on the ventral surface. Peritrophic matrix normally are found only in the midgut of Arthropods, and is a matrix that surrounds the food and aids in food absorption. This is the first time that the matrix has been found on the outside cuticle of an arthropod, and is a modification in Strepsiptera as the food is the host haemolymph, unlike other arthropods when the food is in the midgut (Kathirithamby, unpublished). Two papers have been submitted for publication this aspect.

Sections of young females from the infectivity trials have been examined and they seem to be secreting this matrix by the microvillate cells, but it can only be confirmed that the matrix is formed when late IVth instar females are available. It is important for the female to have such a matrix for food absorption. If Stichotrema has successfully infected Segestidea defoliaria defoliaria from West New Britain a peritrophic matrix will be formed in the later IVth instar females.

Reproduction:

Another unusual feature in Stichotrema is that there is no egg stage and the development of the egg passes from the germ cell to the embryo. They are also connected to each other by putative nutritive chords. As there is no fat body nutrients are passed by these chords (Kathirithamby, unpublished). The origin and function of these chords is now being determined, and again it is important to do a comparative study with specimens from the infectivity trials.

Research Report 3

Fruitset Study

For a number of years now OPRA has conducted a fruitset study at Kapiura plantations, NBPOL. For this study monthly observations are made in experimental plots located in Kautu division 1, Kautu division 2, Bilomi and Kaurausu. Each month the following observations are made at each plot:

- Percentage fruitset
- Number of anthesing male and female inflorescences
- Number of *Elaeidobius* emerging from 5 sets of male spikelets

A detailed account of the methodology used for these studies is given in previous annual reports.

The results of this study for 1997 are shown in Figures 5.4, 5.5, 5.6 and 5.7.

Figure 5.4 Percentage fruitset at each of the trial plots during 1997.

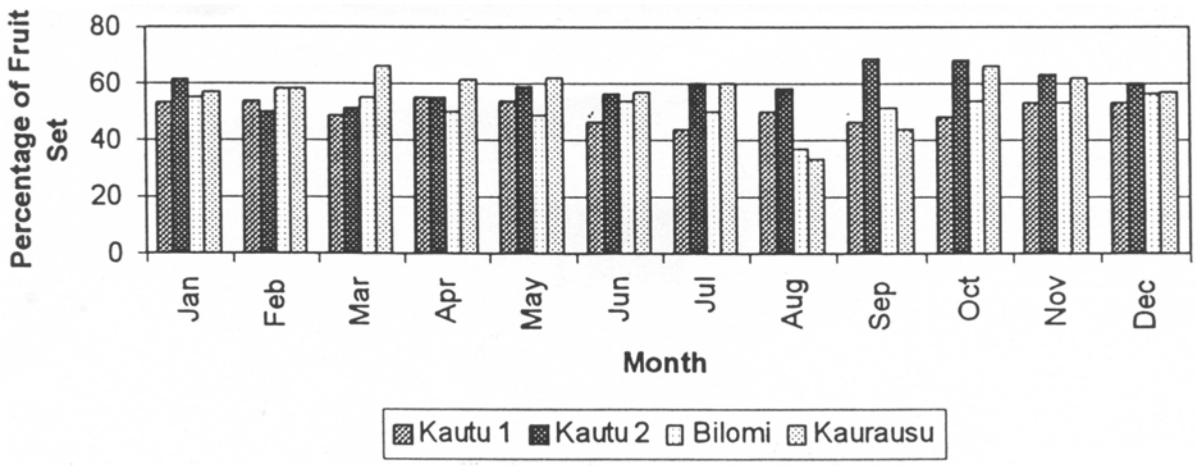


Figure 5.5 Number of receptive female inflorescence for each of the trial plots during 1997.

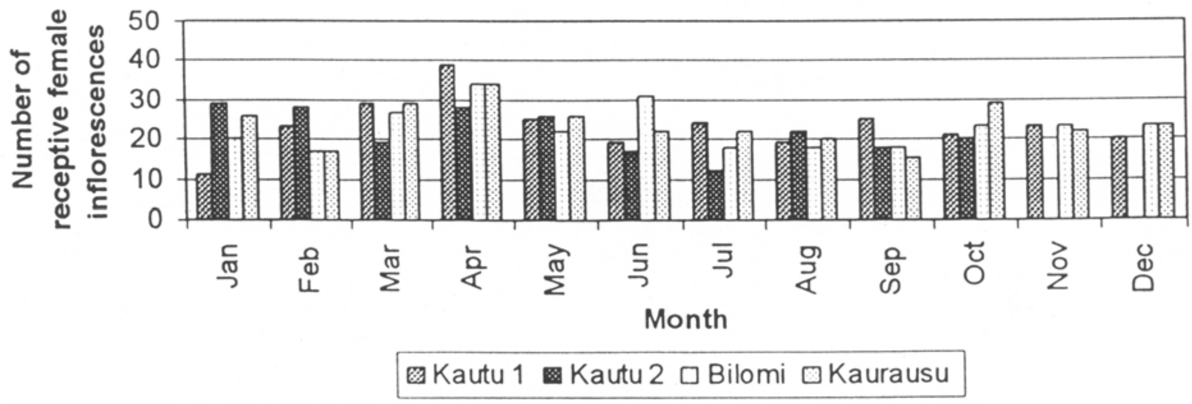


Figure 5.6 Number of anthesing male inflorescence for each of the trial plots during 1997.

