ELEVENTH ANNUAL REPORT

OF THE

PAPUA NEW GUINEA

OIL PALM RESEARCH ASSOCIATION

1991

ELEVENTH ANNUAL REPORT

OF THE

PAPUA NEW GUINEA

OIL PALM RESEARCH ASSOCIATION

1991

CONTENTS

INTRODUCTION

PART 1. ADMINISTRATION

PART 2. RESEARCH

I. AGRONOMY TRIALS
(Islands Provinces)

II. SMALLHOLDER DEMONSTRATION TRIALS
(Islands Provinces)

III. AGRONOMY AND SMALLHOLDER TRIALS

III. AGRONOMY AND SMALLHOLDER TRIALS
(Mainland Provinces)

IV. ENTOMOLOGY AND PATHOLOGY

APPENDICES

MANAGEMENT BOARD

Chairman	Mr J Montgomerie (to March) Mr J Wijnand (From March)
New Britain Palm Oil Development Ltd	Mr J Montgomerie
Higaturu Oil Palms Pty Ltd	Mr C Warn
Milne Bay Estates Pty Ltd	Mr H Marmelstein
Poliamba Plantations Pty Ltd	Mr M Collins
Hargy Oil Palms Pty Ltd	Mr J Wijnand
Dept of Agriculture and Livestock	Mr D Tomlinson
Director of Research	Dr H L Foster
Managing Agents Representative and Secretary	Mr A R McMaster

SCIENTIFIC ADVISORY BOARD

Chairman	Mr J Wijnand
New Britain Palm Oil Development Ltd	Mr M Redshaw
Higaturu Oil Palms Pty Ltd	Mr L Chase
Milne Bay Estates Pty Ltd	Mr L Chase
Poliamba Plantations Pty Ltd	Mr L Chase
Hargy Oil Palms Pty Ltd	Mr D Laing
Dept of Agriculture and Livestock	Dr D Tomlinson
Director of Research	Dr H L Foster
Managing Agents Representative and Secretary	Mr A R McMaster

EXECUTIVE STAFF

Dirctor of Research	H L Foster, MA MSc PhD (until December)
Agronomist (Dami)	I Orrell, BSc
Senior Entomologist* (Dami)	R N B Prior, MSc
O-i-C Higaturu Station (Higaturu)	A S Wilkie, MSc (until May) C Marriott, BSc (from April)
Extension Agronomist (Dami)	P Navus, BAg MSc
Assistant Agronomist (Higaturu)	A Oliver, BSc
Research Assistant (Dami)	P Talopa, BAg DipAg
Assistant Entomologist (Dami)	T M Solulu, BAg
Research Assistant (Higaturu)	J J Yambun, BAg

* On attachment from the Department of Agriculture and Livestock.

NON-EXECUTIVE STAFF

DAMI	
SENIOR TECHNICAL ASSISTANT	Sebastian Embupa
SENIOR SUPERVISOR	Balib Rimandai
SUPERVISOR	Patrick Kamo
SENIOR RECORDER	Blasius Lukara
RECORDERS	Petrus Sokip
	Japson Dapo
	Simon Makai
	Paul Lus
	Jason Yalikua
	Harry Moraki
	Martin Gulan
	Mandako Dungu
	Kelly Naulis
DRIVER/HANDYMAN	James Duke
CONFIDENTIAL SECRETARY	Ludwina Mariu
ACCOUNTS CLERK	Camillus Golu
ASST. ACCOUNTS CLERK	Janet Luan
RECORDS CLERK	Bernadine Bubu
HARGY	
SUPERVISOR	Philip Sio
KAPIURA	
SUPERVISOR	Steven Malagau
POLIAMBA	
SUPERVISOR	Topulul Tiega
HIGATURU	
TECHNICAL ASSISTANT	Daniel Tomare
SUPERVISOR	Wawada Kanama
RECORDERS	Graham Bonga
	Ben Gibson
	Tom Max
RECORDS CLERK	Ian Ereki
DRIVER/RECORDER	Kasup Walpinum
MILNE BAY	
SUPERVISOR	Tom Rivas
RECORDER	Isabel Abraham

CHAIRMAN'S STATEMENT

The past year has seen quite a few staff changes, of which the resignation of the DOR, has made the biggest impact; at time of writing this report he has not been replaced, although interviews have been conducted. It is hope that this situation is remedied soon.

The second influence of importance is the severe financial situation which seems to affect the entire country, but certainly also some of the OPRA member companies and therefore OPRA itself. At this point a word of thanks must be addressed to the managing agents H&C for their continued professional involvement.

It is believed that the main factor limiting oil palm yields in PNG is nutrient deficiency. As a consequence most of PNGOPRA's resources are directed towards investigating crop nutrition. Under the direction of Dr Foster, PNGOPRA has made many advances towards the understanding and correction of a number of nutritionally based constraints to our production. It has been demonstrated in many areas that following PNGOPRA recommendations, major nutritional limitations to optimal crop production, such as nitrogen and potassium deficiences, have been controlled. Also less obvious problems such as widespread sub-optimal chlorine levels are likely to be a thing of the past. As these major nutritional limitations to crop production are being controlled in many regions, other possibly more challenging nutritional problems are coming to the fore and will offer a considerable challenge to the staff of PNGOPRA for a number of years to come.

PNGOPRA continues to police our crop for incursion of damaging pests and diseases. Under the guidance of PNGOPRA the PNG oil palm industry has been following an effective program of integrated pest management. The approach has been made possible due to the successful captive breeding of biocontrol agents by the PNGOPRA Entomology Department.

PNGOPRA smallholder demonstrations have increased in 1991 to a total of 53 distributed throughout the Islands and Mainlands Provinces. A total of 33 educational field days were organised in order to illustrate to the smallholder sector the benefits of correct agronomic management.

The "environment" and "environmental protection" have recently become fashionable concepts. It is interesting to note that PNGOPRA and the PNG oil palm industry has for many years been researching and implementing practices conducive to minimizing the environmental impact of this important industry. Examples include the integrated pest management program which markedly reduces the need for pesticide intervention. Where pesticides must be used, these are delivered in such a way as to strictly limit or totally avoid impact upon non-pest species. Research into crop/mill waste usage has lead to the routine use of mill wastes in an agronomic context. Such an approach has major impact upon reducing environmental contamination, increasing soil organic matter and hence soil fertility, minimising soil erosion and maximising the efficiency of applied inorganic fertilisers. Needless to say research effort is continuing into these areas.

I would like to thank, on behalf of the PNGOPRA Management Board, Dr. Foster and his staff for the quality and productivity of their work over the last year despite the often difficult working environment. I would also like to express our hopes that the standards set over the last few years will be continued in the future.

JOHN WIJNAND
CHAIRMAN

PART 1. ADMINISTRATION

MANAGEMENT BOARD AND SCIENTIFIC ADVISORY BOARD

The Management Board met twice in 1991. The first meeting was held at the offices of Harrisons and Crosfield (PNG) Ltd, Lae, on the 20th March; the second was held at the offices of Higaturu Oil Palms Pty Ltd, Popondetta, on 10th October. The Tenth Annual General meeting of the Association was held in Popondetta on the 10th October at which Mr John Wijnand was elected Chairman of the Association. Harrisons and Crosfield (PNG) Ltd were re-elected as Managing Agents for the ensuing year.

STAFF

The Director of Research, Dr H L Foster, advised the Association in September of his intention to resign in December 1991. Dr. Foster left PNGOPRA in December, but a successor had not been appointed by the end of the year.

The Officer in Charge of the sub-station at Popondetta, Mr A S Wilkie, resigned and left PNGOPRA in May. Mr Willkie's replacement, Mr C Marriott, took up the position in April.

In October, the Senior Entomologist, Mr R N B Prior, advised the Association that he was intending to leave DAL employment in January 1992, thus ending his secondment to PNGOPRA.

Mr Alan Oliver, the Assistant Agronomist at Popondetta, started an MSc course in Tropical Agricultural Development at Reading University, UK , in September 1991.

The non-executive staff establishment at the end of 1991 was eighteen at Dami, seven at Popondetta, two at Milne Bay and one each at Bialla, Kapiura and New Ireland.

VISITORS

To PNGOPRA, Dami:

Brian S Gray	HFAS , UK
J P Baskett	H&C (PNG) Limited
John Zao	Manager IRSD, NBPOD, Mosa
Fraugois Rognon	IRHO Coconut Division, Paris, France
T Ovasuru	PNGCCRI, Rabaul
Albab Akanda	Asian Development Bank, Manila
F Bakani	DAL, Port Moresby
Oscar P Natera	Landell Mills, Australia
A J Barnes	DAL, Kimbe

P Tainole	DAL, Nahavio
Derek Waymark	Landell Mills, England
A T Loclhe	MTPL
Luisa H Tang	Asian Development Bank, Manila
Jean P Morin	CIRAD/IRHO, Santo Vanauta
Tony Royle	Computers & Communication, Port Moresby
Ross McMaster	H & C (PNG) Ltd
Yapi Delabu	Price Waterhouse, Lae
Rodrico Vivas	Amadbus Trading
Robato	E.C.P.R.A.
Felixe Casfilli	Representaciones, Honduras
Carlos Rodriques	C.O.A. Palma, Honduras
J Wijnand	Chairman PNGOPRA / G.M., Hargy Oil Palms.
Dr Surya Natu	Unitec, Lae
Charles Marriot	PNGOPRA, Popondetta
Greg M Mongi	Project Officer, WNBPG
Maggie Moi He	Research Assistant, UNDP, Port Moresby
Philip Colol	Mora Mora Vocational Centre
Isidore Mission	DAL, Lae
Peter Aisa	DAL, Kimbe
R Sumihar	Bah Lias Research Station, Lonsum
Meidy Sumihar	Bah Lias Research Station, Lonsum
Roger Marshall	HOPPL, Popondetta
Mike Thomas	DAL, Port Moresby
Robin Atkins	DAL, Popondetta
K L Lim	Asian Development Bank, Manila
David S Sobel	Asian Development Bank, Manila
A K Auckland	Asian Development Bank, Manila
Ken Praw	Consultant, OPIC
Killian Anoser	DAL, Port Moresby
A J Barnes	DAL, Kimbe
Bernard J Schmiat	Poliamba, New Ireland
Wesley Kurang	Poliamba, New Ireland
Jack Kaeaka	Poliamba, New Ireland
Dauka Bulum	Poliamba, New Ireland
Geoff Brown	H&C PLC, London
Vincent Freedman	KBSA, Kimbe
Nick Lyons	KBSA, Kimbe
W A Greasley	HFAS, Duns, Scotland
G C Easthaugh	HFAS, Duns, Scotland
B S Gray	HFAS, UK
M S Redshaw	HFAS, UK
F Daink	DAL, Port Moresby
Jan Venema	DAL, Port Moresby
Boas Daniel	DAL, Kimbe
Kee Khan Kiang	AAR, Malaysia
I A Dickson	H&C (PNG) Ltd, Mosa
N M Thompson	Senior Manager, NBPOD, Mosa

Norrie Oba	Poliamba, New Ireland
N Jonah	Poliamba, New Ireland
Albert Bika	Poliamba, New Ireland
Eruel Vincent	Poliamba, New Ireland
N Sekhran	Dept of Finance, Waigani, NCD
I Pomaleu	Dept of Finance, Waigani, NCD
Nihal Amerasinghe	ADB, Manila

To PNGOPRA, Higaturu:

Roger S Baboa	HOPPL
Jerry Kanson	HOPPL
Bob Schull	Astrolabe Pty Ltd
Ronald Taita	Astrolabe Pty Ltd
Rob Lockwood	CDC, London
Moal Biron	Volcanology Observation, Rabaul
Julie Ravel	Volcanology Observation, Rabaul
Soldier Buruka	DAL, Port Moresby
Iebiri Ova	DAL, Popondetta
Roger Gillbanks	V A
John Konimor	OPRS, Dami
Peter Taboko	Volcanology Observation, Rabaul
Aipisai Jubille	Volcanology Observation, Rabaul
Dr H L Foster	PNGOPRA, Dami
Pahice-de-Santa	Volcanology Observatory, Rabaul
Sean Trevethan	Volcanology Observatory, Rabaul
Tony Skelton	Islands Helicopters, Rabaul
Kee Khan Kiang	AAR, Malaysia

Note:

ADB	= Asian Development Bank
AAR	= Applied Agricultural Research
CDC	= Commonwealth Development Corporation
DAL	= Department of Agriculture & Livestock
H&C	= Harrisons and Crosfield
HFAS	= Harrisons and Fleming Advisory Services
IRHO	= Institut de Recherches pour les Huiles et Oleagineux
NBPOD	= New Britain Palm Oil Development Ltd
OPRS	= Oil Palm Research Station, Dami
PNGOPRA	= PNG Oil Palm Research Association

INTRODUCTION BY THE DIRECTOR OF RESEARCH

The work described in this report was done in 1991, and the data processing and drafting of reports were done in 1992.

The report is incomplete in some parts, and is being published late. This is because the Director of Research in 1991 resigned at the end of that year, and during most of 1992 the position remained vacant. Also, the Officer-in-Charge at the Higaturu resigned in the middle of 1991, and was replaced by another officer who resigned at the end of 1991. The Senior Entomologist also left at the end of 1991. Thus in 1992 only one out of the four original senior officers was still in post, and there was a new senior officer at Higaturu. Also the computers at Higaturu could not be used for data processing until the end of May, because of trouble with the power supply.

The report is being published now, incomplete though it is, to avoid further delay. The omissions will be made good in the next annual report.

In this Introduction it is more appropriate to say something about our plans than to try to give an overview of the work done in 1991.

Economic Analysis Of Fertiliser Trials

In this kind of research it is normal practice to do an economic analysis of the results of fertiliser trials.

We intend that the trials will be done in a way that will provide results that lend themselves to such analysis, but the analysis will be done as a separate exercise by each of the milling companies and by the extension service, with the help of OPRA where needed. The reason for keeping the economic analysis separate from the analysis of the trial results is that assumptions are needed about the operating costs of the growers, and these will vary from one company to another and will differ between the milling companies and the smallholders.

The economic analysis assumes that as the amount of fertiliser is increased there are diminishing returns in the amount of extra fruit produced. In other words the response curve is convex. The form of the curve is asymptotic, which in the context of fertilisers and yield is called the Mitscherlich curve. For the economic analysis it is sufficient to describe the curve by the use of a polynomial equation, usually a quadratic. If we assume:

* that when we give fertiliser the extra fruit will be produced one to two years later.

* a discounting rate for the value of the extra fruit.

* an opportunity cost for the money invested in fertiliser.

* a marginal value for the fruit that will be produced one to two years from now.

then we can calculate an upper limit to the amount of fertiliser that should be given. At the upper limit the last toea per palm invested in fertiliser will produce a return that is equal to the return from a supposed alternative investment. The grower can then decide how much fertiliser to give on a scale from zero to the upper limit. For a plantation company, if no fertiliser were given production of fruit might decline to a level where it became uneconomic to operate the mill. The amount of fertiliser given has to be at least far enough up the scale for the combined operations of growing and milling to be profitable.

For some trials the economic analysis cannot be done, or can be done but is unreliable, because of the effects of poaching.

Poaching is the transfer of fertiliser from high fertiliser plots to low fertiliser plots. This happens in two ways. Firstly, the roots of the oil palm can extend up to four rows (30 m) away from the stem, and thus in a trial can trespass on the neighbouring plot and absorb fertiliser. Secondly, fertiliser can be moved from plot to plot in runoff during a rainstorm.

Because of poaching the zero and low fertiliser plots receive more fertiliser than they are supposed to, and produce heavier yields than they should. This has two important consequences:

* The response curve is straightened out, or even inverted becoming concave instead of convex. This makes the economic analysis impossible.

* The response to fertiliser is flattened. The yield from the zero plots is heavier than it ought to be, so the apparent increase in yield brought about by the application of fertiliser is less than it ought to be. The response can be completely flattened, so it appears that there is no benefit at all from fertiliser.

Poaching also has the unfortunate consequence that in demonstrations on smallholder blocks there is usually no visible difference between plots that receive fertiliser and those that do not. Such demonstrations fail to put across the message that fertiliser is good for palms. Indeed they might put across the opposite message. A smallholder who sees that palms that do not receive fertiliser appear to be as healthy as those that do might go away thinking that it is a waste of money to give fertiliser to palms.

We shall eliminate poaching by cutting isolation trenches between plots, using a trenching machine. This is not an ideal solution, but it is the best available.

By eliminating poaching we aim to produce response curves that will be suitable for economic analysis, and to put on demonstrations that are more convincing for the smallholders.

Second Generation Fertiliser Trials

We shall put less emphasis on first generation trials, in which three, four, or even five elements are tested at two or three levels,and more emphasis on second generation trials in which one or two elements are tested at several levels.

It is usual practice when oil palms are planted in new areas to do first generation trials to find out which elements are needed and which are not, and to get a rough idea of the quantities needed. In such trials if only two levels of an element are used an economic analysis is not possible, and if three levels are used an economic analysis is possible, but the result is approximate. The importance of these trials is that they tell you which elements should be tested in the second generation trials.

In second generation trials one element at several levels is looked at, or two elements at several levels in factorial combination. The results are more useful for economic analysis, because a response curve, or response surface can be determined more accurately.

We are planning to do a nitrogen x potassium trial on Sagarai Estate at Milne Bay Estates. We know already that there are unlikely to be responses to magnesium and to phosphate. One hundred and four plots have already been planted with 16 progenies that are randomised within each plot. This will help to minimise the variation between plots, and thus decrease the coefficient of variation.

Second generation trials will also be considered for other areas.

Frequency Of Application Of Fertiliser

In some trials the response to nitrogen is almost linear up to 6 kg of ammonium sulphate per palm. The implication is that if more ammonium sulphate were given the yield would continue to rise significantly. Six kilograms of ammonium sulphate is a large dressing, and we would expect that at that level the yield would already be close to the maximum.

It is possible that large applications of fertiliser are needed because much of what is given is lost by run-off of water and soil erosion. The oil palm areas all have high rainfall, and the soils, especially at Higaturu and in West New Britain, are easily eroded.

If much of the fertiliser is lost because of the high rainfall, a possible solution is to give the fertiliser more often, but in smaller doses. This could lead to the same yield being obtained but using less fertiliser, or the same amount of fertiliser being used but giving a heavier yield. This should be investigated to see whether the extra cost of labour is offset by a saving in the amount of fertiliser used, or by an increase in the amount of fruit harvested.

Potassium And Chlorine

At Higaturu there has been a gradual decline over the years in the level of potassium in the fronds. This is probably the result of the fertiliser policy whereby only ammonium chloride and ammonium sulphate have been given in recent years, and potassium has not been given. This policy is based on the belief that the chlorine levels in the fronds were too low, and that when the yield in trials increased in response to applications of muriate of potash it was the chlorine that was effective rather than the potassium. There are few visible signs of potassium deficiency in the fronds (orange spotting, or a diffuse yellowing of the leaflets on the older fronds), and yields have remained around 30 t/ha. But there is much bunch end rot which might be a sign of potassium deficiency.

The questions that we are now facing are whether the potassium levels have fallen so far that yields will be limited by a deficiency of potassium, and should we be recommending the use of muriate of potash. The questions should be answered by trial 310, but it has not been running for long enough (since the present treatments were started) to give a definitive answer.

Magnesium

Trials in West New Britain have shown that the palms respond to applications of fertiliser nitrogen, but over the years the response to nitrogen has declined.

This decline in the response to nitrogen has been paralleled by a decline in the level of magnesium in the fronds. Magnesium levels in many places are now down to levels that would normally be considered as limiting to production.

The implication is that a steadily worsening deficiency of magnesium is causing the decline in the response to nitrogen.

Large applications of kieserite have not brought about any increase in the level of magnesium in the fronds, even in areas where the natural level in the fronds is now very low.

We must find a way of determining whether the palms really are deficient in magnesium. If they are then we must look for a way of making magnesium available to the palms so that they can absorb it, with an increase in yield that is economical.

Phosphorus

In West New Britain and in Higaturu the levels of phosphorus in the fronds are generally very low. Such levels would normally be considered as limiting to yield.

In trials there has usually been no response to the application of phosphate, in either the production of fruit or the level of phosphorus in the fronds. There might be no response because the phosphate that is given as fertiliser is absorbed onto the clay minerals. The soils are derived from recent volcanic ash. Their natural content of phosphate is low, and they contain much allophane, which strongly absorbs phosphate.

We must find a way of determining whether the palms really are deficient in phosphorus. If they are we must look for a way of making phosphorus available to the palms so that they can absorb it, with an increase in yield that is economical.

Data Processing And Statistical Analysis

We intend that our computer programmes for storage and processing of data will be documented, and that our staff will be trained in their use. Oil palm trials generate huge amounts of data. Also the designs of the trials are often complex, and require quite sophisticated statistical analysis. We have custom written programmes for the storage and processing of data, and Genstat for the statistical analyses. However, the methods that we use have evolved over several years, so there are some inconsistencies, and there is little documentation. Now is the time to standardise the methods used throughout OPRA, to document the programmes, and to train our staff in how to use them.