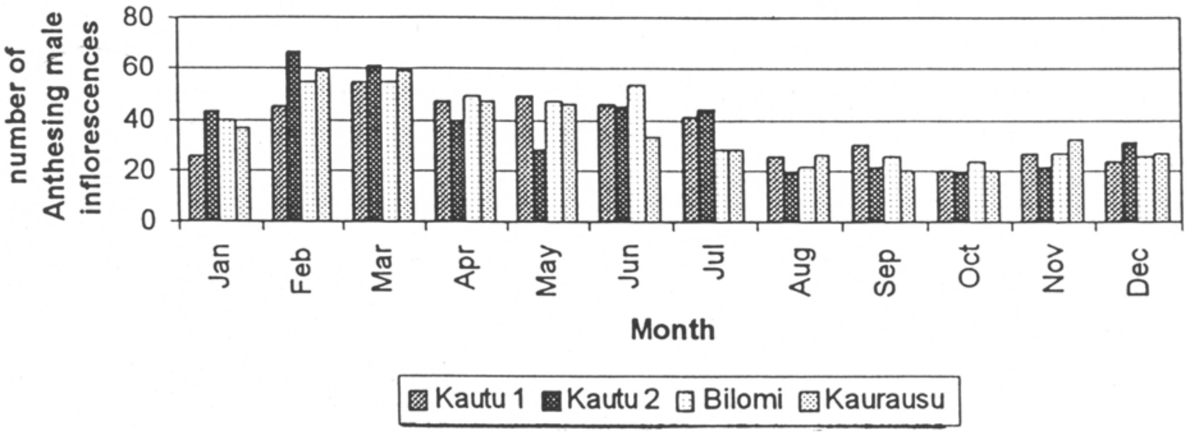
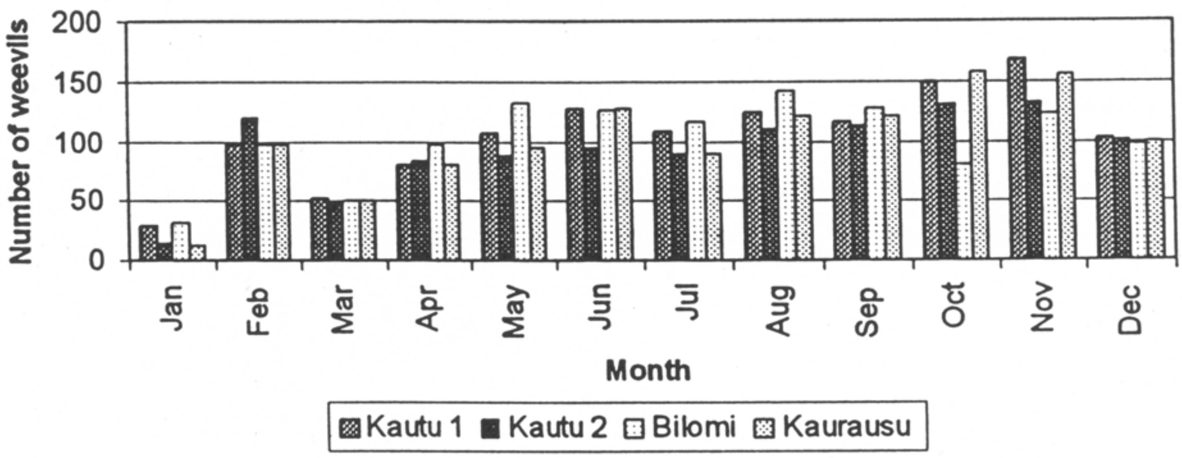


Figure 5.7 Number of pollinating weevils emerging from 5 sets of 20 male spikelets for each trial plot during 1997.



General Report

Training

We have on-going training programmes in entomology for plantation workers and extension officers, as well as smallholder growers. This involves both formal and informal training, as well as features on local radio. These activities were undertaken throughout 1997 in both the Islands and Mainland regions of PNG.

Staff

During 1997 the entomology staff were located as follows:

Hargy Research Centre	Rob Caudwell	Senior Entomologist
	Ross Safitoa	Assistant Entomologist
Dami Research Station	Simon Makai	Supervisor
	Seset Komda	Recorder
Higaturu Research Station	Takis Solulu	Entomologist
	Seno Nyaure	Lab / field assistant
	Nathaniel Yaide	Lab / field assistant

Publications

Caudwell, R.W and Orrell, I. 1997
Integrated pest management for oil palm in Papua New Guinea
Integrated Pest Management Reviews **2,** 17-24

Moore, D. and Caudwell, R.W. 1997
Formulation of entomopathogens for the control of grasshoppers and locusts
Memoirs of the Entomological Society of Canada **171,** 49-66

Kathirithamby, J. 1998
Host parasitoid associations of Strepsiptera: anatomical and developmental consequences
International Journal of Insect Morphology and Embryology **27,** 39-51

Kathirithamby, J, Simpson, S.J, Solulu, T and Caudwell, R. 1988
Strepsiptera parasites – novel biocontrol tools for oil palm integrated pest management in Papua New Guinea. *International Journal of Insect Pest Management* **44**

Kathirithamby, J. Solulu, T and Caudwell, R.W. 1998
Biological control agents for oil palm IPM in Papua New Guinea
*Proceedings of the IOPRI International Oil Palm Conference **1998*** In Press

Caudwell, R.W. and Safitoa, R. 1998
Insect biodiversity associated with the oil palm agroecosystem in Papua New Guinea
International Journal of Pest Management In Prep

6. PLANT PATHOLOGY RESEARCH

(F R Sanderson & C A Pilotti)

Field Research

Surveys

There were two reasons for the implementing of the surveys. The first was to obtain an insight into the epidemiology of the disease, and second to providing information on the incidence, range of symptoms. More importantly, however, the surveys have given us the opportunity to develop and implement the control strategy.