Crop Forecasting

We shall develop a method of forecasting the amount of fruit that will be produced month by month. The forecast will be made further ahead than the four months or so that is possible by the method of black bunch counting. The forecast will be based on weather observations, together with information about the climate, soil conditions, topography, and planting material.

If the forecasting method is sufficiently reliable it will help the plantation companies:

* in drawing up the budget for the following year.
* in giving notice to the mill manager of the amount of fruit to be expected.
* in identifying the cause when there is an unexpected shortfall in the amount of fruit delivered to the mill (as sometimes happens).

We shall use information that is already available from fertiliser trials.

We shall also set up 'benchmark plots'. These will be given either no fertiliser, or generous amounts of fertiliser, and yield will be recorded. The yields will give us the top and bottom reference points on a scale of potential fruit production.

Benchmark plots could be set up on smallholdings. One block of four hectares would be used as one benchmark plot. A four hectare block contains 480 palms, which is a better recording unit than the standard trial plot containing 16 palms. Furthermore, the yield from a smallholder block is recorded accurately at each harvest by the Transport Company, so there would be no need for the OPRA staff to laboriously weigh the fruit on a small balance.

Encouraging The Smallholders

Our main activities in relation to smallholders are:

* to make available the results of research, through the extension service of OPIC. This includes fertiliser recommendations, and the identification and control of pests and diseases.

* to provide technical education and training to the extension officers of OPIC.

* to assist in the technical education and training of smallholders, when asked to do so by the project managers of OPIC.

* to set up demonstration plots on smallholdings so that smallholders can see the benefits of using fertilisers, and of carrying out other cultural practices correctly.

In addition to the above specific duties, anything that OPRA can do to stimulate the smallholders is beneficial to both the smallholders and the milling companies. Increased production by the smallholders increases their income, not only because they sell more fruit, but because the price they receive for the fruit goes up. The more fruit that passes through the mill the lower are the overhead costs (per ton) of the milling company.

OPRA staff can encourage the smallholders by talking to them, both formally and informally, and by putting on demonstrations. These activities should be done over as wide an area as possible, and to as wide an audience as possible.

The smallholders will be stimulated by the benchmark plots mentioned above. They will be able to see how the fertilised blocks differ from those that do not receive fertiliser. The differences will be more visible than in the existing smallholder demonstrations, for the reasons given earlier in the section on poaching.

The benchmark plots will be most effective as demonstrations if they are made by rehabilitating neglected or abandoned blocks.

It might also be possible to encourage holders of neglected blocks to rehabilitate their blocks by following OPRA's example.

In Oro Province, in 1991, 90% of the smallholders produced less than 20t/ha/yr, and 50% produced less than 12.5 t/ha/yr. It is possible to produce heavy yields, as shown by two percent of the smallholders who produced more than 25 t/ha/yr, some getting as much as 31 t/ha/yr.

Among the worst performers are those who do not need the income, and therefore do not bother to harvest the fruit. The bunches are left to rot on the palms. At certain times of the year when money is needed, for example to pay school fees, there is a sudden burst of activity and fruit is harvested enthusiastically for two or three weeks.

There is also a group who would like to manage their blocks well, but are threatened and bullied by others who are not willing to work themselves, and therefore do not want other people to work.

And there is a third group who work hard, but who do not use fertiliser because they are not convinced of its usefulness, or they claim they cannot afford it.

It is members of this last group and who should be encouraged. The amount of fertiliser recommended to be used by smallholders (in Oro Province for example) is 2 kg/palm/yr. This would cost about K200 for a four hectare block. Many smallholders perhaps believe that they cannot afford this amount of money for fertiliser. We should encourage them to put half the amount on half the area, and see the benefit 18 months later. The extra income generated could then be used to put half the amount on the whole area, and so on, until they were giving the full amount to the full area.

Soil Survey On Smallholdings

Most of the information that we have on fertilisers comes from trials that are done on estates. This is because a trial occupies about ten to twenty hectares, and has to be maintained and harvested to a high standard. If such a trial were done on smallholder blocks we would have to use several contiguous blocks, and it would be difficult to control the harvesting and maintenance, especially as the trial would last for several years.

Fertiliser recommendations for smallholdings are therefore based mostly on information from trials on estates. This matters little because the information from estates is directly transferable to the smallholder blocks, provided that there is not much difference in soil conditions.

We intend to do a broad soil survey on the smallholder blocks to check that the main soil types are included in the range of soil types on which trials are done.

If any soil types are found that are not represented in the existing fertiliser trials then we can set up mini trials. With the results from a mini trial we can adapt the fertiliser recommendations for a similar soil type to suit the hitherto unknown soil type.

Pests And Diseases

Pests and diseases are not a serious problem in PNG, compared with other countries where oil palm is grown.

Our main effort is in monitoring the situation. The occurrence of damage caused by insects is recorded, and specimens are examined to see whether they are parasitised or diseased.

As far as possible pests are kept under control by biological methods, i.e. parasites, predators, and pathogens. The biology of the parasites is studied with a view to being able to encourage them in their natural environment, or perhaps cultivate them.

As part of this work reference collections will be made of insect pests of oil palm, and of the insects that are parasitic on the pests.

The most troublesome pest so far has been the grasshopper-like Sexava, which eats the leaves of palms in West New Britain. A programme of rearing and releasing parasitoids of the egg of Sexava has been in operation for some time and will continue. When biological control is not effective chemicals are used. The standard procedure for Sexava is to inject insecticide into the trunk. We shall seek more quantitative criteria for deciding when to use chemicals against Sexava. Up to now the decision to use chemicals has been a subjective decision made by the entomologist.

Diseases of oil palm are infrequent in PNG. We shall continue to monitor the situation.

I. AGRONOMY TRIALS

ISLANDS PROVINCES

(I.Orrell)

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

PURPOSE

To provide information about the response 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: Dami commercial DxP crosses.
Planted in January 1983 at 135 palms/ha.
Treatment 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).

Table 1. Rates of fertilizer 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 is applied as two equal doses per year.

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.

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 ammonium sulphate and nothing else during the first twelve months.

At 12 months (January 1984) half of the plots were given an application of ammonium sulphate (1 kg/palm) as a treatment (establishment nitrogen).

The treatments that are described in Table 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 reponse to other fertilisers.

Leaflet samples for chemical analysis were collected from frond 17 in July 1991.

Bunches were randomly selected at weekly intervals throughout the year and analysed for oil content and physical characteristics.

RESULTS

None of the fertiliser treatments increased the yield significantly in 1991 (Table 2). Kieserite caused a small decrease in yield due to there being fewer bunches. Chlorine caused a small increase in single bunch weight but the associated increase in yield was slight and not significant.

If we consider the average yield over three years (1989-1991) the fertiliser treatments have had no effect on yield (Table 3). Kieserite and sodium chloride both caused small increases in single bunch weight.

The concentration of nitrogen in leaflet tissue was increased by the application of triple superphosphate (Table 4). This effect has been seen in previous years but has not been statistically significant. The ammonium sulphate application also increased leaflet nitrogen concentrations but this effect was not statistically significant.

The concentration of magnesium in leaflet tissue was increased by the application of kieserite. The increase is the same as reported in 1990, and amounts to an increase of only 0.012 percentage points of magnesium in leaflet dry matter for an application of 3 kg of kieserite.

Table 2. Main effects of the fertiliser treatments on yield, number of bunches and bunch weight in 1991 (Trial 107).

Treatment	FFB Yield (t/ha/yr)	Bunches (no/ha/yr)	Single bunch weight (kg)
N 0	23.5	1270	18.6
N 1	23.9	1270	18.8
N 2	23.4	1250	18.8
P 0	23.7	1260	18.9
P 1	23.8	1290	18.6
P 2	23.3	1240	18.9
K 0	23.8	1280	18.8
K 1	23.4	1250	18.7
Mg 0	**24.2**[1]	**1310**	18.5
Mg1	**23.1**	**1220**	19.0
Cl 0	23.3	1270	**18.3**
Cl 1	23.9	1250	**19.2**
cv%	7.2	8.9	5.7
lsd (N & P)	1.0	68	0.7
lsd (K, Mg & Cl)	0.8	56	0.5

[1] In this and all following tables, bold highlighting indicates significance at $p<0.05$.

Table 3. Main effects of the fertiliser treatments on yield, number of bunches and bunch weight From 1989 to 1991 (Trial 107).

Treatment	FFB Yield (t/ha/yr)	Bunches (no/ha/yr)	Single bunch weight (kg)
N 0	26.0	1620	16.1
N 1	26.7	1650	16.2
N 2	26.5	1630	16.3
P 0	26.5	1630	16.2
P 1	26.2	1640	16.0
P 2	26.4	1620	16.4
K 0	26.5	1650	16.1
K 1	26.2	1610	16.3
Mg 0	26.5	1660	**16.0**
Mg1	26.3	1600	**16.5**
Cl 0	26.3	1650	**16.0**
Cl 1	26.5	1610	**16.5**
cv%	5.4	8.2	4.6
lsd (N & P)	0.9	81	0.5
lsd (K, Mg & Cl)	0.7	66	0.4

Table 4. Main effects of the fertiliser treatments on leaflet nutrient concentrations in July 1991 (Trial 107).

Treatment	Concentration of element in leaflet (as a percentage of dry matter)					
	N	P	K	Mg	Ca	Cl
N 0	2.40	0.150	0.81	0.15	0.72	0.30
N 1	2.42	0.149	0.82	0.14	0.71	0.29
N 2	2.42	0.148	0.82	0.14	0.73	0.30
P 0	2.40	0.148	0.83	0.15	0.72	0.30
P 1	2.41	0.150	0.81	0.14	0.72	0.28
P 2	2.43	0.149	0.81	0.15	0.72	0.30
K 0	2.41	0.149	0.82	0.15	0.72	0.30
K 0	2.42	0.149	0.81	0.15	0.72	0.29
Mg 0	2.41	0.149	0.82	0.14	0.73	0.28
Mg 1	2.41	0.148	0.81	0.15	0.71	0.30
Cl 0	2.41	0.149	0.84	0.15	0.71	0.26
Cl 1	2.42	0.149	0.80	0.15	0.73	0.33
cv%	2.1	1.9	12.1	12.3	5.6	11.7
lsd (N&P)	0.03	0.002	0.06	0.01	0.02	0.02
lsd (K,Mg&Cl)	0.03	0.001	0.05	0.01	0.02	0.02

Kieserite decreased the concentration of calcium in the leaflets, while sodium chloride increased it. Such effects have been observed before.

Kieserite and sodium chloride both increased the concentration of chlorine in the leaflets.

The lack of increase in yield as a result of application of fertiliser can be explained by the generally favourable nutrient status of palms in this trial. In the "control" plot (N0,P0,K0,Mg0,Cl0) the concentrations of nutrient elements in the leaflets were adequate. Interplot poaching of nutrients by palm roots might be responsible for the lack of fertiliser response and favourable nutrient status of the control plots.

Ammonium sulphate applications have significantly depressed fruitset (Table 5) resulting in significantly reduced fruit to bunch values and consequently a decrease in oil to bunch percentage.

Table 5. Main effects of the fertiliser treatments on bunch composition in 1990 & 1991 (trial 107).

Treatment Main Effects	NOSP	BW	FFB	FB	FRWT	WMF	DMF	SHF	KF	DMWM	ODM	FS	OWM	OB	KB
N0	158	19.0	**66.8**	**68.2**	12.7	77.5	50.2	12.1	9.7	63.2	80.1	**62.6**	50.6	**27.5**	6.5
N1	161	19.4	**65.8**	**67.2**	12.7	78.5	50.1	12.0	9.6	63.8	80.1	**60.7**	51.2	**27.0**	6.4
N2	162	19.4	**65.2**	**66.8**	13.1	77.6	49.4	12.7	9.7	63.7	79.7	**59.2**	50.8	**26.3**	6.4
P0	**154**	**18.5**	66.3	67.6	12.7	**78.6**	49.6	**12.0**	**9.4**	63.1	**79.4**	60.9	50.3	26.8	**6.2**
P1	**158**	**19.0**	65.3	67.0	13.0	**78.8**	50.6	**11.9**	**9.3**	64.2	**79.8**	59.7	51.3	27.1	**6.1**
P2	**168**	**20.3**	66.2	67.6	12.7	**76.2**	49.6	**12.8**	**10.3**	63.4	**80.3**	61.9	51.0	26.9	**6.9**
K0	157	19.3	66.2	67.6	12.9	77.6	49.9	12.2	9.7	63.3	79.8	61.1	50.6	27.0	6.5
K1	163	19.2	65.7	67.2	12.8	78.1	49.9	12.3	9.6	63.9	80.1	60.6	51.2	26.9	6.4
Mg0	160	19.2	**66.5**	67.7	13.0	77.7	50.1	12.2	9.7	63.4	80.1	61.6	50.8	27.2	6.5
Mg1	160	19.3	**65.4**	67.1	12.7	78.0	49.7	12.4	9.7	63.7	79.8	60.1	50.9	26.6	6.4
Cl0	158	19.1	65.9	67.3	12.8	78.2	49.7	12.3	**9.5**	63.6	79.9	60.5	50.8	26.8	6.3
Cl1	162	19.4	65.9	67.4	12.9	77.5	50.1	12.2	**9.9**	63.6	80.0	61.2	50.9	27.1	6.5
cv %	7.2	11.4	3.3	3.2	9.7	3.6	2.9	7.8	8.0	4.5	1.0	6.5	4.7	4.9	8.8
lsd (N&P)	7	1.3	1.3	1.3	0.8	1.7	0.9	0.6	0.5	1.7	0.5	2.4	1.4	0.8	0.3
lsd (K,Mg & Cl)	6	1.1	1.1	1.1	0.6	1.4	0.7	0.5	0.4	1.4	0.4	2.0	1.2	0.7	0.3

NOSP = Number of Spikelets/bunch; BW = Bunch weight; FFB = % Fertile fruit to bunch; FB = % Fruit to bunch
FRWT = Single fruit weight (g); WMF = % Wet mesocarp to fruit; DMF = % Dry Mesocarp to fruit; SHF = % Shell to fruit
KF = % Kernel to Fruit; DMWM = % Dry mesocarp to wet mesocarp; ODM = % Oil to Dry mesocarp; FS = % Fruit set
OWM = % Oil to wet mesocarp; OB = % Oil to bunch; KB = % Kernel to bunch

Triple superphosphate caused several significant changes in bunch composition though these changes did not significantly affect oil to bunch values. It increased the bunch weight by increasing the number of spikelets per bunch. The highest rate reduced the wet mesocarp to fruit ratio but increased the oil in the dry mesocarp. The reduction in mesocarp to fruit was accompanied by an increase in kernel to fruit and shell to fruit, with a significant increase in kernel to bunch.

Sulphate of potash, kieserite and sodium chloride treatments had little effect on bunch composition though kieserite significantly decreased the fertile fruit to bunch percentage and sodium chloride increased kernel to fruit percentage.

Trial 108 SYSTEMATIC NITROGEN FERTILISER TRIAL AT KUMBANGO PLANTATION.

PURPOSE

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

DESCRIPTION

Site Kumbango Plantation, Fields E7 and F8.

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

Palms Dami commercial DxP crosses.
Planted in 1972 at 120 palms/ha.
Treatment started in 1984.

DESIGN

Two sources of nitrogen are compared in systematically increasing levels of eight equal steps (the "ladder" design) (Table 6). A set of levels of each source abuts a second set but with the direction of increase of dose in one set being opposite to the other. There are 64 plots made up from two sources of nitrogen, each at eight levels, replicated four times. A single plot consists of the two rows on each side of a harvesting path (twin row) and on average consisting of 33 palms. Two of the replicates are in a field that was mulched with 30 tonnes/ha of EFB in March 1985, the other two replicates are in a field that was not mulched. There are no guard rows between levels but the two sources are guarded from each other and the end rows are guarded.

Table 6. Rates of fertiliser used in Trial 108.

	Level							
	0	1	2	3	4	5	6	7
	(kg/palm/yr)							
Ammonium chloride	0.0	0.9	1.8	2.7	3.6	4.5	5.4	6.3
Diammonium phosphate	0.0	1.2	2.4	3.6	4.8	6.0	7.2	8.4

Note: At each level of fertiliser application, both nitrogen sources supply the same quantity of nitrogen.

Because of evidence indicating the development of magnesium deficiency in this trial, application of kieserite at 4 kg/palm/yr began in November 1989.

RESULTS

There is a suggestion that in 1991 there was an increase in yield of about 8% as the amount of nitrogen (from either source) increased from level 0 to level 2, but the increase was not statistically significant (Table 7).

In earlier years the effects were more pronounced (Table 8 and Figures 1 to 3). Ammonium chloride increased the yield by about 20%, up to level 3, but the increase was not significant. Diammonium phosphate increased the yield by about 32%, up to level 4, and the increase was significant. These increases in yield were brought about by increases in both the number of bunches, and single bunch weight. For diammonium phosphate the effect on number of bunches was larger than on single bunch weight.

Following the peak in yield response about 12 months after the first fertiliser application there has been a decline in the yield response to nitrogen fertilisers (Figure 4). The decline is thought to be due to an increasingly severe magnesium deficiency. The introduction of a kieserite treatment has not, up till now, restored the nitrogen response (Figures 5 and 6).

For the period 1989 to 1991 the plots receiving kieserite had a lower mean yield (17.7 compared to 18.2 t FFB/ha/yr). In 1991 the mean yield from plots recieving kieserite was higher than from those not recieving kieserite (15.2 compared to 14.9 t FFB/ha/yr). These effects are not statistically significant but they might indicate that a response to kieserite is beginning.

Table 7. The effects of fertiliser treatments on yield, number of bunches and bunch weight in 1991 (Trial 108).

N Level Applied	FFB Yield (t/ha/yr)				No. of Bunches (No./ha/yr)				Bunch Wgt. (kg/Bunch)			
	A.C.		D.A.P.		A.C.		D.A.P.		A.C.		D.A.P.	
	-Mg	+Mg	-Mg	+Mg	-Mg	+Mg	-Mg	+Mg	-Mg	+Mg	-Mg	+Mg
0	13.0	15.8	13.5	13.4	564	601	581	551	23.0	26.1	23.3	24.5
1	14.3	14.4	15.2	15.3	597	578	672	649	24.0	25.0	22.7	23.7
2	15.3	15.2	15.0	14.4	627	606	645	610	24.6	25.1	23.4	23.6
3	14.6	17.5	15.5	14.7	603	676	681	627	24.3	26.0	22.8	23.4
4	15.7	12.4	16.0	17.2	639	499	632	734	24.6	24.8	25.4	23.3
5	14.8	14.2	16.2	17.2	604	543	721	709	24.4	26.1	22.6	24.3
6	13.5	15.0	15.9	16.6	561	620	688	703	24.0	24.3	23.1	23.6
7	14.0	16.4	14.7	13.4	576	674	653	543	24.3	24.3	22.6	24.8
Linear Response	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Quadratic Response	ns	ns	ns	0.033	ns	ns	ns	0.014	ns	ns	ns	ns

Table 8. The effects of fertiliser treatments on yield, number of bunches and bunch weight from 1989 to 1991 (Trial 108).