1997 Surveys

A change in policy by the Milne Bay Estates from annual to six monthly surveys meant that the fifth survey was completed in February of this year, six months after the 1996 survey. The shorter duration between the surveys was reflected in a marked decrease in the severity of the symptoms of the palms recorded, i.e. in an increase in the number of fruit bunches, less yellowing etc.

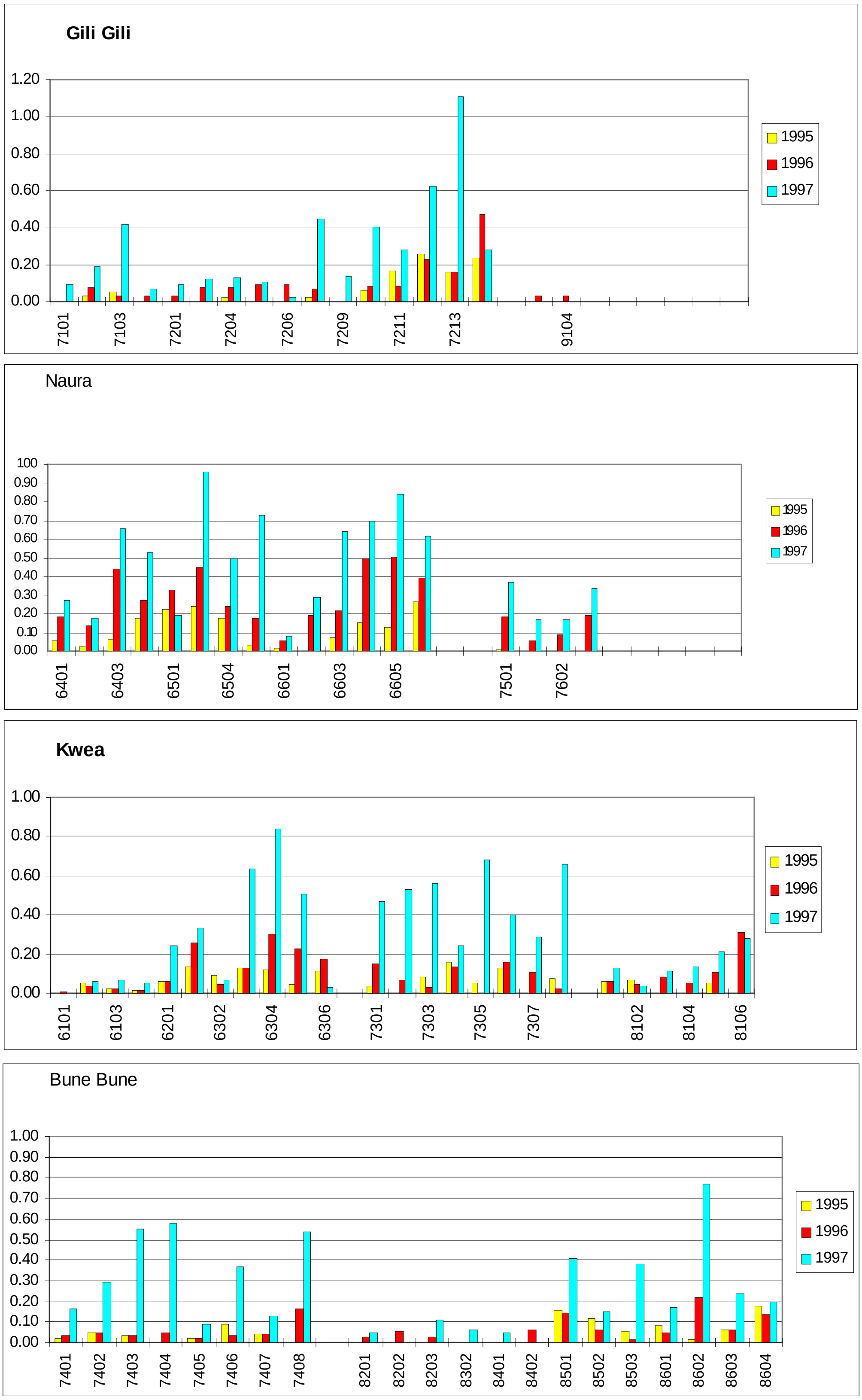
The incidence of infection has been increasing steadily over the 3 years of the surveys starting at 0.05% in 1995, increasing to 0.11% in 1996, and to 0.28% in 1997. The incidence is broken down by the age of palms at each survey in Table 6.1. Nine-year-old palms in the 1995 survey had an incidence of 0.03%, nine-year-old palms in the 1996 survey 0.028% and the nine-year-old palms in the 1997 survey 0.04%.