N Level Applied	FFB Yield (t/ha/yr)		No. of Bunches (No./ha/yr)		Bunch Wgt. (kg/Bunch)	
	A.C.	D.A.P.	A.C.	D.A.P.	A.C.	D.A.P.
0	16.2	15.3	685	663	23.7	23.0
1	16.6	16.3	695	711	23.9	23.0
2	17.8	17.4	725	727	24.6	24.0
3	19.4	17.8	740	743	26.3	23.9
4	17.7	20.2	682	808	25.9	25.0
5	18.4	20.8	696	851	26.4	24.5
6	17.1	20.0	698	812	24.6	24.7
7	18.0	17.9	703	717	25.7	25.0
Linear Resp.	ns	<.001	ns	0.012	0.028	0.003
Quadratic Resp.	ns	0.004	ns	0.010	0.049	ns

Figure 1: Trial 108, FFB Yield, Jan89 - Dec91

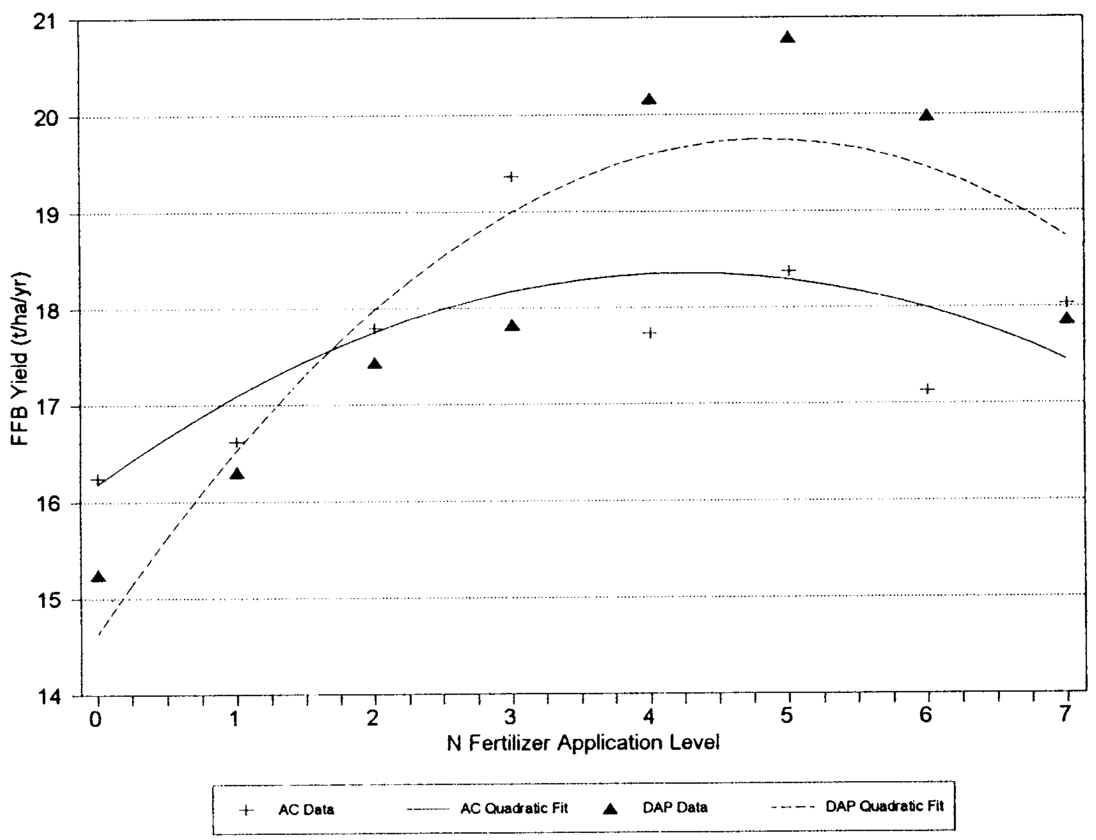


Figure 2: Trial 108, No. of Bunches, Jan89 - Dec91

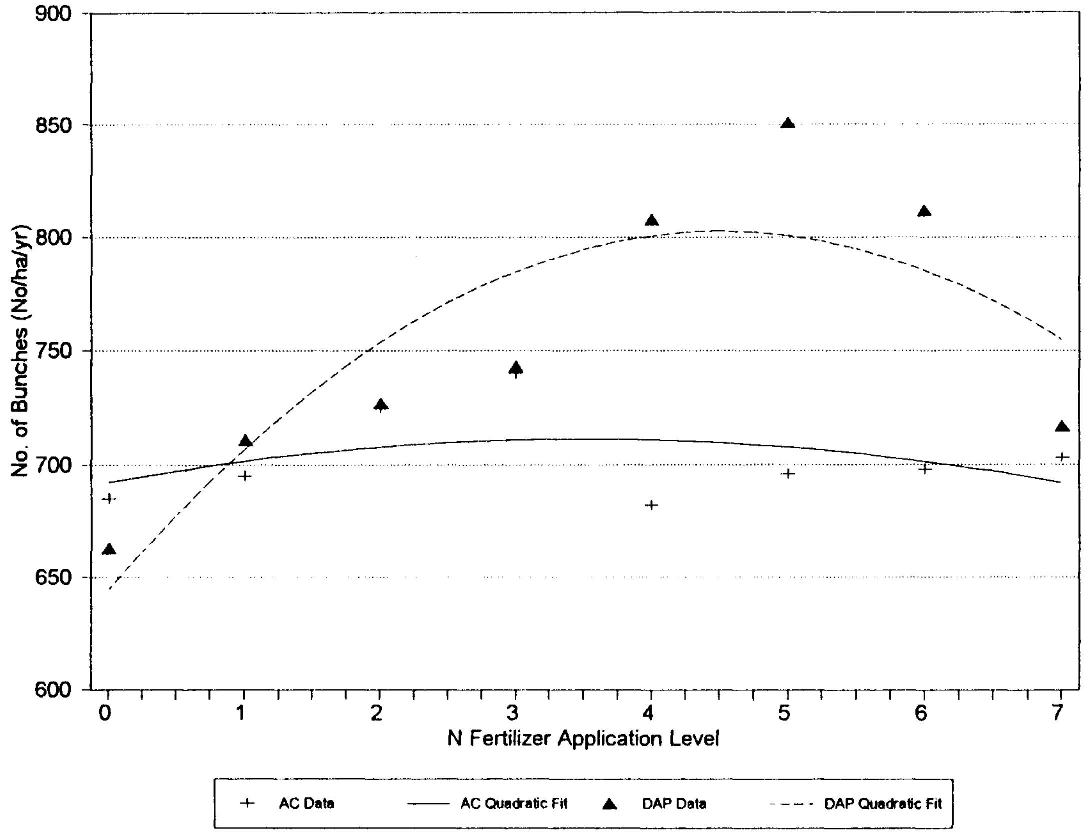


Figure 3: Trial 108, Single Bunch Weight, Jan89 - Dec91

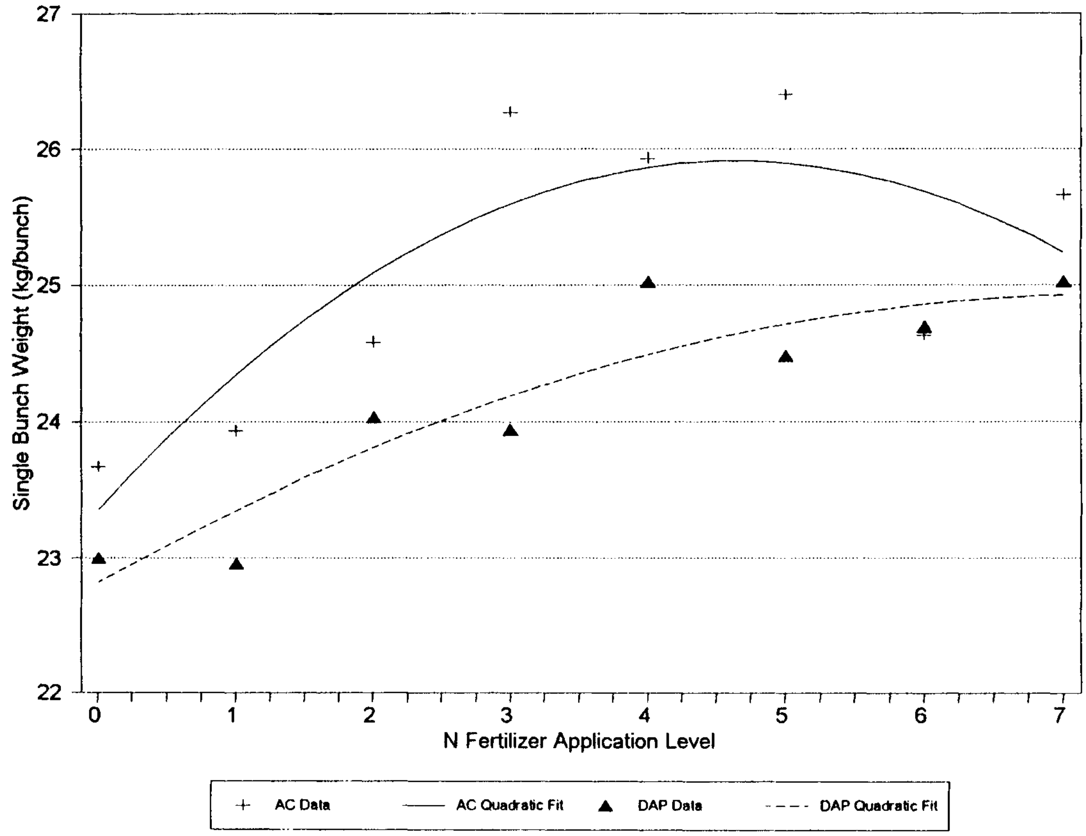


Figure 4: Trial 108. Effect of Treatment and Time on FFB Yield Response.

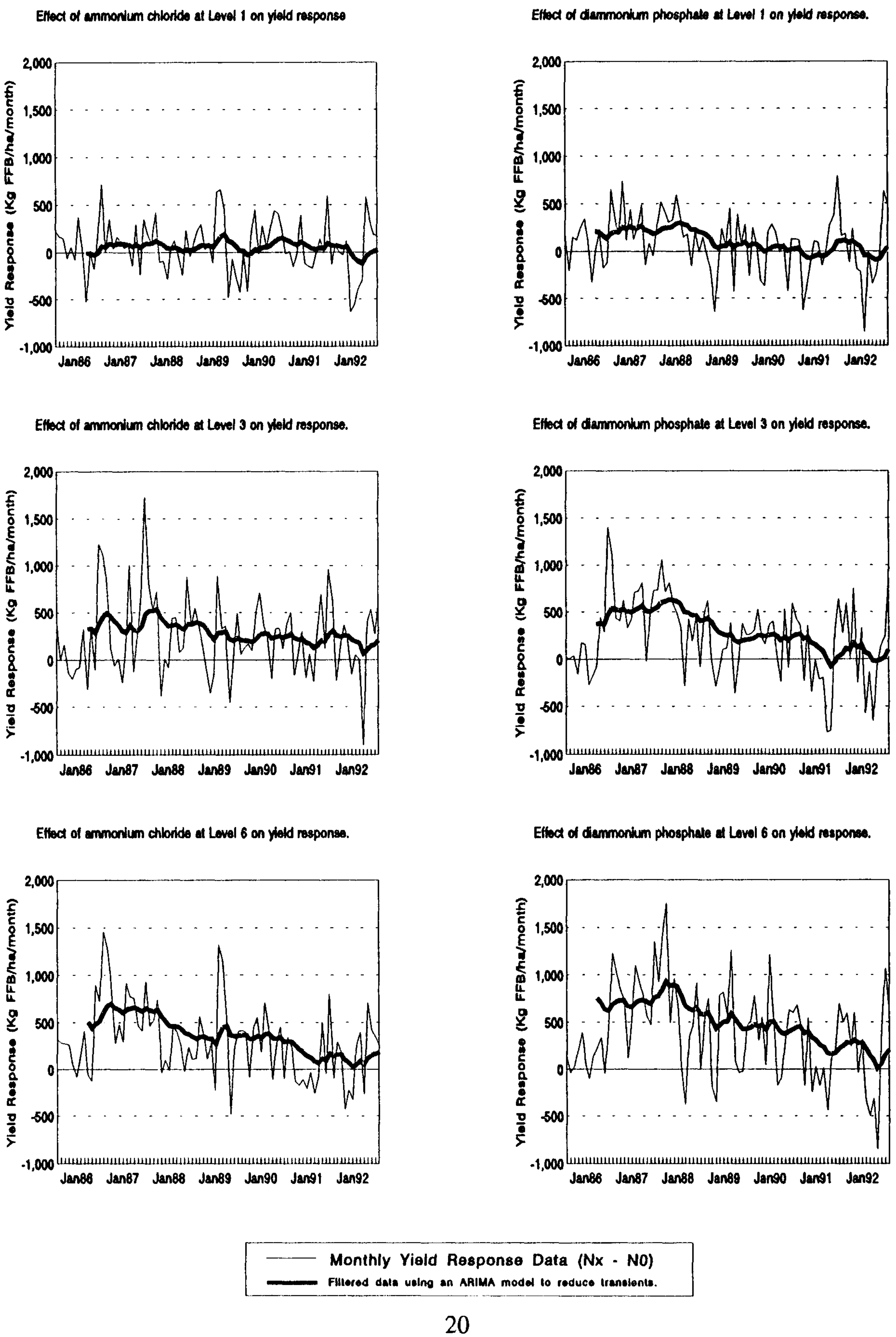
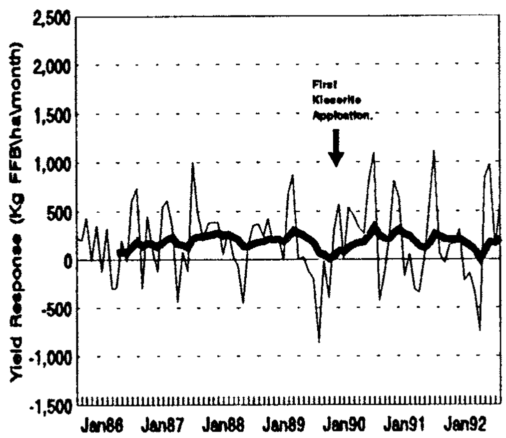
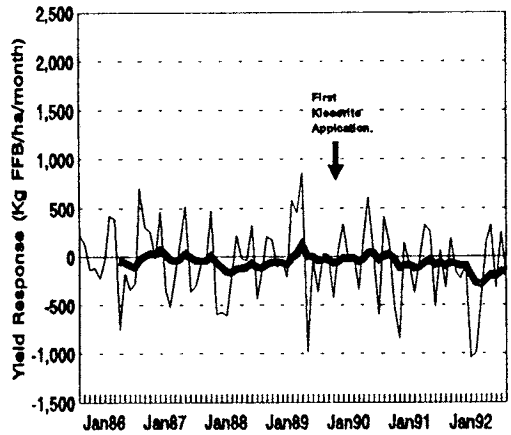


Figure 5: Trial 108. Effect of ammonium chloride treament plus & minus Kieserite.

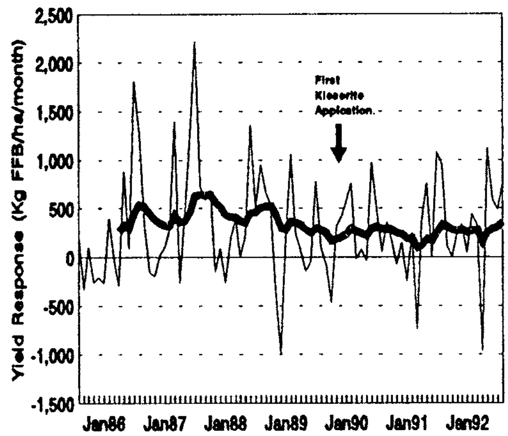
Effect of AC Level 1 minus Mg on FFB yield.



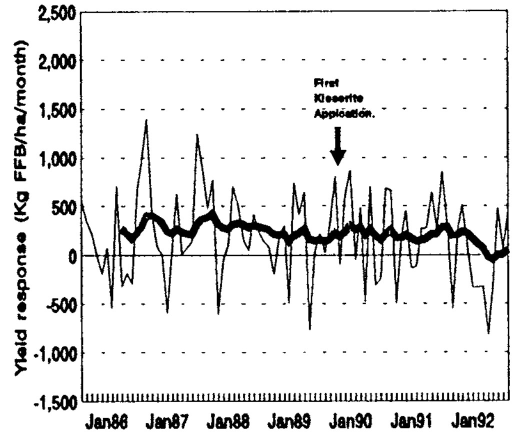
Effect of AC Level 1 plus Mg on FFB yield.



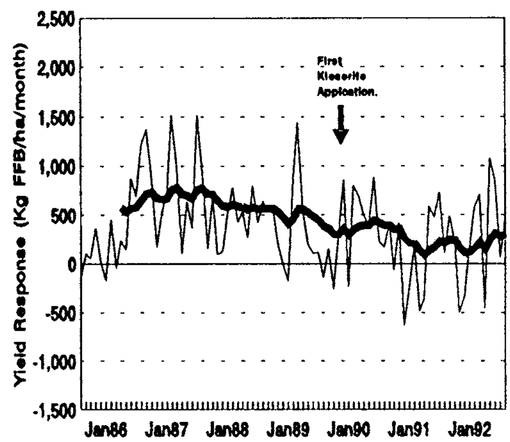
Effect of AC Level 3 minus Mg on FFB yield.



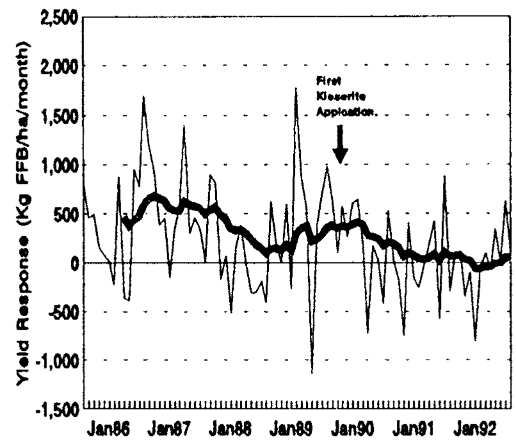
Effect of AC Level 3 plus Mg on FFB yield.



Effect of AC Level 6 minus Mg on FFB yield.

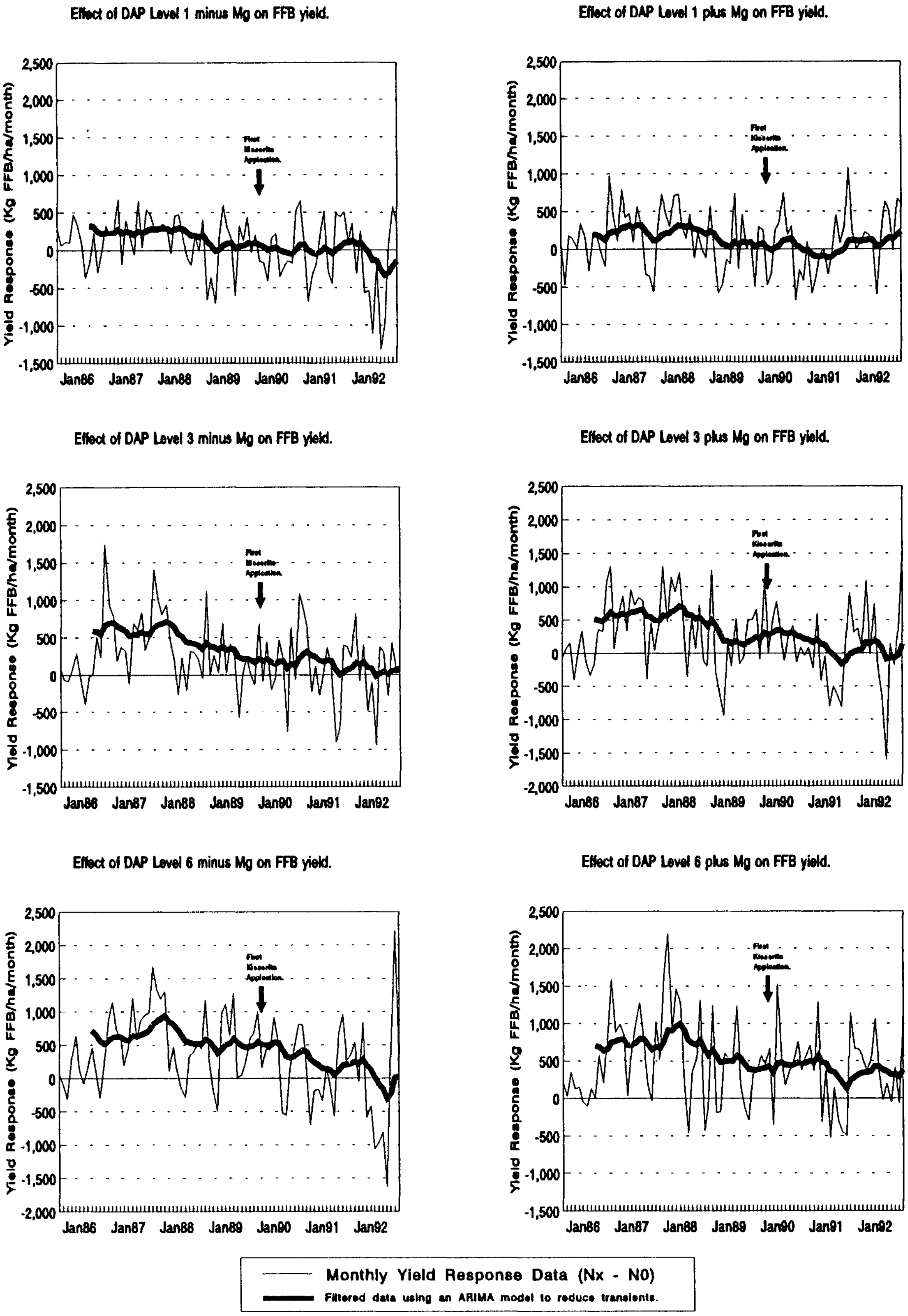


Effect of AC Level 6 plus Mg on FFB yield.



Monthly Yield Response Data (Nx - N0)
Filtered data using an ARIMA model to reduce transients.

Figure 6: Trial 108. Effect of diammonium phosphate treatment plus & minus Kieserite.



Samples of leaflet and rachis, for chemical analysis, were collected in August 1991.

In 1991, due to a problem with fertiliser supply, no fertiliser was applied to the trial prior to sampling. This should be considered when interpreting the effect of treatments on nutrient concentrations in plant tissue.

Both nitrogen fertilisers increased the concentration of nitrogen in the leaflets (Table 9) from about 2.2%N, which is regarded by OPRA as nitrogen deficient, to about 2.4%N, which is regarded low. Ammonium chloride caused a significant increase in the concentration of nitrogen in the rachis. Diammonium phosphate had little effect on the concentration of nitrogen in the rachis.

Diammonium phosphate significantly increased the concentration of phosphorus in the leaflets, but not in the rachis. Ammonium chloride significantly increased the concentration of phosphorus in the leaflets, but caused a reduction in the rachis.

Ammonium chloride increased the concentration of chlorine in the leaflets and rachis. Diammonium phosphate decreased the concentration of chlorine in the rachis and had no effect on the concentration of chlorine in the leaflets.

The nitrogen fertilisers did not significantly affect the concentration of total bases.

Ammonium chloride up to a rate of about 5 kg/palm/year, increased the concentration of calcium in the leaflets and rachis. It did not significantly change the concentration of potassium in the leaflets or rachis. At rates less than 2 kg palm/yr it increased the concentration of magnesium in the leaflets, but all rates decreased the ratio of magnesium to total bases in the leaflets. It did not significantly affect the concentration of magnesium in the rachis.

Diammonium phosphate increased the concentration of magnesium and potassium in the leaflets, and significantly decreased the concentration of calcium. It did not significantly affect the concentration of bases in the rachis.

Table 9a. Effect of fertiliser treatments on leaflet tissue levels in August 1991 (Trial 108).

A.C.	Frond 17 Leaflet Nutrient Levels (as % D.M.)						Base/Total Bases (as %)			Total Bases
Level	N	P	K	Ca	Mg	Cl	K	Ca	Mg	(meq/100g)
0	2.23	0.140	0.74	0.76	0.15	0.33	27.2	54.7	18.1	69.1
1	2.22	0.139	0.70	0.82	0.16	0.35	24.9	57.0	18.1	71.7
2	2.26	0.141	0.75	0.87	0.16	0.38	25.2	57.4	17.4	75.5
3	2.29	0.140	0.71	0.83	0.14	0.38	25.4	58.4	16.2	71.0
4	2.28	0.143	0.69	0.84	0.14	0.37	24.7	59.1	16.2	71.1
5	2.32	0.143	0.73	0.82	0.14	0.40	26.1	57.9	16.1	71.1
6	2.35	0.145	0.70	0.81	0.13	0.40	25.8	58.8	15.5	68.9
7	2.40	0.146	0.75	0.83	0.15	0.40	26.3	57.1	16.6	72.7
linear response	<.001	<.001	ns	ns	0.009	0.001	ns	0.043	0.003	ns
quadratic resp.	ns	ns	ns	0.046	ns	ns	ns	0.013	ns	ns

D.A.P.	Frond 17 Leaflet Nutrient Levels (as % D.M.)						Base/Total Bases (as %)			Total Bases
Level	N	P	K	Ca	Mg	Cl	K	Ca	Mg	(meq/100g)
0	2.21	0.140	0.78	0.79	0.16	0.30	27.5	54.6	17.9	72.1
1	2.25	0.143	0.73	0.79	0.16	0.27	26.4	55.6	18.0	70.5
2	2.26	0.142	0.74	0.75	0.16	0.23	27.4	53.9	18.7	69.1
3	2.31	0.147	0.80	0.75	0.16	0.23	28.9	52.6	18.5	70.8
4	2.31	0.151	0.79	0.75	0.17	0.24	28.1	52.4	19.5	71.5
5	2.36	0.154	0.79	0.77	0.18	0.24	27.5	52.8	19.7	72.9
6	2.39	0.154	0.81	0.77	0.17	0.24	28.2	52.7	19.1	73.0
7	2.38	0.150	0.86	0.72	0.16	0.24	30.9	50.4	18.7	71.2
linear response	<.001	<.001	<.001	ns	0.036	ns	0.001	<.001	(0.066)	ns
quadratic resp.	ns	0.004	0.034	ns	ns	ns	ns	ns	ns	ns

Table 9b. Effect of fertiliser treatments on rachis nutrient levels in August 1991 (Trial 108).

A.C.	Frond 17 Rachis Nutrient Levels (as % D.M.)						Base/Total Bases (as %)			Total Bases
Level	N	P	K	Ca	Mg	Cl	K	Ca	Mg	(meq/100g)
0	0.23	0.067	1.84	0.40	0.05	0.59	66.4	28.4	5.2	70.8
1	0.24	0.061	1.71	0.44	0.05	0.64	62.9	31.5	5.6	69.7
2	0.23	0.059	1.74	0.44	0.05	0.70	63.2	31.5	5.3	70.3
3	0.25	0.056	1.76	0.45	0.05	0.86	63.2	31.6	5.2	71.3
4	0.26	0.056	1.81	0.50	0.05	0.85	61.8	33.3	4.9	75.0
5	0.25	0.056	1.81	0.48	0.05	0.85	62.1	32.4	5.5	74.6
6	0.28	0.056	1.74	0.47	0.04	0.85	62.3	32.8	4.9	71.3
7	0.27	0.056	1.70	0.46	0.05	0.83	62.0	32.8	5.3	70.2
linear response	<.001	0.021	ns	0.027	ns	<.001	<.001	<.001	ns	ns
quadratic resp.	ns	ns	ns	(0.066)	ns	0.023	0.023	0.020	ns	ns

D.A.P.	Frond 17 Rachis Nutrient Levels (as % D.M.)						Base/Total Bases (as %)			Total Bases
Level	N	P	K	Ca	Mg	Cl	K	Ca	Mg	(meq/100g)
0	0.23	0.080	1.51	0.35	0.04	0.31	65.3	29.2	5.5	59.2
1	0.23	0.102	1.40	0.34	0.04	0.27	63.6	30.5	5.9	56.2
2	0.35	0.107	1.44	0.34	0.04	0.23	64.7	29.5	5.8	56.8
3	0.23	0.103	1.42	0.31	0.04	0.21	66.2	27.9	6.0	54.9
4	0.23	0.088	1.36	0.29	0.04	0.21	66.5	27.6	5.9	52.4
5	0.24	0.090	1.48	0.33	0.04	0.23	65.7	28.6	5.7	57.5
6	0.24	0.080	1.39	0.30	0.04	0.19	66.1	28.2	5.7	53.7
7	0.24	0.080	1.44	0.33	0.04	0.20	65.2	29.0	5.8	56.4
linear response	ns	0.012	ns	0.050	ns	0.045	ns	ns	ns	ns
quadratic resp.	ns	0.001	ns	0.035	ns	ns	ns	ns	ns	0.037

Bunches were collected at random from application levels 0, 3 and 6 from both ammonium chloride and diammonium phosphate treaments in May and July. The results of bunch analysis from the two samplings have been combined to increase precision (Table 8).

Ammonium chloride and diammonium phosphate significantly decreased percentage oil to bunch. This decrease in percentage oil to bunch due is caused by a reduction in dry mesocarp to fruit. The other factors affecting percentage oil to bunch, namely fruit to bunch and oil to dry mesocarp, showed no significant changes due to the application of ammonium chloride (although a reduction in oil to dry mesocarp might be approaching significance). The decrease in dry mesocarp to fruit is due to an increase in mesocarp moisture content. The mesocarp moisture content in the control was actually quite low and the application of ammonium chloride increased the mesocarp moisture content back to normal values.

The decrease in oil to bunch caused by diammonium phosphate application was due to a decrease in the percentage of fruit to bunch.

Table 10. Effects of fertiliser treatments on bunch characteristics in May & July 1991 (Trial 108).

	Ammonium Chloride Level			F Probability		Diammonium Phosphate Level			F Probability	
	0	3	6	Linear Term	Deviation from Linearity	0	3	6	Linear Term	Deviation from Linearity
Bunch Wgt (kg)	26.3	29.2	24.4	ns	<0.001	24.9	25.8	23.5	ns	ns
No Spikelets/Bunch	199.2	202.2	204.5	ns	ns	187.6	205.4	214.6	0.001	ns
% Fruit Set	61.5	62.0	61.0	ns	ns	67.6	64.3	61.4	ns	ns
% Fert. Fruit to Bunch	65.7	64.8	66.1	ns	ns	68.0	65.9	64.7	0.046	ns
% Fruit to Bunch	66.9	66.2	67.6	ns	ns	68.9	66.2	65.2	0.018	ns
Single Fruit Weight (g)	11.0	10.5	10.7	ns	ns	9.9	10.4	10.3	ns	ns
% Wet Mesocarp to Fruit	75.8	73.7	73.6	0.044	ns	75.0	73.8	74.0	ns	ns
% Dry Mesocarp to Fruit	50.4	47.6	46.7	0.003	ns	49.9	48.6	48.7	ns	ns
% Shell to Fruit	13.5	14.4	14.6	ns	ns	14.1	15.1	15.1	ns	ns
% Kernel to Fruit	10.7	11.9	11.8	ns	ns	11.0	11.1	10.9	ns	ns
% Mesocarp Moisture	33.5	35.5	36.6	0.010	ns	33.6	34.3	34.3	ns	ns
% Oil to Dry Mesocarp	82.0	81.8	81.0	(.053)	ns	82.4	81.4	82.2	ns	0.030
% Oil to wet Mesocarp	54.6	52.8	51.4	0.009	ns	54.8	53.5	54.1	ns	ns
% Oil to Bunch	27.7	25.8	25.5	0.026	ns	28.3	26.3	26.1	0.036	ns
% Kernel to Bunch	7.0	7.8	7.9	ns	ns	7.5	7.4	7.1	ns	ns

Trial 117 SYSTEMATIC NITROGEN FERTILISER TRIAL, KUMBANGO PLANTATION.

PURPOSE

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

DESCRIPTION

Site Kumbango Plantation, Fields D8 and D9.

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

Palms Dami commercial DxP crosses.
Planted in 1975 at 120 palms/ha.
Treatments started in April 1987.

DESIGN

Two sources of nitrogen are compared in systematically increasing amounts (the "ladder" design) (Table 11). A set of levels of each source abuts a second set but with the direction of increase of dose in one set being opposite to the other. There is a total of 56 plots made up from two sources of nitrogen, each at five levels, replicated four times. The zero level in each replicate occupies three adjacent plots. A single plot consists of the two rows on each side of a harvesting path (twin row) and containing about 35 palms. There are no guard rows between levels but the two sources are guarded from each other and the end rows are guarded.

Table 11. Rates of fertiliser used in Trial 117.

	Level						
	0	0	0	1	2	3	4
	(kg /palm/year)						
Ammonium chloride	0.00	0.00	0.00	1.50	3.00	4.50	6.00
Urea	0.00	0.00	0.00	0.85	1.70	2.55	3.40

Note: At each level, both sources supply the same quantity of nitrogen.

There are two applications of fertiliser per year.

Trial fertiliser application commenced in April 1987.

RESULTS

Ammonium chloride increased the yield in 1991 (Table 12) and the cumulative yield for 1989 to 1991 (Table 13 and Figures 7 to 9). One kilogram of ammonium chloride increased the yield by about 0.83 tonnes FFB/ha/yr. The increase in yield was due to an increase in the number of bunches.

Urea increased the yield in 1991 and the cumulative yield for 1989 to 1991. The effect of urea on yield was smaller than that of ammonium chloride. Urea application equivalent to one kilogram of ammonium chloride increased the yield by about 0.33 tonnes FFB/ha/year. Both sources increased the number of bunches by a similar amount.

Table 12. Effect of fertiliser on yield, numbers of bunches and bunch weight in 1991 (Trial 117).

Level	Yield of FFB (t/ha/yr)		Bunches (no/ha/yr)		Bunch wt (kg)	
	AC	Urea	AC	Urea	AC	Urea
0	20.3	18.4	830	786	24.6	23.8
1	19.1	20.4	735	847	25.9	24.1
2	21.6	21.0	854	928	25.3	22.7
3	23.3	20.1	971	884	24.3	22.7
4	22.1	23.2	874	982	25.3	23.6
linear resp.	0.006	0.002	ns	0.011	ns	ns
quadratic resp.	ns	ns	ns	ns	ns	ns

Table 13. Effect of fertiliser on yield, numbers of bunches and bunch weight from 1989 to 1991 (Trial 117).

Level	Yield of FFB (t/ha/yr)		Bunches (no/ha/yr)		Bunch wt. (kg)	
	AC	Urea	AC	Urea	AC	Urea
0	20.9	20.4	856	860	24.5	23.9
1	20.7	21.2	815	877	25.4	24.3
2	23.2	21.6	897	928	25.9	23.5
3	24.7	21.6	972	935	25.6	22.9
4	24.2	22.9	930	960	26.1	24.0
linear resp.	<.001	0.038	0.005	ns	ns	ns
quadratic resp.	ns	ns	ns	ns	ns	ns

Figure 7: Trial 117, FFB Yield, Jan89 - Dec91.

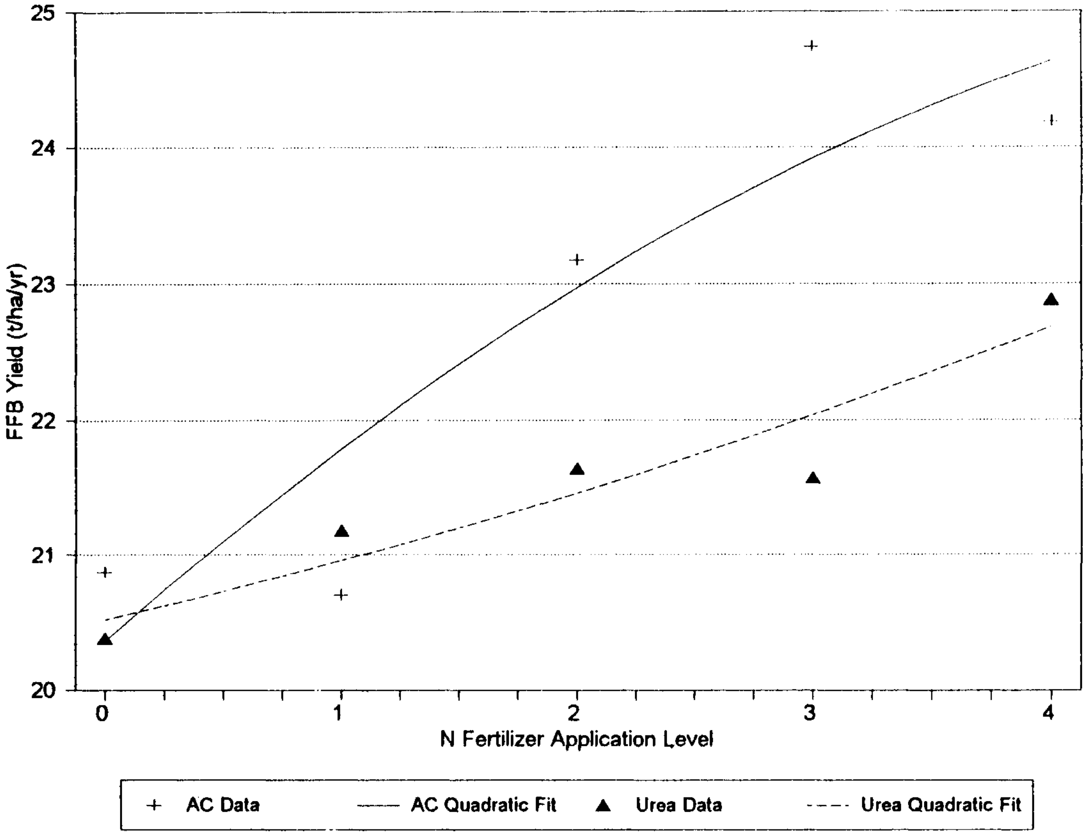


Figure 8: Trial 117, No of Bunches, Jan89 - Dec91.

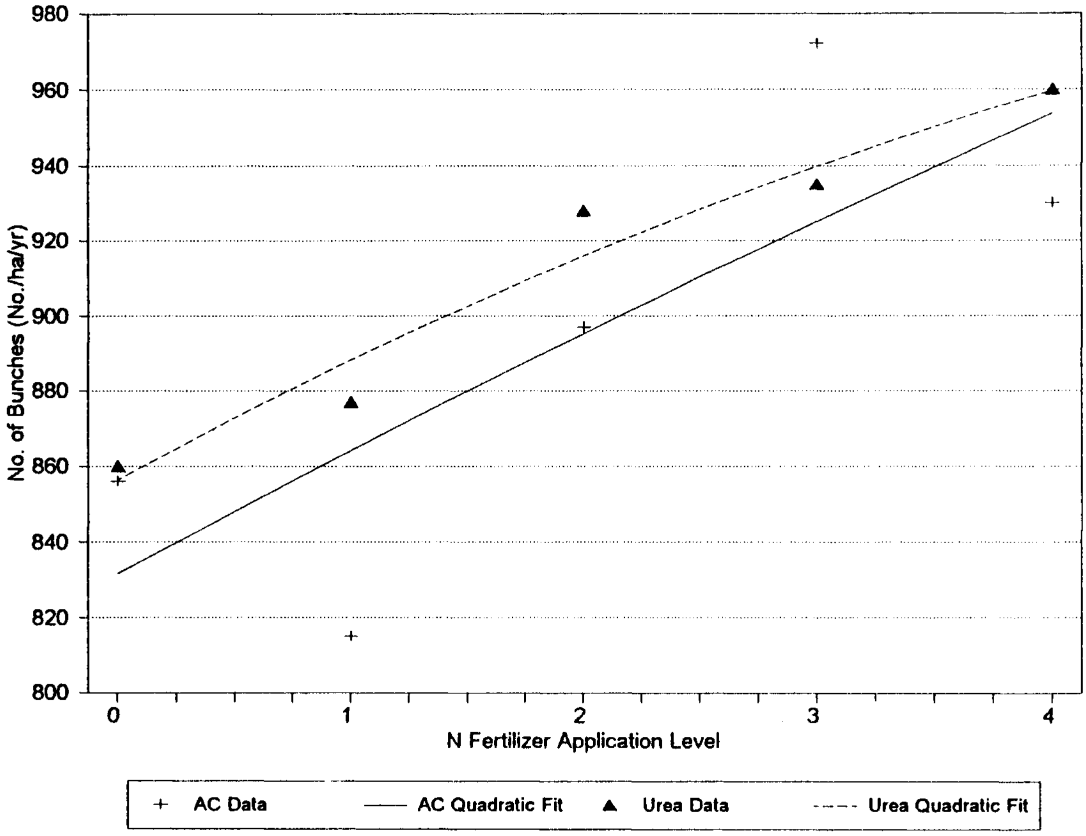
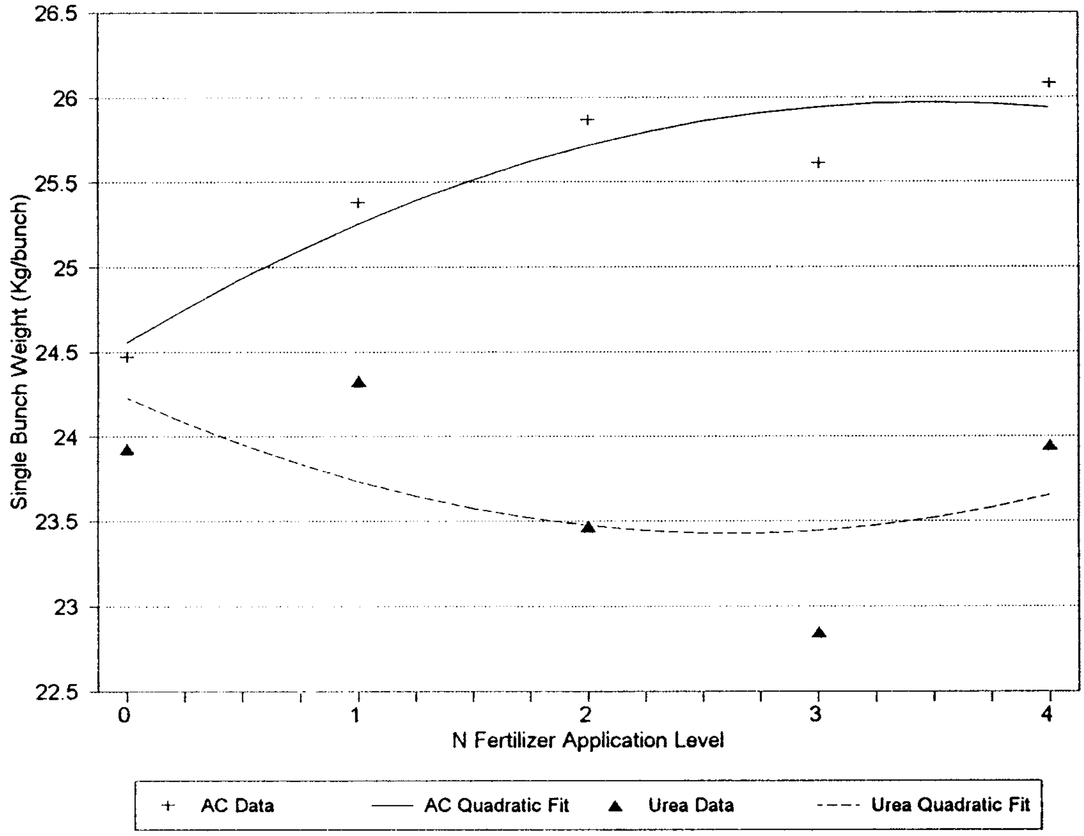


Figure 9: Trial 117, Single Bunch Weight, Jan89 - Dec91.