Table 6.1: Incidence of infection for all blocks planted in 1986, 87 and 88, as recorded during the 1995, 96 and 97 surveys.

Age of palms	Year of Survey		
	1995	1996	1997
7	0.010		
8	0.014	0.016	
9	0.030	0.028	0.040
10		0.067	0.103
11			0.132
	0.054	0.111	0.275

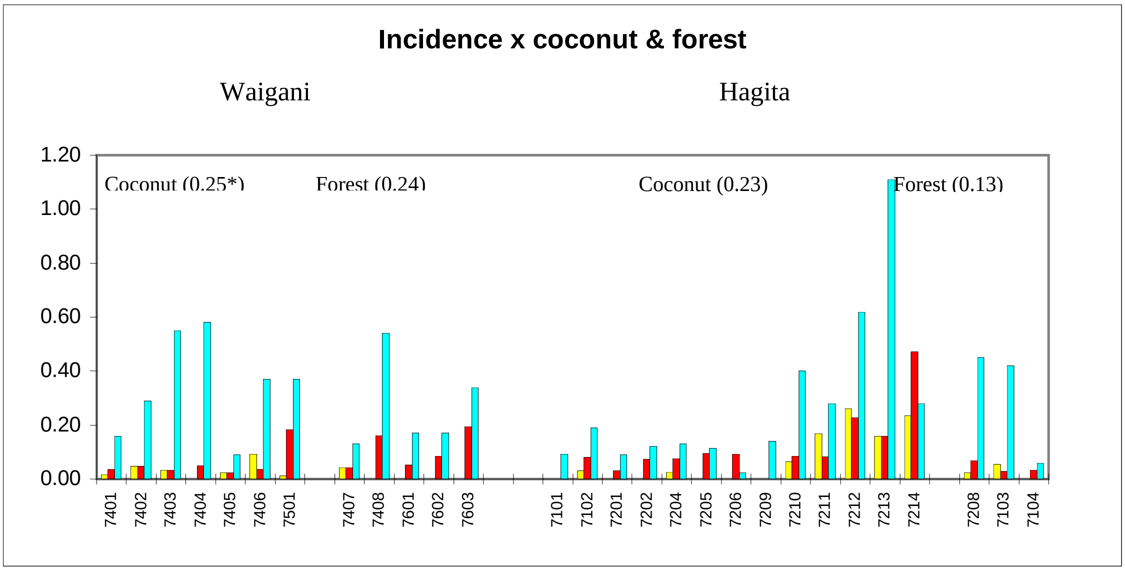
Site differences, however, exert a far greater influence on the incidence of *Ganoderma* infection than the age of the palms (Figure 6.1).

Figure 6.1: Site differences as represented by the block number have a greater influence on incidence than age. Blocks 6 - planted in 1986; 7- planted in 1987; 8 - planted in 1988.



Differences in incidence related to planting after coconut or forest are also masked by the greater influence of site (Table 6.3) although there is a suggestion at Hagita of a greater incidence after coconut.

Figure 6.2: Site differences again have a greater effect on incidence of Ganoderma than whether the oil palm followed either coconut or forest. * Mean incidence



The 1996 survey data hint that the application of palm oil mill effluent (POME) was having an influence on the incidence of disease. This is perhaps not surprising considering the stress placed on the palms. Differences in the incidence of infection in the 1986 Naura and 1987 Kwea blocks with and without POME (Figure 6.4) is again masked by other site differences, however, when all results are bulked a pattern is again suggested (Figure 6.3).

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Figure 6.3: The incidence of infection combined, for all Naura and Kwea blocks with and without POME.

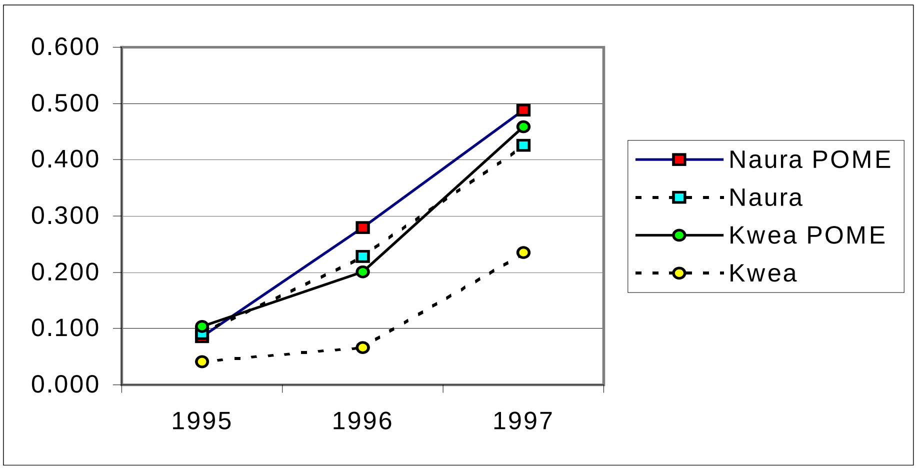

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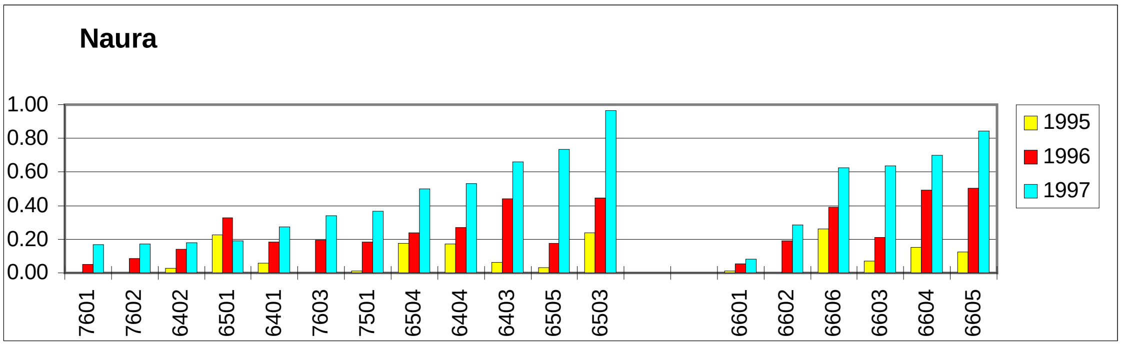
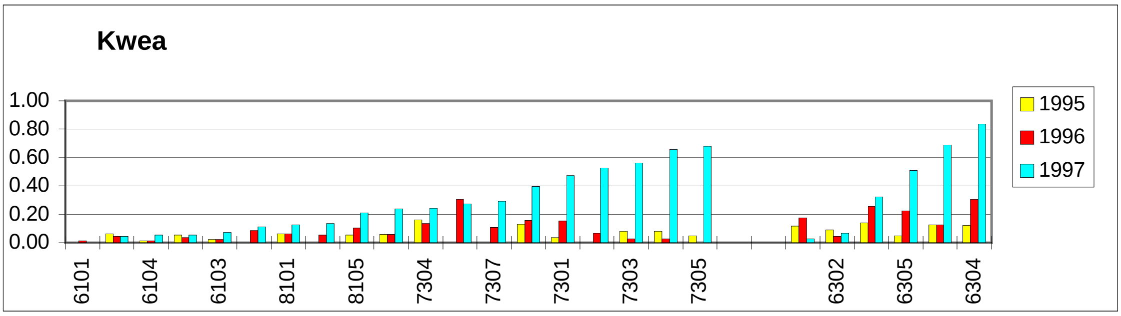
Figure 6.4: The apparent effect of the application of POME on the incidence of Ganoderma as suggested by Figure 6.3 is also masked by the greater variations due to site.





Control Strategy

Background: Spore-initiated infection

As part of our research programme we pushed over two small-blocks of palms to assess the actual level of infection within these two blocks. Half of the palms fractured about 1 - 2 cm above the basal plate. Protruding from the fractured surface of the trunk was a large number of small, 1 - 2 cm long, vascular bundles; vascular bundles that were once directly connected to the young frond bases. These are easily distinguished from the vascular bundles to the roots that are larger and more complex. One palm with no top symptoms had a small area of dry rot from which *Ganoderma* was easily isolated. More importantly the protruding vascular bundles associated with the basal stem rot also had lesions from which *Ganoderma* was consistently isolated.

We have observed infection of rachis tissue in three-year-old palms, the lower leaves of which had been pruned prematurely. On sequentially cutting back the rachis, it was possible to follow lesions down into the stem base. At a later date, this infection would appear to have originated near the centre of the palm base via the roots, rather than having arisen from the rachis via the connecting vascular bundles.

Susceptibility of oil palm to *Ganoderma*

The major enigma associated with spores as the source of infection, is the belief that because there is such a large aerial spore load, it would be inevitable that all palms would eventually become infected.

There are many publications (TAN, *et al* 1989; PURBA, *et al* 1994; UTOMO, *et al* 1994; and HASTJARJO and SOEBIAPRADJA, 1995) that describe varying levels of susceptibility between seed lines to basal stem rot.

In nature there are very strong evolutionary pressures towards resistance, especially to wood rotting fungi such as *Ganoderma*. It is therefore, not unreasonable to expect that the parent oil palms used in the seed gardens have high levels of resistance to *Ganoderma*. The progeny of crosses, whether they are *Elaeis guineensis* Deli *dura* x *tenera* or *dura* x *pisifera*, or *E. guineensis* x *E. oleifera*, are segregating populations. This in all probability would include traits such as susceptibility to basal stem rot.

The incidence of basal stem rot within a block of oil palm is therefore a reflection of the level of susceptibility within the seed line and a measure of the aggressiveness evolved within the pathogen population, and not a reflection of the aerial spore load.

Implementation of the control strategy

The initial control strategy that was implemented in PNG was the same as that used overseas at the time; i.e. the identification of infected palms, all of which were then dug up, cut up and removed.

As we became convinced that infection was related to spores and not to root-to-root contact the control strategy changed to one of a policy of 'zero-brackets' in the plantation. In its simplest form this was a matter of removing brackets and then cutting up the palms as they collapsed. The root ring was removed to about 10 - 15 cm below ground and the hollow left behind was covered with soil.

There has been one major modification to this process. It was found that as long as the cut trunk sections were placed onto the frond pile new brackets did not develop. Unfortunately this was not always done and about 10% of cut-up sections developed further brackets. For this reason we are now felling and removing all palms that have been identified with brackets; this is about 30% of all infected palms. This recommendation will continue unless we find that effective control of brackets can be achieved with chemicals.