Samples of leaflet and rachis, for chemical analysis, were collected in January 1991.

Both kinds of fertiliser increased the concentration of nitrogen in the leaflets by similar amounts (Table 14). This indicates that the difference in yield response between ammonium chloride and urea might not be due to differences in nitrogen uptake. Both nitrogen sources increased the concentration of nitrogen in the rachis, but ammonium chloride did so to a much greater degree.

Ammonium chloride and urea increased the concentration of phosphorus in the leaflets and decreased the concentration in the rachis.

Ammonium chloride increased the concentration of chlorine in the leaflet and rachis tissue. Urea significantly decreased the concentration of chlorine in the leaflets.

Ammonium chloride significantly increased the concentration of calcium and decreased the concentration of magnesium, but had no significant effect on the concentration of potassium, in the leaflets. It increased the concentrations of potassium, magnesium and calcium in the rachis tissue, producing a significant increase in the concentration of total bases. Urea decreased the concentration of magnesium in the leaflets and rachis and increased the potassium in the leaflets.

Table 14a. Effects of fertiliser treatments on leaflet nutrient levels in Sept 1991 (Trial 117).

A.C. Level	Frond 17 Leaflet Nutrient Levels (as % D.M.) N	P	K	Ca	Mg	Cl	Base/Total Bases (as %) K	Ca	Mg	Total Bases (meq/100g)
0	2.25	0.141	0.73	0.86	0.16	0.25	24.9	57.7	17.4	74.7
1	2.33	0.144	0.75	0.87	0.15	0.34	25.5	58.1	16.5	74.6
2	2.34	0.146	0.68	0.95	0.15	0.36	22.5	61.3	16.2	77.1
3	2.38	0.148	0.68	0.95	0.14	0.35	22.7	62.3	15.1	76.2
4	2.38	0.149	0.69	0.90	0.14	0.35	23.9	60.9	15.2	73.9
linear response	0.001	0.003	ns	0.018	0.006	<.001	ns	0.006	0.001	ns
quadratic resp.	ns	ns	ns	ns	ns	0.032	ns	ns	ns	ns

UREA Level	Frond 17 Leaflet Nutrient Levels (as % D.M.) N	P	K	Ca	Mg	Cl	Base/Total Bases (as %) K	Ca	Mg	Total Bases (meq/100g)
0	2.22	0.142	0.75	0.84	0.17	0.20	25.6	56.2	18.2	74.8
1	2.24	0.143	0.77	0.81	0.16	0.18	26.9	55.4	17.7	73.0
2	2.32	0.146	0.78	0.85	0.15	0.16	26.9	56.9	16.2	74.7
3	2.37	0.148	0.81	0.82	0.14	0.14	28.2	55.8	16.0	73.0
4	2.39	0.148	0.82	0.85	0.15	0.16	28.0	56.3	15.8	75.1
linear response	0.009	0.004	0.016	ns	0.001	0.005	(0.069)	ns	0.001	ns
quadratic resp.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 14b. Effects of fertiliser treatments on rachis nutrient levels in Sept 1991 (Trial 117).

A.C. Level	Frond 17 Rachis Nutrient Levels (as % D.M.) N	P	K	Ca	Mg	Cl	Base/Total Bases (as %) K	Ca	Mg	Total Bases (meq/100g)
0	0.23	0.052	1.50	0.40	0.04	0.36	62.4	32.3	5.3	61.6
1	0.24	0.050	1.55	0.44	0.05	0.64	60.5	33.9	5.6	65.5
2	0.25	0.053	1.60	0.47	0.05	0.75	60.1	34.5	5.5	67.8
3	0.27	0.049	1.54	0.47	0.04	0.73	59.0	35.7	5.2	66.4
4	0.30	0.049	1.76	0.48	0.05	1.01	61.8	32.8	5.4	72.8
linear response	0.002	ns	(0.057)	<.001	0.021	<.001	ns	ns	ns	0.006
quadratic resp.	ns	ns	ns	ns	ns	ns	(0.067)	(0.069)	ns	ns

UREA Level	Frond 17 Rachis Nutrient Levels (as % D.M.) N	P	K	Ca	Mg	Cl	Base/Total Bases (as %) K	Ca	Mg	Total Bases (meq/100g)
0	0.25	0.053	1.43	0.37	0.04	0.22	62.8	31.9	5.3	58.1
1	0.24	0.046	1.34	0.35	0.04	0.16	62.4	32.0	5.6	54.8
2	0.25	0.047	1.35	0.34	0.03	0.15	63.0	32.1	4.9	54.3
3	0.26	0.047	1.34	0.37	0.03	0.14	61.8	33.4	4.8	55.5
4	0.27	0.047	1.44	0.37	0.03	0.17	63.6	31.7	4.6	57.7
linear response	(0.059)	(0.079)	ns	ns	0.020	ns	ns	ns	0.029	ns
quadratic resp.	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Trial 118 SYSTEMATIC NITROGEN FERTILISER TRIAL, KUMBANGO PLANTATION.

PURPOSE

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

DESCRIPTION

Site Kumbango Plantation, Field B9.

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

Palms Dami commercial DxP crosses.
Planted in 1977 at 120 palms/ha.
Treatments started in April 1987.

DESIGN

Five rates of ammonium chloride are compared in systematically increasing equal steps (the ladder design)(Table 15). A set of rates (ie one replicate) abuts a second set, but with the direction of increase opposite in the two sets. There are 28 plots made up from four replicates and seven rates (levels). Within each replicate the zero rate (level 0) occupies three adjacent plots, and the other rates (levels 1,2,3, & 4) occupy one plot each. One plot consists of two rows of palms on each side of a harvesting path (twin-row) and containing about 33 palms. There are no guard rows between levels but the row ends are guarded.

Table 15. Rates of fertiliser used in Trial 118.

	Level						
	0	0	0	1	2	3	4
	(kg /palm/year)						
Ammonium chloride	0.0	0.0	0.0	1.5	3.0	4.5	6.0

Annual fertiliser applications are split into two applications per year.

Trial fertiliser application commenced in April 1987.

RESULTS

Application of ammonium chloride up to a rate of about 3 kg/palm/yr, increased yield. Above this rate there was a decrease in yield (Figure 10 and Tables 16 and 17).

As the application rate increased up to about 3 kg/palm/yr single bunch weight increased, but at higher application rates the response flattened off (Figure 11). Ammonium chloride decreased the number of bunches (Figure 12).

Table 16. Effects of ammonium chloride on yield, numbers of bunches and bunch weight in 1991 (Trial 118).

Application rate (kg/palm/yr)	Yield of FFB (t/ha/yr)	Bunches (no/ha/yr)	Bunch weight (kg)
0.0	22.9	993	23.1
1.5	22.3	916	24.4
3.0	23.4	983	23.8
4.5	24.9	974	25.5
6.0	20.1	856	23.9
Linear response	ns	ns	ns
Quadratic resp.	0.016	ns	ns

Table 17. Effects of ammonium chloride on yield, numbers of bunches and bunch weight from 1989 to 1991 (Trial 118).

Application rate (kg/palm/yr)	Yield of FFB (t/ha/yr)	Bunches (no/ha/yr)	Bunch weight (kg)
0.0	24.1	1045	23.0
1.5	24.9	1020	24.5
3.0	25.7	1054	24.4
4.5	25.5	1014	25.1
6.0	24.3	988	24.7
Linear response	ns	ns	0.005
Quadratic resp.	0.003	ns	ns

Figure 10: Trial 118, FFB Yield, Jan89 - Dec91.

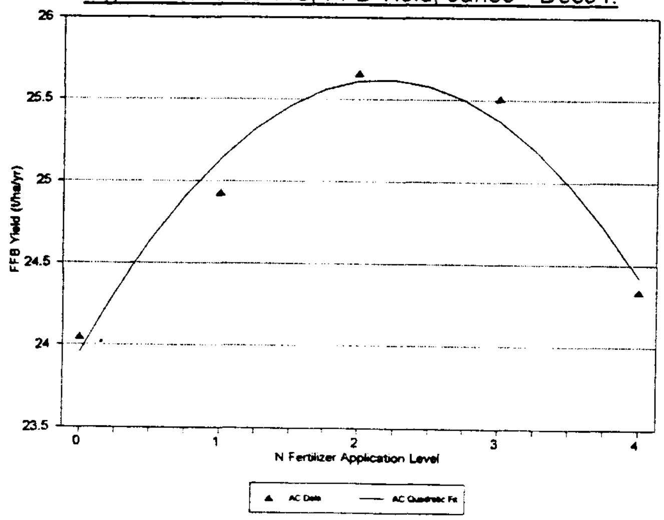


Figure 11: Trial 118, No. of Bunches, Jan89 - Dec91.

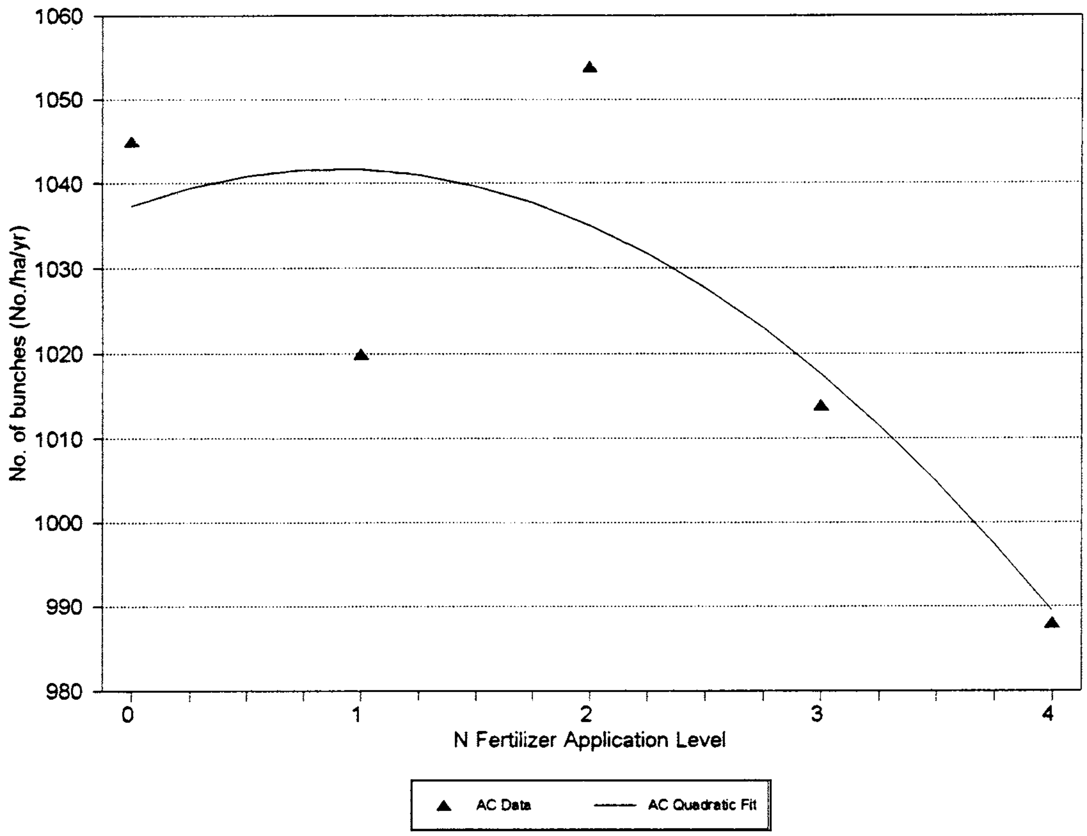
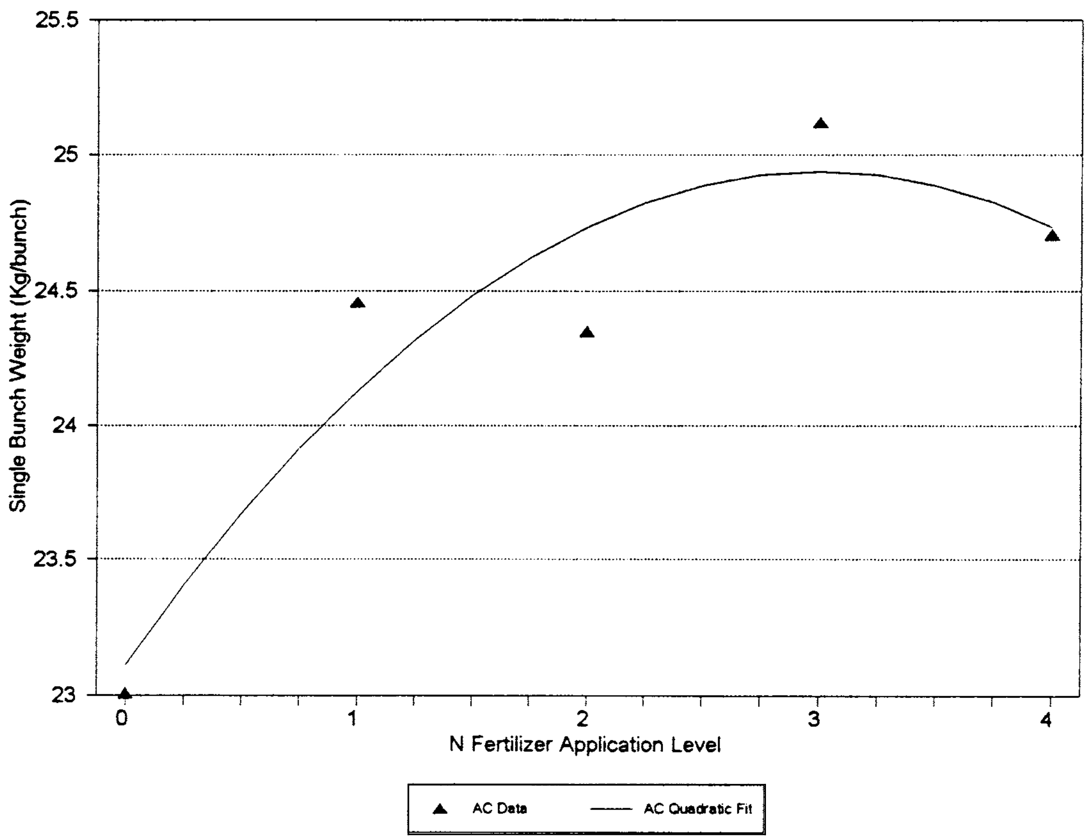


Figure 12: Trial 118, Single Bunch Weight, Jan89 - Dec91.



Leaflet and rachis tissue was sampled from frond 17 in September.

Ammonium chloride had little effect on the concentrations of nitrogen and phosphorus , but significantly increased the concentration of chlorine, in the leaflets and rachis (Table 18).

It decreased the potassium concentration in the leaflets, but increased the concentration in the rachis. It decreased the concentration of magnesium in the leaflets, but increased it in the rachis. It increased the concentration of calcium in the leaflets and rachis, and significantly increased the concentration of total bases in the rachis but not the leaflets.

Table 18a. Effect of fertiliser treatments on leaflet nutrient levels in September 1991 (Trial 118).

A.C.	Frond 17 Leaflet Nutrient Levels (as % D.M.)						Base/Total Bases (%)			Total Bases
Level	N	P	K	Ca	Mg	Cl	K	Ca	Mg	(meq/100g)
0	2.34	0.146	0.90	0.75	0.15	0.28	31.6	51.6	16.8	72.5
1	2.35	0.147	0.85	0.74	0.14	0.32	31.3	52.8	15.9	69.6
2	2.38	0.146	0.81	0.78	0.13	0.36	29.8	55.6	14.7	69.7
3	2.38	0.148	0.81	0.84	0.13	0.41	28.3	57.2	14.5	73.4
4	2.39	0.148	0.81	0.84	0.14	0.39	27.9	56.6	15.5	73.9
linear response	ns	ns	<.001	0.001	0.011	<.001	0.001	<.001	<.001	ns
quadratic resp.	ns	ns	ns	ns	0.002	ns	ns	ns	0.012	0.032

Table 18b. Effect of fertiliser treatments on rachis nutrient levels in September 1991 (Trial 118).

A.C.	Frond 17 Rachis Nutrient Levels (as % D.M.)						Base/Total Bases (%)			Total Bases
Level	N	P	K	Ca	Mg	Cl	K	Ca	Mg	(meq/100g)
0	0.27	0.057	1.54	0.38	0.04	0.29	63.7	31.0	5.3	61.8
1	0.28	0.059	1.68	0.43	0.04	0.63	63.4	31.7	4.9	67.5
2	0.29	0.056	1.71	0.46	0.04	0.68	62.7	32.4	4.9	70.3
3	0.28	0.058	1.66	0.46	0.04	0.81	61.6	33.3	5.0	69.0
4	0.29	0.060	1.71	0.47	0.05	0.84	61.8	33.1	5.2	71.0
linear response	(0.077)	ns	0.039	0.005	(0.097)	<.001	(0.062)	0.034	ns	0.011
quadratic resp.	ns	ns	ns	ns	ns	(0.057)	ns	ns	ns	ns

Trial 119 NITROGEN/ANION FERTILISER TRIAL, MALILIMI 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 Malilimi Plantation, Fields A7 and A8.

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

Palms Dami commercial DxP crosses.
Planted in October 1985 at 135 palms/ha.
Treatments started in May 1989.

DESIGN

There are twelve treatments (Table 19), 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 36 palms of which the central 16 are recorded.

Table 19. Rates of fertilisers, and resulting combinations of elements used in Trial 119. (Treatment numbers are in brackets.)

	Nil	Muriate of potash	Kieserite
Nil	--- (1)	K+Cl (5)	Mg+S (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+S+Mg (11)
Ammonium chloride	N+Cl (4)	N+Cl+K (8)	N+Cl+Mg+S (12)

Diammonium phosphate = 3.9 kg palm^{-1} year^{-1}
Ammonium sulphate = 3.8 kg palm^{-1} year^{-1}
Ammonium chloride = 3.0 kg palm^{-1} year^{-1}
Muriate of potash = 4.2 kg palm^{-1} year^{-1}
Kieserite = 3.7 kg palm^{-1} year^{-1}

RESULTS

The overall treatment effect on yield and number of bunches in 1991 is not significant (Table 20). The overall treatment variance was partitioned into a number of contrasts to assess the effects of the various fertilisers and combinations of fertilisers. None of the contrasts were statistically significant. The yield at this site is high and it is unlikely that a shortage of nutrients is limiting productivity.

Fertiliser treatments did affect single bunch weight in 1991. Analysis of treatment variance showed muriate of potash to have significantly increased single bunch weight from 11.2 kg to 11.9 kg. Ammonium chloride increased the single bunch weight from 10.6 kg to 10.7 kg. In the presence of the nitrogen fertilisers, kieserite increased single bunch weight from 11.0 kg to 11.5 kg.

Table 20. Effects of fertiliser treatments on yield, number of bunches and bunch weight in 1991 (Trial 119).

Treatment number	Elements applied	Yield of FFB (t/ha/yr)	Bunches (no/ha/yr)	Bunch wt (kg)
1	Nil	32.5	2899	11.2
2	N+P	33.0	3088	10.7
3	N+S	32.3	3095	10.5
4	N+Cl	33.8	2902	11.7
5	K+Cl	34.4	2821	12.2
6	N+P+K+Cl	34.0	2956	11.5
7	N+S+K+Cl	35.7	3094	11.6
8	N+Cl+K	34.3	2824	12.2
9	Mg+S	32.2	2843	11.3
10	N+P+Mg+S	34.4	2993	11.5
11	N+S+Mg	32.7	2915	11.2
12	N+Cl+Mg+S	34.8	2979	11.7
	%cv	9.4	10.9	4.6
	lsd	4.6	462	0.8

The treatments had no effect on the average yield and number of bunches for 1990 an 1991 (Table 21), but there was an effect on single bunch weight. Partitioning of the treatment variance showed that the application of muriate of potash in the presence of nitrogen increased single bunch weight from 10.1 kg to 10.9 kg. Ammonium chloride increased the single bunch weight from 9.8 kg to 10.8 kg.

Table 21. Effects of fertiliser treatments on yield, number of bunches and bunch weight from 1989 to 1991 (Trial 119).

Treatment number	Elements applied	Yield of FFB (t/ha/yr)	Bunches (no/ha/yr)	Bunch wt (kg)
1	Nil	28.5	2796	10.2
2	N+P	27.7	2805	9.9
3	N+S	28.3	2916	9.7
4	N+Cl	29.0	2709	10.8
5	K+Cl	29.8	2735	10.9
6	N+P+K+Cl	30.5	2840	10.8
7	N+S+K+Cl	30.5	2862	10.7
8	N+Cl+K	30.2	2714	11.2
9	Mg+S	26.3	2465	10.6
10	N+P+Mg+S	30.2	2826	10.7
11	N+S+Mg	28.0	2718	10.3
12	N+Cl+Mg+S	30.2	2784	10.9
	%cv	8.4	9.3	4.8
	lsd	3.5	371	0.7

Diammonium phosphate increased the concentration of phosphorus from 0.165% to 0.169 % , and fertilisers containing sulphur decreased the concentration of phosphorus from 0.168% to 0.164% (Table 22).