Our current recommendation:

- Surveys to identify infected palms which are marked as either
  - Infected without brackets.
  - Infected with brackets.
- Palms without brackets are left, harvested, and monitored for future development of brackets.
- Palms with brackets are felled and any infection at the base of the trunk cut up and removed from the block.
- The root ring and trunk base should be removed to a depth of 10 - 15 cm below ground level and the hollow filled with soil. As long as the infected palm base and roots are covered with soil, the infected stem base and roots are of little consequence as brackets cannot form and a host of other wood decaying organisms soon invades them.

The worst scenario possible is to dig a hole and remove the root boll and leave the root/soil block exposed above ground. The soil acts as a reservoir for moisture and guarantees an impressive crop of brackets.

A change in the basic strategy is required at replanting. Every effort must be made to identify and remove all infected palms, so that at replanting, the only old trunks left in the field are of healthy wood and not likely to be a source of brackets.

Implementation of the control in other Plantations

A training course is to be implemented early next year to instruct staff from other plantations on the skills required implementing the control strategy. This will be conducted under the auspices of the training officer at Milne Bay Estates and OPRA staff. A second session will be held to bring the Field Managers up to date as to the reasons for our actions.

Wood degrading fungi

While at the IMI last year I learnt of a small programme looking at the potential of wood degrading fungi as biological control of *Ganoderma*. I see a great potential in the idea but no future in plodding along in the laboratory testing enzymes systems.

Dr Roland True spent six-weeks in the Milne Bay Laboratory during March and April. During this time he isolated 29 wood degrading fungi, which are currently stored in water in the laboratory. Twenty-five of these were inoculated into felled oil palm trunks.

Cultures inoculated on the 27 March

Logs were left lying on the ground and inoculated by drilling either 3 or 4 pairs of holes 20 cm vertically into the top of the log using a 12 mm auger. The holes were either drilled into a cut surface of the log or directly into the old frond base. The inoculum was based on kernel fibre supplemented with yeast extract. The holes were sealed with candle wax.

Row & palm N^o	Recorded on		9 June	13 August
382-10	2710	Volvariella	Some activity around both holes >1cm	Still active but very slow >2 cm
386-10	2730	Lenzites	Some activity > 2 cm	No longer active
387-12	2698	Trametes	No activity	No activity
141-3	2702	Marasmius	Some activity > 1cm	Whole log decayed by soft black rot with associated Coprinus. Strong smell of ammonia.
139-2	2728	Pleurotus	Slight activity at the base of the plug. Area later colonised by soft rot	Activity along surface between inoculation points and down into plugs.
402-1	2752	Lentinus	Small area of activity at the base of the plug. Black soft rot around the top part of the plug.	Extensive soft wet rot and Coprinus activity.
17-7	2699	Marasmius	no activity	No activity. Black soft rot and Coprinus.
32-8	2700	Schizophyllum	Some activity around plug. >1 cm.	Some activity around plug. >1 cm.
166-6	2709	Trametes	No activity.	Very slight activity. Some black soft rot and Coprinus.
74-1	2701	Pycnoporus	Not recorded	No activity
93-3	2707	Trametes	Not recorded	Very slight activity < 1 cm

Cultures inoculated on 26 April

2703	Lentinus	2705	Gymnopilus	2709	Trametes
2711	Gymnopilus	2718	Phellinus	2726	Marasmius
2727	Trametes	2728	Pleurotus	2730	Lenzites
2746	Trametes	2749	Sterium	2751	Trametes
2752	Lentinus	2753	Tremella		

Logs were cut into three sections and placed on their ends to provide a flat cut surface. Three 12 mm by 20 cm deep holes were drilled into the cut surface. Each hole was marked and 9 of the 15 cultures used per palm. Five palms were inoculated giving 3 replicates of each isolate. The same inoculum was used as above and the holes were again sealed with candle wax.

Although inoculating the flat surface of the palm trunk was much easier, the large cut surface provided an ideal surface to retain moisture and was a site for colonisation by other organisms that masked the activity of the test fungi.

Sites 8604 4 663 11 and 8401 6 102 11. All six blocks were colonised by the same wood rot which had colonised the whole top surface as well as down into the inoculated holes.

Sites 8604 4 662 11, and 8604 4 666 6. All sections of logs were almost completely broken down by the black soft rot.

Conclusion

Although some wood degrading activity was demonstrated in the majority of isolates, in all cases it was limited to less than 3 cm of the inoculation point after about four months. Cutting the logs and leaving them on their end would go a long way to speeding up the break down process. Two other naturally invading complexes were much more successful in degrading the logs.

The most impressive, a black soft rot complex that rapidly breaks down the soft woody cells. Although the vascular tissue is left intact, the process completely breaks down the structure of the wood. Ammonia is associated with this complex as is *Coprinus*. Mushroom growers as an indication of a poor peak-heat and the presence of ammonia use *Coprinus* on mushroom compost after second phase composting.

I would suggest that this is the complex that we should be utilising as the complete break down could be as fast as two months.

Aeroponics

The two test units have now been running for six months with the successful establishment of young seedling oil palms.