Muriate of potash decreased the concentration of magnesium from 0.19% to 0.17% and kieserite increased the concentration of magnesium from 0.15% to 0.19%.

Muriate of potash increased the concentration of calcium in the leaflets from 0.92% to 0.97%.

Fertilisers containing chlorine significantly increased the concentration of chlorine in the leaflets from 0.16% to 0.39%.

Table 22. Effects of fertiliser treatments on concentrations of elements in leaflets in September 1991 (Trial 119).

Treatment number	Elements applied	Concentration (% of dry matter)					
		N	P	K	Ca	Mg	Cl
1	Nil	2.61	0.17	1.02	0.91	0.18	0.17
2	N+P	2.57	0.17	0.96	0.92	0.19	0.13
3	N+S	2.63	0.16	0.97	0.97	0.19	0.13
4	N+Cl	2.62	0.17	0.91	0.93	0.17	0.39
5	K+Cl	2.59	0.17	0.95	0.98	0.17	0.38
6	N+P+K+Cl	2.63	0.17	0.90	0.97	0.17	0.37
7	N+S+K+Cl	2.64	0.16	0.91	0.87	0.17	0.42
8	N+Cl+K	2.64	0.17	0.93	0.96	0.16	0.42
9	Mg+S	2.60	0.16	0.98	0.92	0.20	0.16
10	N+P+Mg+S	2.65	0.17	0.96	0.93	0.20	0.22
11	N+S+Mg	2.60	0.16	0.95	0.88	0.18	0.15
12	N+Cl+Mg+S	2.66	0.17	0.93	0.88	0.20	0.41
	%cv	1.8	1.2	6.1	4.7	8.7	12.0
	lsd	0.07	0.003	0.08	0.06	0.02	0.05

Trial 120 NITROGEN/ANION FERTILISER TRIAL, 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 19), 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 36 palms of which the central 16 are recorded.

Table 23. Ratesof fertiliser and resulting combinations of elements used in Trial 120. (Treatment numbers are in brackets.)

	Nil	Muriate of potash	Kieserite
Nil	--- (1)	K+Cl (5)	Mg+S (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+S+Mg (11)
Ammonium chloride	N+Cl (4)	N+Cl+K (8)	N+Cl+Mg+S (12)

Diammonium phosphate = 3.9 kg palm^{-1} year^{-1}
Ammonium sulphate = 3.8 kg palm^{-1} year^{-1}
Ammonium chloride = 3.0 kg palm^{-1} year^{-1}
Muriate of potash = 4.2 kg palm^{-1} year^{-1}
Kieserite = 3.7 kg palm^{-1} year^{-1}

RESULTS

The overall treatment effect on yield was significant (Table 24). The treatment variance was partitioned into components to assess the effect of the different types and combinations of fertilisers. Only kieserite had a significant effect on yield. Kieserite increased yield from 24.9 to 27.7 tonnes FFB/ha/yr. The increase in yield was due to a significant increase in number of bunches, from 1642 to 1852 bunches/ha/yr. There was no effect on single bunch weight.

Table 24. Effects of fertiliser treatments on yield, numbers of bunches and bunch weight in 1991 (Trial 120).

Treatment number	Elements applied	Yield of FFB (t/ha/yr)	Bunches (no/ha/yr)	Bunch wt (kg)
1	NIL	24.5	1664	14.8
2	N+P	24.8	1687	14.8
3	N+S	23.0	1494	15.4
4	N+Cl	24.1	1557	15.5
5	K+Cl	23.5	1544	15.4
6	N+P+K+Cl	24.8	1563	15.9
7	N+S+K+Cl	26.8	1834	14.7
8	N+Cl+K	27.9	1789	15.6
9	Mg+S	29.9	1898	15.8
10	N+P+Mg+S	27.8	1860	15.1
11	N+S+Mg	26.8	1796	14.9
12	N+Cl+Mg+S	26.4	1854	14.2
	%cv	10.7	12.5	6.7
	lsd	4.0	310	1.5

The average yield and number of bunches in 1990 and 1991 were significantly affected by the treatments (Table 25). Kieserite increased the yield from 29.7 to 32.1 tonnes FFB/ha/yr. This effect was due to an increase in the number of bunches, from 2036 to 2182 bunches/ha/yr. No other fertiliser had a significant effect on yield or yield components.

Table 25. Effects of fertiliser treatments on yield, numbers of bunches and bunch weight from 1990 to 1991 (Trial 120).

Treatment number	Elements applied	Yield of FFB (t/ha/yr)	Bunches (no/ha/yr)	Bunch wt (kg)
1	Nil	27.8	1950	14.2
2	N+P	29.2	2029	14.5
3	N+S	27.2	1865	14.6
4	N+Cl	29.4	1959	15.0
5	K+Cl	28.9	2037	14.3
6	N+P+K+Cl	30.4	2010	15.1
7	N+S+K+Cl	31.3	2212	14.2
8	N+Cl+K	33.4	2222	15.0
9	Mg+S	34.2	2224	15.4
10	N+P+Mg+S	29.8	2112	14.2
11	N+S+Mg	32.3	2206	14.7
12	N+Cl+Mg+S	32.2	2187	14.8
	%cv	7.8	8.2	6.8
	lsd	3.4	246	1.4

Table 25. Effects of fertiliser treatments on concentrations of elements in leaflets in October 1991 (Trial 120).

Treatment number	Elements applied	Concentration of element (% dry matter)					
		N	P	K	Ca	Mg	Cl
1	Nil	2.38	0.149	0.91	0.77	0.15	0.29
2	N+P	2.41	0.153	0.87	0.79	0.15	0.33
3	N+S	2.44	0.148	0.86	0.76	0.14	0.32
4	N+Cl	2.40	0.148	0.88	0.72	0.15	0.38
5	K+Cl	2.41	0.150	0.85	0.80	0.14	0.38
6	N+P+K+Cl	2.42	0.150	0.85	0.79	0.13	0.36
7	N+S+K+Cl	2.40	0.148	0.88	0.76	0.14	0.38
8	N+Cl+K	2.38	0.149	0.84	0.83	0.14	0.37
9	Mg+S	2.41	0.147	0.85	0.76	0.15	0.32
10	N+P+Mg+S	2.44	0.150	0.86	0.77	0.15	0.34
11	N+S+Mg	2.39	0.146	0.89	0.70	0.13	0.34
12	N+Cl+Mg+S	2.38	0.151	0.87	0.80	0.15	0.35
	%cv	2.2	2.1	6.6	6.6	10.8	12.5
	lsd	0.08	0.005	0.08	0.07	0.02	0.01

Leaflets were sampled in September 1991 from frond 17.

Kieserite significantly increased leaflet magnesium from 0.142% to 0.145% (Table 26).

Trial 201 FACTORIAL FERTILISER TRIAL, HARGY PLANTATION.

PURPOSE

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

DESCRIPTION

Site Hargy Plantation, Blocks 4,6 and 8.

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

Palms I.R.H.O. commercial DxP crosses.
Planted in 1973 at 115 palms/ha.
Treatments started in June 1982.

DESIGN

There are 81 treatments comprising all factorial combinations of N, P, K and Mg each at three levels (Table 27). Fertilisers are applied twice yearly.

Table 27. Rates of fertiliser used in Trial 201.

	June 92 - Dec 90 Level			From Jan 91 Level		
	0	1	2	0	1	2
	(kg/palm/year)			(kg/palm/year)		
Sulphate of ammonia	0.0	1.0	2.0	0.0	3.0	6.0
Triple superphosphate	0.0	0.8	1.6	0.0	2.0	4.0
Muriate of potash	0.0	1.0	2.0	0.0	1.5	3.0
Kieserite	0.0	1.0	2.0	0.0	1.5	3.0

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

There are 81 plots, each consisting of 36 palms (6x6) of which the central 16 are recorded.

The 81 treatments are replicated only once and are divided among three blocks. High order interactions provide the error term in the statistical analysis.

Prior to October 1986, potassium was applied as bunch ash at rates of 0.0, 1.5 and 3.0 kg/palm/year.

In 1991 the fertiliser application rates were increased.

RESULTS

In 1991 only triple superphosphate had an effect that was significant : it increased yield by increasing the number of bunches (Table 27).

Table 27. Main effects of fertiliser on yield, number of bunches and bunch weight in 1991 (Trial 201).

Treatment (Main effects)	Yield of FFB (t/ha/yr)	Bunches (no/ha/yr)	Bunch wt (kg)
N 0	20.0	910	22.1
N 1	19.3	857	22.7
N 2	20.7	934	22.2
P 0	**18.5**	**843**	22.0
P 1	**20.6**	**927**	22.3
P 2	**20.9**	**932**	22.6
K 0	20.0	911	21.9
K 1	20.0	890	22.6
K 2	20.1	900	22.5
Mg 0	20.3	905	22.5
Mg 1	19.3	877	22.1
Mg 2	20.5	919	22.4
%cv	18.0	15.1	7.1
lsd	2.1	80	1.0

The effect of triple superphosphate was similar when averaged over the years 1989 to 1991 (Table 29).

There was a limited yield response to the application of phosphorus in the absence of nitrogen and no response to nitrogen in the absence of phosphorus (Table 30). The highest yields are attained with a combination of nitrogen and phosphorus fertiliser.

Table 29. Main effects of the fertiliser treatments on yield, number of bunches and bunch weight from 1989 to 1991 (Trial 201).

Treatment (Main effects)	Yield of FFB (t/ha/yr)	Bunches (no/ha/yr)	Bunch wt (kg)
N 0	19.1	865	22.2
N 1	19.0	842	22.6
N 2	20.1	900	22.3
P 0	**18.0**	**817**	22.0
P 1	**19.8**	**886**	22.4
P 2	**20.1**	**904**	22.7
K 0	19.3	871	22.1
K 1	19.2	854	22.6
K 2	19.8	883	22.5
Mg 0	19.4	855	22.7
Mg 1	19.0	857	22.2
Mg 2	19.9	895	22.3
%cv	15.2	14.3	6.3
lsd	1.7	73	0.8

Table 30. Effect of the NxP interaction on yield of FFB in 1991 (Trial 201).

	P 0	P 1	P 2
N 0	18.5	19.1	19.9
N 1	16.9	19.6	20.5
N 2	18.5	20.7	21.2
lsd		3.0	

Trial 401 FACTORIAL FERTILISER TRIAL, KAUTU PLANTATION.

PURPOSE

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

DESCRIPTION

Site Kapiura Estates, Kautu Plantation, Fields 1F and 1G.

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 31).

Table 31. Rates of fertiliser used in trial 401.

	Level		
	0	1	2
	(kg /palm/year)		
Ammonium chloride	0	3	6
Triple superphosphate	0	2	4
Muriate of potash	0	3	---
Kieserite	0	3	---

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

RESULTS

None of the treatments caused a significant difference in yield in 1991 (Table32) or in the cumulative yield in 1989 to 1991 (Table 33).

Table 32. Main effects of fertiliser treatments on yield, numbers of bunches and bunch weight in 1991 (Trial 401).

Treatments (main effects)	Yield of FFB (t/ha/yr)	Bunches (no/ha/yr)	Bunch wt (kg)
N 0	27.1	2657	10.2
N 1	28.1	2667	10.5
N 2	28.3	2606	10.9
P 0	27.3	**2573**	10.6
P 1	27.7	**2635**	10.5
P 2	28.4	**2722**	10.5
K 0	27.3	2607	10.5
K 1	28.3	2679	10.6
Mg 0	27.9	2688	**10.4**
Mg 1	27.7	2599	**10.7**
cv%	11.7	10.3	5.6
lsd (N&P)	1.9	159	0.4
lsd (K&Mg)	1.6	130	0.3

Ammonium chloride caused a significant increase in single bunch weight averaged over 1990 and 1991.

Triple superphosphate increased the number of bunches in 1991 (Table 32).

Kieserite significantly increased single bunch weight 1990 and 1991 (Tables 32 & 33).

Table 33. Main effects of fertiliser treatments on yield, numbers of bunches and bunch weight from Apr 90 to 1991 (Trial 401).

Treatments (main effects)	Yield of FFB (t/ha/21 months)	Bunches (no/ha/21mth)	Bunch wt (kg)
N 0	42.9	4585	**9.4**
N 1	45.4	4754	**9.6**
N 2	44.7	4485	**10.0**
P 0	44.0	4535	9.7
P 1	44.6	4620	9.7
P 2	44.4	4669	9.5
K 0	43.6	4548	9.6
K 1	45.1	4668	9.7
Mg 0	44.6	**4710**	**9.5**
Mg 1	44.1	**4506**	**9.8**
cv%	8.6	8.2	5.6
lsd (N&P)	2.2	221	0.3
lsd (K&Mg)	1.8	181	0.3

The cumulative data for 1990 and 1991 showed a significant nitrogen x phosphate interaction (Table 34).

Table 34. Effect of the NxP interaction on FFB yield from April 90 to 1991 (Trial 401).

	P 0	P 1	P 2
N 0	41.6	42.6	44.4
N 1	44.1	45.2	47.0
N 2	46.3	46.0	41.8
lsd		3.9	

At the highest rate of nitrogen application, triple superphosphate reduced yield and similarly at the highest rate of triple superphosphate application, nitrogen reduced yield. At the nil or low rate of nitrogen, application of triple superphosphate produced a yield increase and similarly ammonium chloride produced a yield increase at the nil or low rate of triple superphosphate. The highest yields were obtained from either the highest rate of ammonium chloride alone or the N1-P2 treatment combination (3 kg ammonium chloride and 4 kg triple superphosphate /palm/year).

Trial 402 FACTORIAL FERTILISER TRIAL, 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 35).

Table 35. Rates of fertiliser used in trial 402.

	Level		
	0	1	2
	(kg /palm/year)		
Ammonium chloride	0	3	6
Triple superphosphate	0	2	4
Muriate of potash	0	3	---
Kieserite	0	3	---

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.

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

RESULTS

There are yield records for only one year after the start of the treatments, so any conclusions are tentative only.

The treatments have had no significant effect upon yield (Table 36).

Table 36. Main effects of treatments on yield, number of bunches and bunch weight in 1991 (trial 402).

Treatments (main effects)	Yield of FFB (t/ha/yr)	Bunches (No/ha/yr)	Bunch wt (kg)
N 0	22.4	2355	9.5
N 1	23.4	2403	9.7
N 2	22.2	2261	9.8
P 0	23.2	2415	9.6
P 1	21.9	2269	9.7
P 2	22.8	2335	9.8
K 0	23.1	**2403**	9.6
K 1	22.1	**2276**	9.7
Mg 0	22.4	2350	**9.5**
Mg 1	22.9	2329	**9.8**
cv%	11.1	10.9	5.4
lsd (N&P)	1.5	148	0.3
lsd (K&Mg)	1.2	121	0.3

Muriate of potash caused a significant decrease in the number of bunches.

Kieserite significantly increased the single bunch weight.

Ammonium chloride increased single bunch weight (p=0.062).

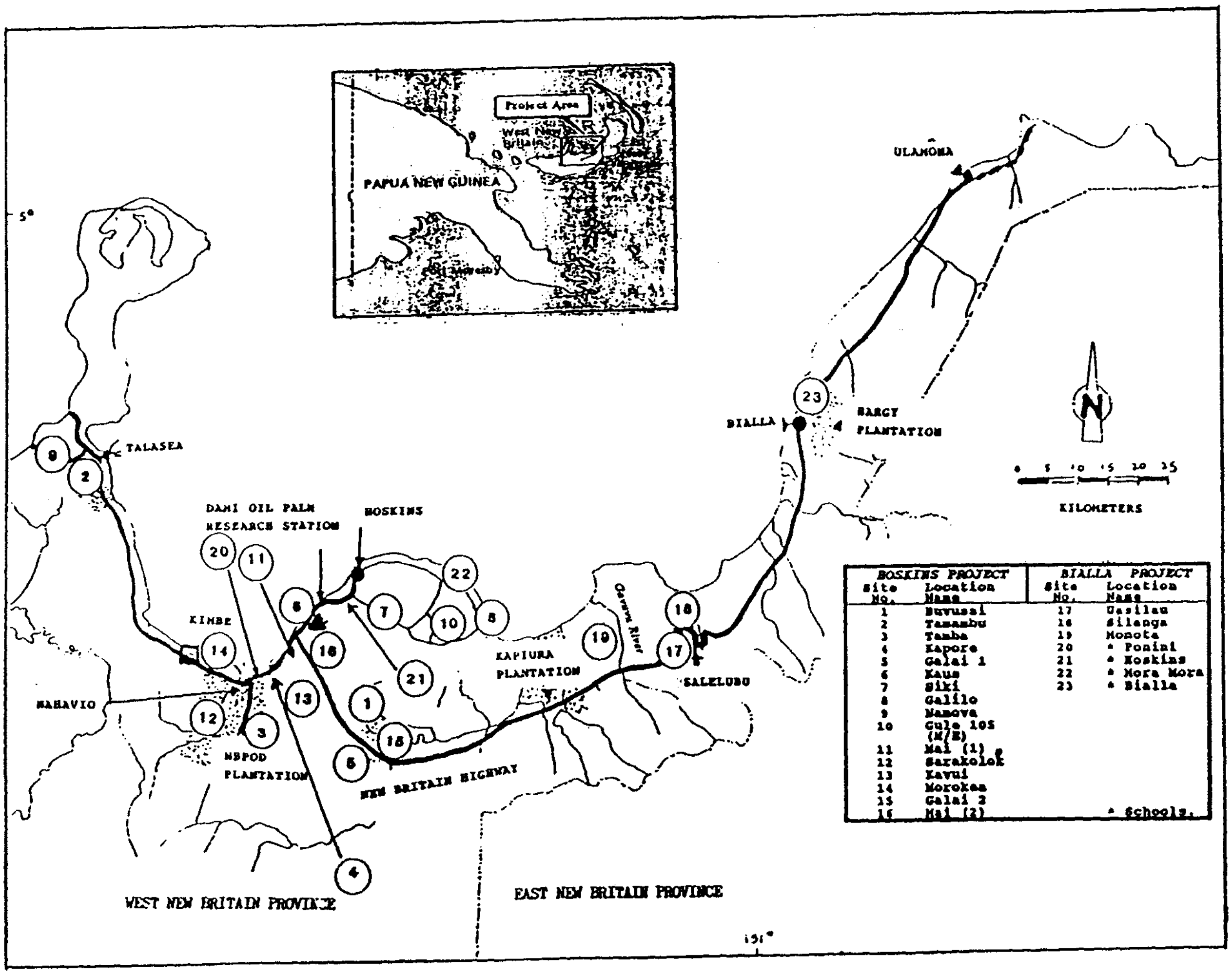
II. SMALLHOLDER DEMONSTRATION TRIALS.

WEST NEW BRITAIN PROVINCE

(P. Navus)

Fertiliser demonstration trials were continued and their number increased on selected smallholder blocks in the mature palm areas in West New Britain Province (Figure 13).

Figure 13: Distribution of smallholder demonstration trials in West New Britain (Hoskins, Bialla & Kapiura) oil palm schemes.



Experiment 112 **NITROGEN AND PHOSPHATE DEMONSTRATION TRIALS.**

PURPOSE

To determine why oil palm growth and yield are poor in the Buvussi Subdivision of the Hoskins Oil Palm Project, and to demonstrate that poor fertility can be alleviated by application of fertiliser. To demonstrate that use of fertiliser combined with good management can maintain or increase yields.

LOCATION AND HISTORY

In 1984 declining yield was reported to OPRA by the Department of Agriculture and Livestock at Hoskins. This trial was set up in Buvussi subdivision, where the soil conditions were suspected of limiting yield, on eight smallholder blocks (Figure 13, site No. 1).

DESCRIPTION

Site Buvusi subdivision, blocks 1150, 1152, 1194, 1397, 1193, 1151, 1142 & 1396.

Palms Dami commercial D X P.
Planted in 1980 at 120 palms/ha.
Treatments started in April 1986.

DESIGN

Each of the eight smallholder blocks provides a single replicate, within which are three treatments: no fertiliser (control), phosphate, and phosphate plus nitrogen (Table 37). Each plot contains 16 recorded palms, surrounded by a guard row.

Table 37. Treatments used in Trial 112.

	Amount of fertiliser (kg/palm/year)	
Treatment number	Ammonium chloride	Triple super phosphate
1	0	0
2	0	1
3	2	1

Treatments were started in April 1986 and revised in November 1988 when ammonium chloride was increased from 1kg/palm/year to 2kg/palm/year. Ammonium chloride is applied twice a year in May and November.

The yield was recorded in three months (February, June, and October), and leaf samples (frond 17) were taken for analysis in December.

RESULTS

Application of phosphorus (treatment 2), and phosphorus plus nitrogen (treatment 3), increased the mean yield, but the increases were not statistically significant because the yields were rather variable (Table 37). Some blocks appeared to respond to phosphorus (1150,1152,1194, & 1397, and some appeared to respond to nitrogen (1151, 1193, & 1397). Blocks 1142 and 1396 responded to neither, and 1397 responded to both. Block 1142 and 1396 had very poor yields with all treatments, while blocks 1193 and 1397 had good yields even with no fertiliser.

Although there appeared to be an increase in yield caused by phosphorus application, and a further increase if nitrogen is given, we cannot make a general recommendation for the use of fertiliser based on these results.

The components of yield (number of bunches and single bunch weight) show wide variation. Nitrogen application does cause a significant increase in single bunch weight.

The variation from block to block that was seen in 1991 differs from that which was seen in 1990, and they both differ from that in 1989.

Such inconsistency in the results must lead us to question whether the methods that we are using are appropriate. In trials such as this, the blockholder does the harvesting and leaves the bunches near the palms. The OPRA staff weigh and record the bunches. For the records to be reliable the blockholder must harvest regularly, cut all fruit that is ripe, and leave the fruit near the palm. The fact that the OPRA staff visit the block to record the harvest on only 9 out of 36 possible harvesting occasions could mean that the blockholder is tempted not to do the job properly on the harvesting occasions when OPRA staff are not visiting. This could lead to inaccuracies in the recording of fruit on the occasions when OPRA staff do visit.

We shall take a closer look at this trial to see whether fewer blocks should be used, but all of the harvests recorded to get more reliable data.

Table 38 Effect of fertiliser treatments on yield, number of bunches and single bunch weight on eight smallholder blocks in the Buvussi area, in 1991 (Trial 112).

	Yield (t/ha/yr)			Bunches (no/ha/yr)			Single bunch weight (kg)		
	Treatment			Treatment			Treatment		
Block	1	2	3	1	2	3	1	2	3
1150	11.2	12.8	12.8	740	772	704	15.2	16.7	18.3
1152	10.6	15.5	14.6	600	932	632	17.6	15.6	23.1
1194	12.9	15.8	15.2	664	812	720	19.4	19.4	21.1
1397	20.7	23.6	27.2	1072	1076	1144	19.3	21.9	23.8
1193	26.7	28.0	32.4	1288	1192	1244	20.8	23.4	26.1
1151	11.3	10.2	23.0	756	772	1260	15.0	13.2	18.3
1142	6.1	5.6	3.2	312	296	184	19.4	19.2	17.7
1396	9.3	9.9	8.3	432	492	424	21.6	19.9	19.6
Mean	13.6	15.0	17.1	732	792	788	18.5	18.6	21.0
$lsd_{5\%}$		3.1			160			2.1	
cv %		18.9			19.0			10.4	

Treatment: 1 = control (no fertiliser).
2 = 1 kg TSP/palm/yr.
3 = 1 kg TSP/palm/yr plus 2 kg AC/palm/yr.

The concentrations of nitrogen and chlorine in leaflets were higher in plots that received ammonium chloride, and the concentrations of potassium were lower (Table 39). The concentrations of all elements, except calcium, were very low. In the plots that did not receive ammonium chloride the concentrations of chlorine were extremely low. The concentration of chlorine that is recommended is 0.3 - 0.4%, while the average for palms on plots not receiving ammonium chloride was 0.09%. However, in some plots where the chlorine was very low yields were reasonably high (eg in one plot that had a chlorine concentration of 0.06% the yield was 28t/ha, and in another that had a chlorine concentration of 0.07% the yield was 26.7t/ha).

Table 39 The mean effect of fertiliser treatments on yield and leaf 17 nutrient concentrations on eight smallholder blocks in the Buvussi area in 1991 (Trial 112).

Treatment number	Nutrients applied	Leaf nutrient content (% dry matter)					
		N	P	K	Ca	Mg	Cl
1	Nil	1.84	0.119	0.76	0.85	0.14	0.09
2	P	1.85	0.123	0.75	0.80	0.13	0.09
3	N+P	1.92	0.127	0.64	0.88	0.12	0.26
	lsd	0.060	0.005	0.054	0.086	0.034	0.026
	cv %	2.0	2.6	8.8	5.9	15.4	10.0

Experiment 121 DEMONSTRATION OF RECOMMENDED MANAGEMENT AND FERTILISER APPLICATION ON OIL PALM SMALLHOLDINGS (HOSKINS).

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 121 is located on the DAL Hoskins Oil Palm Scheme (Figure 13, Site Nos 2-8) at Kapore, Tamambu, Tamba, Sarakolok, Buvussi, Galai 1 & 2, Siki, Namova, Morokea, Mai 1 & 2, Gule and Galilo.

Palms Dami commercial D X P planting material.
Planted between 1982 and 1986 at 120 palms/ha.
Treatments started in April/May 1989.

DESIGN

Each of the seven smallholder blocks provides a single replicate within which are six treatments: no fertiliser (control), recommended nitrogen rate (demonstration) and three others with the specific purpose of testing nitrogen application in the presence of phosphorus, potassium and magnesium. One further plot tests a higher rate of nitrogen (Table 40). Each plot has at least 12 recorded palms surrounded by a guard row.

Table 40. Treatments used in Trial 121.

	Amount of fertiliser (kg/palm/yr)			
Treatment number	Ammonium chloride	Triple superphosphate	Muriate of potash	Kieserite
1	0	0	0	0
2	2	2	0	0
3	2	0	2	0
4	2	0	0	2
5	2	0	0	0
6	3	0	0	0

Treatments were started in April/May 1989. Fertiliser is applied twice a year in May and November.

RESULTS

The application of ammonium chloride (treatment 2 and 6), ammonium chloride (AC) plus triple superphosphate (treatment 3), AC plus muriate of potash (treatment 4), AC plus kieserite (treatment 5), increased the mean yield, but the increases were not statistically significant because the yields were rather variable (Table 41A). Some blocks appeared to respond to AC (3, 4, 7 & 8), some to AC plus triple superphosphate (2, 4, 5, 6 & 8), some to AC plus muriate of potash (3, 4, & 8), and some appeared to respond to AC plus kieserite (2, 3, 4, 5, 6, 7 & 8). Blocks 2, 5 & 6 did not appear to respond to AC, blocks 3 & 7 did not appear to respond to triple superphosphate (TSP) and 2, 5, 6 & 7 did not appear to respond to muriate of potash (MOP). Blocks 4 & 8 responded to all treatments, blocks 3, 4, 5 & 6 had poor yields with most treatments while blocks 2, 7 & 8 had good yields even without fertiliser. Blocks 3, 7 & 8 responded to the higher level (3kg/palm/yr) of AC. Kieserite appeared to increase mean yields in all seven blocks. There appears to be some benefit from applying fertiliser, however at this stage the results are not sufficient to make recommendation for fertiliser usage.

The components of yield ,number of bunches and single bunch weight, showed wide variation (Table 41B & 41C), but the differences are not statistically significant. As with Trial 112, such inconsistency in the results must lead us to question whether the methods we are using are appropriate. In trials such as this, the blockholder does the harvesting, and leaves the bunches near the palms. The OPRA staff weigh and record the bunches. For the records to be reliable the blockholder must harvest regularly, cut all fruit that is ripe, and leave the fruit near the palm. The fact that the OPRA staff visit the block to record the harvest on only 9 out of 36 possible harvesting occasions could mean that the blockholder is tempted not to do the job properly on the harvesting occasions when OPRA staff are not visiting. This could lead to inaccuracies in the recording of yield on the occasions when OPRA staff do visit.

We shall take a closer look at this trial to see whether fewer blocks should be used and all of the harvests be recorded to get more reliable data.

The concentrations of nitrogen and chlorine in frond 17 leaflet tissue were higher in plots that received ammonium chloride (treatments 2, 3, 4, 5 & 6), and concentrations of potassium were lower (Table 42). The concentrations of all elements, except calcium, are low. The concentration of chlorine that would be regraded as adequate is 0.3 - 0.4%, the average for palms not receiving ammonium chloride was 0.22%. Application of triple superphosphate (treatment 3), had no effect on leaflet phosphorus concentrations. In plots that did not receive any fertiliser (treatment 1), the concentration of potassium in the leaflets is relatively high, while in plots that received fertiliser treatments, including muriate of potash, the average concentration of potassium in the leaflets was reduced. Application of kieserite had no significant effect on leaflet magnesium concentrations.

Table 41A. Effect of fertiliser treatments on yield on seven blocks in the Hoskins project area in 1990-1991 (Trial 121).

	Yield of FFB (t/ha/yr)						
	Treatment Number						
Block	1	2	3	4	5	6	Mean
2	22.9	20.9	23.8	21.8	26.6	16.5	22.1
3	11.6	15.1	11.2	13.6	12.8	17.2	13.6
4	7.1	10.6	12.8	18.0	20.3	8.1	12.8
5	13.3	10.3	14.5	13.1	14.0	10.7	12.7
6	13.6	13.3	14.8	13.3	16.9	12.7	14.1
7	14.8	18.4	13.1	11.3	18.0	18.3	15.7
8	16.3	22.6	19.8	17.1	19.2	19.6	19.1
Mean	14.2	15.9	15.7	15.5	18.3	14.7	15.7
lsd				3.2			
cv %				18.9			

Treatments:
1 = control.
2 = ammonium chloride (AC), 2 kg/palm/yr.
3 = AC plus triple superphosphate, 2 kg/palm/yr.
4 = AC, 2 kg/palm/yr, and muriate of potash, 2 kg/palm/yr.
5 = AC, 2 kg/palm/year, plus kieserite, 2 kg/palm/year.
6 = AC, at 3 kg/palm/yr.

Table 41B. Effect of fertiliser treatments on number of bunches on seven blocks in the Hoskins project area, in 1990 - 1991 (Trial 121).

	Bunches (no/palm/year)						
	Treatment number						
Block	1	2	3	4	5	6	Mean
2	1112	960	1228	1094	1280	732	1068
3	816	912	904	926	864	1166	931
4	796	930	1140	1488	1808	654	1140
5	1152	804	1160	924	1124	876	1007
6	734	780	810	720	916	736	783
7	1096	1184	876	766	984	1036	990
8	1778	2244	1764	1650	1756	1800	1832
Mean	1069	1116	1126	1081	1247	1000	1107
lsd				247			
cv %				20.4			

Table 41C. Effect of treatments on single bunch weight on seven blocks in the Hoskins project area in 1990 - 1991 (Trial 121).

	Single Bunch Weight (kg)						
	Treatment number						
Block	1	2	3	4	5	6	Mean
2	20.6	21.8	19.3	20.0	20.8	22.5	20.8
3	14.3	16.5	12.4	14.7	14.8	14.7	14.6
4	8.9	11.4	11.1	12.1	11.2	12.5	11.1
5	11.6	12.8	12.4	14.2	12.4	12.2	12.6
6	18.5	17.0	18.3	18.5	18.4	17.3	18.0
7	13.5	15.6	14.9	14.8	18.3	17.7	15.8
8	9.2	10.1	11.2	10.3	10.9	10.9	10.4
Mean	13.8	15.0	14.2	14.9	15.3	15.4	14.8
lsd				1.2			
cv %				7.4			

Table 42A. Affect of fertiliser treatments on nutrient concentrations of frond 17 leaflets on seven blocks in the Hoskins project area in 1991 (Trial 121).

	Nitrogen (%)						
	Treatment Number						
Block	1	2	3	4	5	6	Mean
2	2.36	2.44	2.47	2.36	2.40	2.33	2.40
3	2.25	2.34	2.39	2.17	2.37	2.30	2.30
4	2.13	2.26	2.30	2.37	2.39	2.44	2.23
5	2.13	2.26	2.33	2.27	2.46	2.36	2.30
6	2.23	2.30	2.27	2.34	2.37	2.34	2.30
7	2.33	2.27	2.26	2.30	2.23	2.37	2.30
8	2.20	2.37	2.47	2.42	2.33	2.44	2.40
Mean	2.23	2.32	2.40	2.32	2.36	2.37	2.32
lsd				0.09			
cv %				3.5			

Treatments:
1 = control.
2 = ammonium chloride (AC), 2 kg/palm/yr,
3 = AC, plus triple superphosphate, 2 kg/palm/yr,
4 = AC, 2 kg/palm/yr, and muriate of potash, 2 kg/palm/yr
5 = AC, 2 kg/palm/yr, plus kieserite, 2 kg/palm/yr
6 = AC, at 3 kg/palm/yr.

Table 42B. Effect of fertiliser treatments on nutrient concentrations of frond 17 leaflets on seven blocks in the Hoskins project area in 1991 (Trial 121).

Phosphate (%)							
	Treatment number						
Block	1	2	3	4	5	6	Mean
2	0.149	0.152	0.149	0.146	0.148	0.148	0.149
3	0.137	0.141	0.146	0.141	0.141	0.139	0.141
4	0.136	0.144	0.150	0.146	0.145	0.146	0.145
5	0.139	0.141	0.148	0.141	0.147	0.146	0.144
6	0.138	0.143	0.146	0.147	0.141	0.142	0.143
7	0.141	0.143	0.145	0.143	0.139	0.147	0.143
8	0.134	0.149	0.150	0.150	0.142	0.150	0.146
Mean	0.140	0.150	0.150	0.145	0.143	0.145	0.145
lsd				0.005			
cv %				3.0			

Table 42C. Effect of fertiliser treatments on nutrient concentrations of frond 17 leaflets on seven blocks in the Hoskins project area in 1991 (Trial 121).

Potassium (%)							
	Treatment number						
Block	1	2	3	4	5	6	Mean
2	0.90	0.68	0.70	0.68	0.74	0.82	0.75
3	0.92	0.66	0.60	0.74	0.62	0.66	0.70
4	0.86	0.80	0.66	0.66	0.60	0.60	0.70
5	0.82	0.92	0.78	0.64	0.82	0.72	0.78
6	0.70	0.60	0.66	0.76	0.92	0.72	0.73
7	0.74	0.64	0.68	0.70	0.78	0.60	0.69
8	0.92	0.80	0.76	0.82	0.74	0.72	0.79
Mean	0.84	0.73	0.69	0.71	0.75	0.69	0.73
lsd				0.1			
cv %				11.6			

Table 42D. Effect of fertiliser treatments on nutrient concentrations of frond 17 leaflets on seven blocks in theHoskins project area in 1991 (Trial 121).

Calcium (%)							
	Treatment Number						
Block	1	2	3	4	5	6	Mean
2	0.87	0.89	0.78	0.83	0.86	0.83	0.84
3	0.75	0.79	0.80	0.77	0.79	0.75	0.77
4	0.84	0.93	0.73	0.87	0.75	0.79	0.81
5	0.79	0.91	0.92	0.91	0.92	0.97	0.90
6	0.76	0.90	0.79	0.93	0.82	0.84	0.84
7	0.78	0.88	0.89	0.99	0.93	0.93	0.90
8	0.70	0.77	0.83	0.92	0.83	0.89	0.82
Mean	0.78	0.87	0.82	0.89	0.84	0.86	0.82
lsd				0.06			
cv %				6.2			

Table 42E. Effect of fertiliser treatments on nutrient concentrations of frond 17 leaflets on seven blocks in the hoskins project area in 1991 (Trial 121).

Magnesium (%)							
	Treatment number						
Block	1	2	3	4	5	6	Mean
2	0.13	0.10	0.12	0.12	0.12	0.12	0.12
3	0.13	0.09	0.12	0.09	0.11	0.09	0.11
4	0.20	0.18	0.17	0.13	0.15	0.14	0.17
5	0.12	0.13	0.15	0.13	0.15	0.11	0.13
6	0.11	0.13	0.11	0.11	0.15	0.12	0.12
7	0.11	0.12	0.12	0.12	0.13	0.12	0.13
8	0.11	0.12	0.13	0.13	0.14	0.13	0.13
Mean	0.13	0.12	0.13	0.12	0.14	0.12	0.13
lsd				0.02			
cv %				12.3			

Table 42F. Effect of fertiliser treatments on nutrient concentrations of frond 17 leaflets on seven blocks in the hoskins project area in 1991 (Trial 121).

	Chlorine (%)						
	Treatment number						
Block	1	2	3	4	5	6	Mean
2	0.26	0.36	0.39	0.40	0.37	0.44	0.37
3	0.21	0.31	0.30	0.27	0.29	0.37	0.29
4	0.32	0.41	0.39	0.47	0.36	0.37	0.39
5	0.15	0.36	0.38	0.40	0.43	0.38	0.35
6	0.23	0.32	0.31	0.35	0.32	0.37	0.32
7	0.14	0.36	0.39	0.37	0.31	0.28	0.31
8	0.21	0.39	0.36	0.36	0.36	0.41	0.35
Mean	0.22	0.36	0.36	0.37	0.35	0.37	0.34
lsd				0.04			
cv %				11.8			

Experiment 124 **DEMONSTRATION OF RECOMMENDED MANAGEMENT AND FERTILISER APPLICATION ON OIL PALM SMALLHOLDINGS IN SCHOOLS (HOSKINS).**

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

Sites — Experiment 124 is on DAL Hoskins Oil Palm Scheme (Figure 13, Site Nos 20, 21& 22) at Ponini Agricultural School, Hoskins Provincial High School and Mora Mora Vocational Centre.

Palms — Dami commercial D X P planting material.
Planted between 1985 & 91 at 120 palms/ha and 95 palms/ha at Mora Mora.
Treatments started in July 1991.

DESIGN

Each of the three blocks provides a single replicate, within which are six treatments: no fertiliser (control), recommended nitrogen rate (demonstration) and three others with the specific purpose of testing nitrogen application in the presence of phosphorus, potassium and magnesium. One further plot tests a higher rate of nitrogen (Table 43). Each plot has at least 12 recorded palms, surrounded by a guard row.

Table 43. Treatments used in Trial 124.

	Amount of fertiliser (kg/palm/yr)			
Treatment number	Ammonium chloride	Triple superphosphate	Muriate of potash	Kieserite
1	0	0	0	0
2	2	2	0	0
3	2	0	2	0
4	2	0	0	2
5	2	0	0	0
6	3	0	0	0

Treatments were started in July 1991. Fertiliser was applied twice a year in May and November.

The yield was recorded in three months (February, June, and October), and leaflet samples were taken for analysis in December.

RESULTS

Frond 17 leaflet tissue was sampled and the nutrient concentrations were analysed before any treatments were applied (Table 44). The concentrations of nutrient elements at both sites are lower than the recommended minimum for the Mosa area.

Table 44. Pretreatment frond 17 leaflet nutrient concentrations in 1991 (Trial 124).

Site Number	Site Name	N %	P %	K %	Mg %	Ca %	Cl %
20	PAS	2.48	0.148	0.82	0.19	0.86	0.16
21	HHS	-	-	-	-	-	-
22	MVC	2.15	0.128	0.79	0.19	0.64	0.25

PAS Ponini Agricultural School
HHS Hoskins Provincial High School
MVC Mora Mora Vocational Centre

III. AGRONOMY AND SMALLHOLDER TRIALS

MAINLAND PROVINCES

(K.Gales)

Trial 305 FERTILISER TRIAL AT AREHE ESTATE

PURPOSE

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

The 72 plots are divided into two replicates of 36. In each replicate there are 36 treatments, made up from all combinations of three levels each of N and K, and two levels each of P and Mg (Table 45).

Table 45. Types of fertiliser and amounts used in trial 305.

Element	Type of fertiliser	Amount of fertiliser Level 0	Level 1	Level 2
		(kg/palm/year)		
N	SOA	0	2.0	4.0
P	TSP	0	2.0	-
K	MOP	0	2.0	4.0
Mg	Kies	0	1.0	-

RESULTS

There was a large and statistically significant increase in yield caused by SOA, up to level 1, and then a smaller increase up to level 2 (Table 46). This increase was made up from an increase in number of bunches per hectare, and single bunch weight. There was also an increase in yield due to MOP, up to level 1, though it was not statistically significant.

Table 46. Main effects of N, P, K, and Mg on yield and yield components in oil palm (Trial 305).

	Nutrient element and level			Statistics		
				sig	sed	lsd
	N0	N1	N2			
Yield (t/ha/yr)	21.7	32.1	33.4	***	1.64	3.3
Bunches/ha	1020	1330	1390	***	62.2	130
Bunch weight (kg)	20.7	24.4	24.2	***	0.67	1.4
	K0	K1	K2			
Yield (t/ha/yr)	27.5	29.5	30.2	ns	-	-
Bunches/ha	1280	1220	1230	ns	-	-
Bunch weight (kg)	21.3	23.8	24.1	***	0.67	1.4
	P0	P1				
Yield (t/ha/yr)	28.8	29.3	-	ns	-	-
Bunches/ha	1240	1250	-	ns	-	-
Bunch weight (kg)	23.0	23.1	-	ns	-	-
	Mg0	Mg1				
Yield (t/ha/yr)	29.8	28.4	-	ns	-	-
Bunches/ha	1280	1210	-	ns	-	-
Bunch weight (kg)	23.0	23.2	-	ns	-	-

The interaction between N and K is not significant, but the NxK two-way table (Table 47) shows that the maximum yield of 34 to 36 t/ha/yr is achieved with 4 kg SOA per palm plus between 2 and 4 kg MOP per palm.

There was no response to TSP or kieserite.

A formal economic analysis of the results would be unreliable, because the effects of poaching would flatten the response curves. A rough estimate suggests that the optimum amount of fertiliser would be equivalent to 2 kg SOA per palm per year.

Table 47. Effect of N on yield at different levels of K.