Even using a half strength of nutrients the misting nozzles are still sensitive to salt build up and this has to be continually monitored. The units have been modified so that the nozzles are outside the boxes. Rubber rings hold them in the end of a short tube protruding through he wall. It is now an easy matter to unplug them weekly for cleaning.

The shade house has been completed and we are in the process of purchasing the boxes and fittings to set up the working unit.

Laboratory Studies

Equipment and reagents

All essential equipment for the molecular work arrived in June 1996 and methods and equipment were tested during a visit by Dr. Paul Bridge from IMI.

Problems were encountered with the microcentrifuge and the freeze dryer. The microcentrifuge is now operational but the freeze dryer is still without a vacuum pump.

Most reagents required to begin the molecular and isozyme work were obtained by July 1996.

Reagents for the other molecular work (RAPDs) were obtained in November 1996.

Genetic studies

A general plan of the genetic studies was formulated in consultation with Dr Paul Bridge of IMI Egham UK, and Dr Elizabeth Aitken of the Botany Department, University of Queensland.

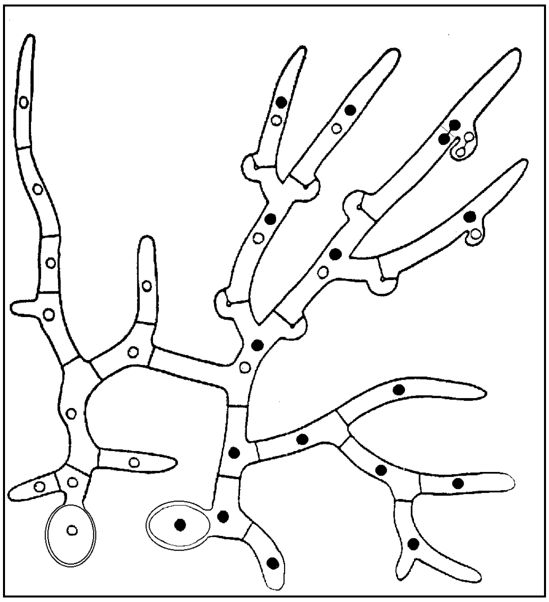
Spore prints were obtained from four fruiting bodies in August 1996. Twenty single spores were isolated from each. These were to form the basis of the genetic studies. The number of families was later modified to three so as to keep the isolate numbers at a minimum, storage being limiting.

Background - Single Spore Cultures and Mating Types

The first thing that is apparent when looking at a range of single spore isolates of *Ganoderma* is the wide diversity of these cultures. Growth rates, pigmentation and colony morphology all vary dramatically. Each isolate is an individual with its own characteristics.

Spores as they are released from the *Ganoderma* bracket have only one nucleus (monokaryons). To survive, however, they must come into contact with another *Ganoderma* of a complementary mating type. Fusion takes place followed by an exchange of nuclei. The resulting fungus with two nuclei (dikaryon, Figure 6.5), is usually more vigorous, faster growing and therefore much more likely to compete successfully. It is also a prerequisite for the sexual fusion of the nuclei and the production of fruiting bodies

Figure 6.5: Two germinating spores produce hyphae with only one nucleus. On fusion and exchange of nuclei the resulting hyphae containing two nuclei is more vigorous and better suited for survival.



Reciprocal crosses

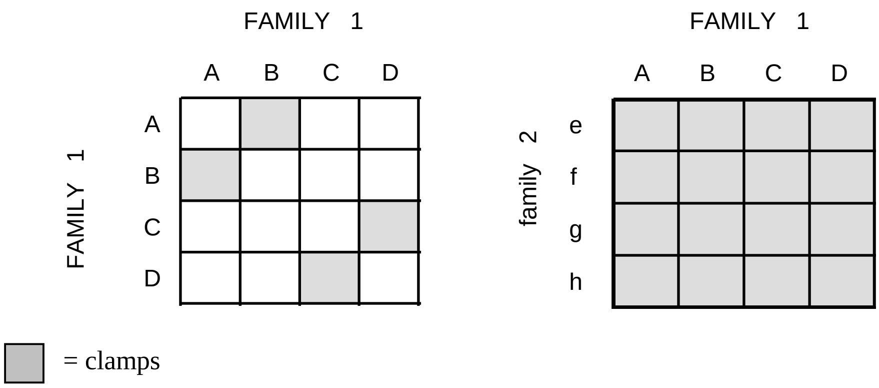
Reciprocal crosses within families were carried out to determine mating types and generate sib-composed dikaryons.

It was confirmed that the *Ganoderma* we are working with has four mating types (tetrapolar) (HSEU *et. al*. 1989), each has two loci with two possible alleles. These are expressed as A_1B_1, A_2B_2, A_1B_2, & A_2B_1. For the mating types to be compatible the alleles of the two loci must be different i.e. A1B1 will produce clamps with A_2B_2 but will not with A_2B_1 or A_1B_2. Nor of course will it produce clamps with itself. This in practice means that any spore has a 1:4 chance of successfully fusing and producing clamps when confronted with other spores from the same family.

Later out-crosses were also made to generate non sib-composed dikaryons. However, instead of the standard 1:4 ratio of clamps, it was found that all confrontations result in the development of clamps (Figure 6.4). Instead of the basic tetrapolar system of two loci and two alleles there has evolved a system with two loci and multiple alleles, a highly sophisticated mating system that discourages inbreeding, and strongly encourages outcrossing.

This is a system that maximises the ability of the fungus to test new combinations of aggressiveness genes and to accumulate already successful ones. A complex system, which could only have evolved if sexual recombination was an integral part of the life cycle.

Figure 6.6 A cross between the four mating types within a family results in 4 of the 16 crosses producing clamps. The out cross between two unrelated families results in all 16 crosses being successful.



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Di-mon matings

The results observed in dikaryon-monokaryon (di-mon) matings for sib-composed dikaryons indicated that the nucleus containing the mating type opposite to the original parent is donated to the monokaryon. Dikaryotization occurred readily where the dikaryon was backcrossed to its component parent. In non sib-composed di-mon matings either of the two nuclei has an equal chance of being donated as all should have different mating types alleles. This was demonstrated as dikaryotization of non-sibling monokaryons occurred in all matings.

Sporophore production

Culture and production of Ganoderma sporophores was investigated under laboratory conditions for the continuation of the genetic studies. A selected number of synthesised dikaryons have now been cultured on oil palm mesocarp fibre ready for sporophore production and further genetic studies.

Molecular characterisation

All tester single spore isolates (monokaryons) and generated dikaryons have been cultured and total DNA extracted.

Mitochondrial DNA (mtDNA)

The plant pathology laboratory does not have the facilities to separate mt DNA from other fungal DNA. On advice from IMI, restriction enzyme digests were carried out on total genomic DNA using recommended enzymes. Initial digests on monokaryons showed some differences between families but not within a family, however, resolution of fragments on gels was not satisfactory. A probe was made from a single copy mitochondrial fragment at IMI and brought to PNG by Rob Miller in November 1996. A subsequent visit by Paul Bridge to verify the use of the probe revealed that there was some mitochondrial polymorphism. A probe was then made from one of the single spore isolates for later use. As the probe involves a procedure that can take several days to obtain a result, its use has been discontinued pending an investigation of other methods.

It was decided that a PCR method would be used to initially screen monokaryons in a family to reveal any polymorphism. This has been done for a minimum of ten single spore isolates from three families. Isolates that have shown differences have been crossed and cultured for further analysis of mitochondrial DNA.

Nuclear DNA

Initial suggestions on the use of various markers including isozymes were not considered of use in the genetic studies on *Ganoderma* since most of these methods were testing products from total genomic (?) DNA. The use of PCR RAPDs as a potential tool for this work was therefore pursued. Twenty primers were obtained and single spore isolates were screened from each family. Preliminary screening involved optimising the reaction conditions for each primer for reproducible results. Several primers revealed polymorphism in nuclear DNA between sibling monokaryons but these did not correlate with mating type. Polymorphism was more evident between families. Having established the characterisation of individual monokaryons the next step was to determine if generated dikaryons could be identified after mon-mon matings. This was demonstrated after some variations in PCR reaction conditions. The same technique is now being optimised for use in the di-mon matings as a means of following nuclear exchange during dikaryotization.

Population studies

Planning for this work has been finalised and confirmation on numbers and sampling plan will be finalised with a statistician before work begins.

Work will begin shortly on amplification of the ITS region and other markers (SSreps, Scars etc.) for use in field population studies.

Publications

Three papers have been accepted for publication during the year. The first two were overviews designed at introducing workers in the field of *Ganoderma* to a new perspective of basal stem rot control.

- ***Ganoderma* Basal Stem Rot, An Enigma, Or Just Time To Rethink an Old Problem.** Accepted in May for publication in **The Planter**.
- **The Importance of Spores in the Epidemiology of Ganoderma.** Presented at the ISOPA Conference in Colombian during early September.
- A poster paper entitled **Basal Stem Rot of Oil Palm - Back to Basics**. Is to be presented at the APPS meeting in Perth in September.

Appendix 1

Meteorological Data – 1997

Table: Rainfall (mm)

Month	NBPOL (Dami)	Hargy	Poliamba (Lakurumau)	Milne Bay (Waigani)	Higaturu (PNGOPRA)	SIPL
Jan	406	442	193	210	236	290
Feb	600	448	370	154	279	248
Mar	439	976	42	209	57	605
Apr	86	163	242	162	82	275
May	152	203	379	89	131	28
Jun	113	35	2	92	1	26
Jul	214	121	44	232	87	25
Aug	0	13	1	72	24	137
Sep	152	48	52	76	33	135
Oct	0	7	22	31	67	47
Nov	169	325	50	30	83	47
Dec	256	366	368	33	315	61
Total	**2587**	**3147**	**1765**	**1390**	**1396**	**1924**

Table: Sunshine Hours

Month	NBPOL (Dami)	Hargy	Poliamba (Kavieng)	Milne Bay (Bomata)	Higaturu (PNGOPRA)	SIPL
Jan	78	174	179	163	159	156
Feb	28	117	121	120	131	133
Mar	53	76	199	108	144	141
Apr	140	201	167	156	148	159
May	184	188	200	214	196	213
Jun	235	198	258	166	122	211
Jul	137	136	172	145	130	183
Aug	274	282	288	202	158	139
Sep	238	251	259	187	200	166
Oct	277	263	253	256	200	227
Nov	164	210	227	232	149	225
Dec	165	183	184	229	112	203
Total	**1973**	**2279**	**2507**	**2178**	**1849**	**2156**