	Yield (t/ha/yr)		
	Level of N		
Level of K	0	1	2
0	20.5	31.4	30.5
1	22.2	32.3	34.1
2	22.6	32.4	35.6

Note: Interaction not significant.

Trial 306 FERTILISER TRIAL AT AMBOGO ESTATE

PURPOSE

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

DESCRIPTION

Site	Ambogo Estate block 79B
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 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 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, sometimes two.

The 81 plots are a single replicate containing 81 treatments, made up from all combinations of three levels each of N, P, K, and Mg (Table 48). 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 48. Types and amounts of fertiliser used in Trial 306.

Element	Type of fertiliser	Amount of fertiliser Level 0	Level 1	Level 2
		(kg/palm/yr)		
N	SOA	0	3.0	6.0
P	TSP	0	0.5	1.0
K	MOP	0	2.5	5.0
Mg	Kies	0	0.75	1.5

RESULTS

Application of N caused a large and statistically significant increase in yield, up to level 1, and a further, but smaller increase up to level 2 (Table 49). This was the result of increases in both number of bunches and single bunch weight.

Application of K caused a small but significant increase in yield due to an increase in single bunch weight.

Table 49. Main effects of N, P, K, and Mg on yield and yield components in oil palm (Trial 306).

	Nutrient element and level			Statistics		
				sig	sed	lsd
	N0	N1	N2			
Yield (t/ha/yr)	26.7	32.0	34.5	***	1.01	2.0
Bunches/ha	1250	1340	1450	***	38.2	77
Bunch weight (kg)	21.3	23.9	23.8	***	0.51	1.0
	K0	K1	K2			
Yield (t/ha/yr)	29.5	31.6	32.1	*	1.01	2.0
Bunches/ha	1350	1330	1370	ns	-	-
Bunch weight (kg)	21.9	23.8	23.3	***	0.51	1.0
	P0	P1	P2			
Yield (t/ha/yr)	31.0	30.5	31.7	ns	-	-
Bunches/ha	1360	1320	1370	ns	-	-
Bunch weight (kg)	22.8	23.1	23.1	ns	-	-
	Mg0	Mg1	Mg2			
Yield (t/ha/yr)	30.0	31.4	31.8	ns	-	-
Bunches/ha	1320	1360	1360	ns	-	-
Bunch weight (kg)	22.6	23.1	23.3	ns	-	-

The interaction between N and K is not significant, but the NxK two-way table (Table 50) shows that the maximum yield of about 36 t/ha/yr is achieved with 6 kg/palm of SOA and 3 kg/palm of MOP.

There was no response to TSP or kieserite.

A formal economic analysis of the results would be unreliable because the effects of poaching would flatten the response curves. A rough estimate suggests that the optimium amount of fertiliser would be equivalent to about 3 kg SOA per palm per year.

Table 50. Effect of N on yield at different levels of K.

	Yield (t/ha/yr)		
	Level of N		
Level of K	0	1	2
0	26.6	30.6	31.3
1	27.4	31.7	35.7
2	26.1	33.8	36.5

Note: Interaction not significant.

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 in 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 palm are recorded at intervals of 14 days. In each plot the core palms are surrounded by at least one guard row, sometimes two.

The 35 plots are divided into five replicate blocks, each containing seven treatments that are randomised (Table 51). The treatments are combinations of fertilisers. The lower half of Table 7 shows the amount of each element that is applied to each treatment. The effect of an element is found by comparing the yields from two treatments: for example the effect of Cl in the presence of K and S is found by comparing treatments 6 and 4, and the effect of Cl in the absence of K and S is found by comparing treatments 3 and 1.

The treatments that were used before November 1991 were similar, but there are some important differences (Table 52). All treatments used to get their N from urea, but now only treatment 1 does. The others get it from SOA or AMC. Treatment 6 now has Cl but did not before, while 7 now has S but did not before.

RESULTS

In 1991 it is too soon after the start of the present treatments (November 1990) to draw any definite conclusions about their effects. The present treatments are probably not yet having their full effect, and there is probably still a residual effect of the treatments that were applied before November 1990. In any case there are no significant differences between any of the treatments (Table 53).

Table 51. Amount of each type of fertiliser, and each element, used for each treatment (Trial 310).

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

Table 52 Amount of each element used in each treatment from November 1988 until May 1990 (Trial 310).

	Treatment number						
	1	2	3	4	5	6	7
	(kg element/palm/yr)						
N	0.54	0.54	0.54	0.54	0.54	0.54	0.54
Na	-	0.87	0.79	-	-	-	
K	-	-	-	0.83	1.3	0.83	1.3
S	-	0.61	-	0.68	-	0.68	-
Cl	-	-	1.2	-	1.2	-	1.2

Note: All N is from urea.

Before November 1988 the treatments were similar, but Mg salts were used instead of Na salts as sources of S and Cl.

Table 53 Yields in 1991 (Trial 310).

Treatment number						
1	2	3	4	5	6	7
(t/ha/yr)						
25.3	26.5	29.1	26.2	27.4	26.7	27.6

The values do not differ significantly from one another. sem = 1.41, error df = 24, ems = 9.92

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

PURPOSE

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

DESCRIPTION

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

DESIGN

There are 32 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, sometimes two.

The 32 plots are a single replicate containing 32 treatments, made up from all combinations of four levels each of N and K, and two levels of EFB (Table 54). Sulphate of ammonia (SOA) is the source of N, and muriate of potash (MOP) is the source of K. The EFB is applied by hand as a mulch between the palm circles. The weights of EFB given in Table 10 are the fresh weights ex-mill. When EFB was given 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 give this amount every two years.

Table 54 Amounts of fertiliser and EFB used in trial 311.

Type of fertiliser or EFB	Amount Level 0	Level 1	Level 2	Level 3
		(kg/palm/yr)		
SOA	0	2	4	6
MOP	0	2	4	6
		(kg/palm/two years)		
EFB	0	500	-	-

Notes: SOA and MOP have been applied twice a year since April 1988.

EFB has been applied once every two years (November 1988 and September 1990).

RESULTS

The results of this trial are rather variable, which makes it difficult to say with certainty whether EFB can be used economically as a mulch to replace or supplement chemical fertilisers. The EFB would certainly be beneficial as a mulch in that it would help to protect the soil against erosion, and the cost of transporting it to the field and spreading it could be offset by a decrease in the amount of fertiliser used.

In 1991 there was a significant increase in yield due to N, up to level 1, averaged over all levels of K and EFB (Table 55). There was a significant but erratic effect of K, and no effect of EFB. However , there were significant interactions between all three factors.

The effects of the treatments averaged over the years 1989 to 1991 are broadly similar to those in 1991, but there is a small increase in yield with EFB (Table 56).

In the absence of EFB increasing N causes a steady increase in yield up to about 6 kg SOA/palm/yr (Table 57). In the presence of EFB there is an increase in yield, up to 2kg SOA/palm /yr.

EFB causes an increase in yield at the lower rates of N but not the higher ones.

Though the effects of K and its interactions are significant the effects are small and are erratic.

Table 55 Main effects of N, K, and EFB on yield and yield components in 1991. (Trial 311).

	Nutrient element or EFB and level				Statistics sig	sed	l s d
	N0	N1	N2	N3			
Yield (t/ha/yr)	27.9	32.8	32.8	32.4	***	0.60	1.4
Bunches/ha	1060	1270	1210	1230	***	32.4	75
Bunch weight (kg)	26.3	25.9	27.2	26.5	ns	-	-
	K0	K1	K2	K3			
Yield (t/ha/yr)	31.7	31.8	29.9	32.4	**	0.60	1.4
Bunches/ha	1250	1180	1120	1220	*	32.4	75
Bunch weight (kg)	25.3	27.0	26.7	26.8	*	0.46	1.1
	EFB0	EFB1					
Yield (t/ha/yr)	31.3	31.7			ns	-	-
Bunches/ha	1200	1190			ns	-	-
Bunch weight (kg)	26.2	26.7			ns	-	-

Table 56 Main effects of N, K, and EFB on yield and yield components in 1989-91. (Trial 311).

	Nutrient element or EFB and level				Statistics sig	sed	l s d
	N0	N1	N2	N3			
Yield (t/ha/yr)	28.6	31.8	32.9	33.5	***	0.52	1.2
Bunches/ha	1190	1310	1300	1350	**	29	67
Bunch weight (kg)	24.1	24.3	25.4	24.8	ns	-	-
	K0	K1	K2	K3			
Yield (t/ha/yr)	31.2	31.1	31.1	33.4	**	0.52	1.2
Bunches/ha	1320	1240	1250	1340	*	29	67
Bunch weight (kg)	23.7	25.0	25.0	24.9	ns	-	-
	EFB0	EFB1					
Yield (t/ha/yr)	31.0	32.4			**	0.37	0.9
Bunches/ha	1270	1300			ns	-	-
Bunch weight (kg)	24.3	25.0			ns	-	-

It is not possible to do a proper economic analysis of the results because of the effects of poaching. We have no proper baseline from which to measure the economic benefits of either fertiliser or EFB. The very high yields of the zero plots (around 27 - 28 t/ha/yr) are the result of a combination of high residual soil fertility and the poaching of fertiliser from neighbouring plots.

Table 56. Effects of combinations of N and K, N and EFB, and K and EFB, on yield from 1989 to 1991. (Trial 311)

	Yield (t/ha/yr)			
	Level of N			
Level of K	0	1	2	3
0	28.2	30.6	33.8	32.3
1	26.0	29.4	33.6	35.4
2	29.5	32.9	29.9	32.0
3	30.9	34.3	34.1	34.4
Level of EFB				
0	27.7	29.6	32.6	34.0
1	29.6	34.0	33.1	33.0
	Level of K			
Level of EFB	0	1	2	3
0	29.8	28.6	31.8	33.7
1	32.6	33.5	30.3	33.2

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

PURPOSE

To test the response to N, P, K, and Mg in factorial combination on the Mamba soil, to get information that will help in making fertiliser recommendations.

DESCRIPTION

Site Komo Estate block 27

Soil Dark sandy loam, derived from airfall 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 palms. The numbers and weights of bunches from each individual core palm are recorded at intervals of 14 days. The core palms are surrounded by trenches (one meter deep) to separate them from adjoining plots.

The 36 plots are a single replicate containing 36 treatments, made up from all combinations of three levels of N and K and two levels of P and Mg (Table 58).

Table 58 Types of fertiliser and amounts used in trial 317.

Element	Type of fertiliser	Amount of fertiliser Level 0	Level 1	Level 2
		(kg/palm/year)		
N	SOA	0	2.5	5
P	TSP	0	2.5	-
K	MOP	0	2.5	5
Mg	Kies	0	2.5	-

RESULTS

There was a significant but small effect of K on yield, but no effect of N, P,or Mg (Table 59). All of the yields were heavy, with a baseline yield of about 27 t/ha/yr.

It is possible that the lack of response in this trial is due to the residual fertility of the soil, from the fertiliser that was given before the trial started. The experimental treatments began in March 1990.

It is also possible that there is poaching in this trial, even though there are trenches between the plots. The site is often flooded, which would wash the fertiliser from plot to pot, and wash it away from the site altogether.

Table 59 Main effects of N, P, K, and Mg on yield and yield components (Trial 317).

	Nutrient element and level			Statistics		
				sig	sed	lsd
	N0	N1	N2			
Yield (t/ha/yr)	29.5	27.7	29.1	ns	-	-
Bunches/ha	1910	1790	1960	ns	-	-
Bunch weight (kg)	15.5	15.5	14.9	ns	-	-
	K0	K1	K2			
Yield (t/ha/yr)	27.7	27.4	31.3	*	1.56	3.3
Bunches/ha	1850	1810	2000	ns	-	-
Bunch weight	15.0	15.5	14.9	ns	-	-
	P0	P1				
Yield (t/ha/yr)	27.9	29.6		ns	-	-
Bunches/ha	1840	1930		ns	-	-
Bunch weight (kg)	15.2	15.4		ns	-	-
	Mg0	Mg1				
Yield (t/ha/yr)	28.1	29.5		ns	-	-
Bunches/ha	1870	1900		ns	-	-
Bunch weight (kg)	15.0	15.6		ns	-	-

Table 60 Effect of K on yield at different levels of N.

	Yield (t/ha/yr)		
	Level of K		
Level of N	0	1	2
0	27.8	28.7	32.0
1	26.2	26.7	30.1
2	29.0	26.6	31.8

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 27.

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 palms. The numbers and weights of bunches from each individual core palm are recorded at intervals of 14 days. The core palms are surrounded by trenches (one meter deep) to separate them from adjoining plots.

The 36 plots are a single replicate containing 36 treatments, made up from all combinations of three levels of N and K and two levels of P and Mg (Table 61).

Table 61 Types of fertiliser and amounts used in trial 318.

Element	Type of fertiliser	Amount of fertiliser Level 0	Level 1	Level 2
		(kg/palm/year)		
N	SOA	0	2.5	5
P	TSP	0	2.5	-
K	MOP	0	2.5	5
Mg	Kies	0	2.5	-

RESULTS

None of the treatments had a significant effect on yield (Table 62), though there was a non-significant effect of K, similar to that seen in trial 317. All of the yields were heavy with a baseline yield of about 27 t/ha/yr, as in trial 317.

It is possible that the lack of response in this trial is due to the residual fertility of the soil, from the fertiliser that was given before the trial started. The experimental treatments started in March 1990.

Table 62 Main effects of N, P, K, and Mg on yield and yield components (Trial 318).

	Nutrient element and level			Statistics		
				sig	sed	lsd
	N0	N1	N2			
Yield (t/ha/yr)	31.0	27.9	29.6	ns	-	-
Bunches/ha	2220	1850	2110	ns	-	-
Bunch weight (kg)	14.0	15.1	14.1	ns	-	-
	K0	K1	K2			
Yield (t/ha/yr)	27.9	29.9	30.6	ns	-	-
Bunches/ha	2000	2100	2080	ns	-	-
Bunch weight	14.1	14.3	14.8	ns	-	-
	P0	P1				
Yield (t/ha/yr)	28.8	30.2		ns	-	-
Bunches/ha	2000	2120		ns	-	-
Bunch weight (kg)	14.5	14.3		ns	-	-
	Mg0	Mg1				
Yield (t/ha/yr)	29.7	29.3		ns	-	-
Bunches/ha	2080	2040		ns	-	-
Bunch weight (kg)	14.5	14.4		ns	-	-

Table 63. Effect of K on yield at different levels of N.

	Yield (t/ha/yr)		
	Level of K		
Level of N	0	1	2
0	29.2	31.4	32.5
1	24.9	28.3	30.4
2	29.8	30.1	29.1

Trial 501 FERTILISER TRIAL AT HAGITA ESTATE.

PURPOSE

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

DESCRIPTION

Site Hagita Estate

Soil Plantation family. Alluvial clay loam with seasonally high water table.

Palms Dami commercial DxP crosses. Planted in April 1986 at 127 palms/ha. Trial started in July 1986.

DESIGN

There are 54 plots , each with a core of 8 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, sometimes two.

The 54 plots are divided into three replicates blocks each containing 18 treatments, made up from all combinations of three levels of N and K, and two levels of P (Table 64).

There are four additional plots that are given no potassium at all, because in the main part of the trial the level 0 amount of potassium is 0.5 kg MOP/palm/year. This is because in some parts of the estate such severe deficiency symptoms were seen that it was thought the palms might die.

Table 64 Types of fertiliser and amounts used in trial 501.

Element	Type of fertiliser	Amount of fertiliser Level 0	Level 1	Level 2
		(kg/palm/year)		
N	SOA	0	1.8	3.6
P	TSP	0	1.0	2.0
K	MOP	0.5	2.5	4.5

RESULTS

There was no response in yield to N or P, but there was a significant increase in yield due to K (Table 65). This was because of an increase in bunch weight.

All of the yields were heavy. The mean yield of the three N0-K0-P0 plots (which receive 0.5 kg MOP/palm/yr) was 28.1 t/ha. The mean yield of the four extra plots (which received no MOP at all) was 27.3 t/ha, with a range of 20.2 to 32.3 t/ha. The heaviest yields are between 31 and 32 t/ha/year.

There was no interaction between the effects of N and K. There was a small but significant interaction between the effects of N and P, but this appeared to be spurious.

The lack of response to N and P in this trial, and the smallness of the response to K could be because of poaching.

If we take the results at face value the yield without any fertiliser at all would be about 27.3 t/ha/year, and the yield with 1.5 kg MOP/palm/yr would be 29.7 t/ha/yr.

Table 65 Main effects of N, P, K, and Mg on yield and yield components (Trial 501).

	Nutrient element and level			Statistics sig	sed	lsd
	N0	N1	N2			
Yield (t/ha/yr)	30.6	31.0	29.2	ns	-	-
Bunches/ha	3140	3200	2970	*	93	188
Bunch weight (kg)	9.76	9.71	9.84	ns	-	-
	K0	K1	K2			
Yield (t/ha/yr)	28.3	30.8	31.6	**	0.96	1.9
Bunches/ha	3170	3050	3090	ns	-	-
Bunch weight	8.93	10.2	10.2	***	0.22	0.4
	P0	P1				
Yield (t/ha/yr)	30.2	30.3		ns	-	-
Bunches/ha	3090	3110		ns	-	-
Bunch weight (kg)	9.79	9.76		ns	-	-

Trial 502 FERTILISER TRIAL AT WAIGANI ESTATE.

PURPOSE

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

DESCRIPTION

Site	Waigani Estate
Soil	Plantation family. Alluvial clay loam with seasonally high water table.
Palms	Dami commercial DxP crosses. Planted in 1986 at 127 palms/ha. Trial started in March 1990.

DESIGN

There are 48 plots each containing 16 core palms. The numbers and weights of bunches of each individual core palm are recorded at intervals of 14 days. In each plot the core palms are surrounded by at least one guard row, sometimes two.

The 48 plots are divided into two replicate blocks each containing 24 treatments made up from all combinations of three levels of N, two levels of P, and four levels of K (Table 66).

Table 66. Types of fertiliser and amounts used in trial 502.

Element	Type of fertiliser	Amount of fertiliser Level 0	Level 1	Level 2	Level 3
		(kg/palm/year)			
N	SOA	0	2.5	5.0	-
P	TSP	0	2.0	-	-
K	MOP	0	2.5	5.0	7.5

RESULTS

There were small but significant increases in yield in response to N and to K, but no response to P (Table 67). There was no interaction between N and K.

All of the yields were heavy. The yield was about 27 t/ha/year without fertiliser, and about 32 t/ha/year with both N and K.

A formal economic analysis is not possible, but taken at face value the results show that there is not an economic response to any fertiliser.

The smallness of the response to fertiliser in this trial is possibly because of poaching, and also because there is probably a residual effect of fertiliser that was given before the treatments started in March 1990.

Table 67. Main effects of N, P, and K on yield and yield components in 1991. (Trial 502).

	Nutrient element and level				Statistics		
					sig	sed	l s d
	N0	N1	N2				
Yield (t/ha/yr)	28.1	28.2	29.9		*	1.07	2.2
Bunches/ha	2640	2650	2890		*	89.9	186
Bunch weight (kg)	10.7	10.7	10.4		ns	-	-
	K0	K1	K2	K3			
Yield (t/ha/yr)	27.2	29.9	28.8	28.9	*	0.87	1.8
Bunches/ha	2570	2890	2740	2720	*	104	215
Bunch weight (kg)	10.7	10.4	10.5	10.6	ns	-	-
	P0	P1					
Yield (t/ha/yr)	28.6	28.8			ns	-	-
Bunches/ha	2690	2760			ns	-	-
Bunch weight (kg)	10.7	10.4			ns	-	-

IV. ENTOMOLOGY AND PATHOLOGY

(T.M. Solulu and R.N.B. Prior)

INVESTIGATION 603 THE POLLINATING WEEVIL *ELAEIDOBIUS KAMERUNICUS*.

Purpose

To introduce the pollinating weevil *Elaeidobius kamerunicus* to areas of oil palm in Papua New Guinea and to measure its effect on fruitset.

Background

The weevil was first released in Papua New Guinea in 1981, in West New Britain and Oro Province. In April 1989 it was released in Milne Bay, and in April 1991 in Poliamba (New Ireland). These later releases are being followed with some detailed observations.

Observations are made in Hagita and Waigani Estates (Milne Bay) and Bolegila, Baia, and Maramakas Estates (Poliamba). In each estate a group of 100 palms is used and the following observations are made:

Numbers of *Elaeidobius kamerunicus* emerging from 20 male spikelets.

Numbers of male and female infloresences at anthesis. (As a rule of thumb ten anthesing males are required per hectare to achieve good pollination.)

Percentage fruitset on 20 bunches. (Less than 50% is considered poor.)

Milne Bay

Weevil Population

The numbers of weevils emerging from male spikelets at Hagita and Waigani estates in 1991 are considered to be adequate for pollination throughout the year, although they were a little low in February, March, May, August and September (Figure 14).

Flower Census

The numbers of anthesing males were low during most of the year. At Waigani they were very low during May, July, and August (Figure 15).

Fruitset

The percentage fruitset was low in January, February, and March, and again in October, November and December (Figure 16). The low values in the early part of the year are probably the result of a shortage of male inflorescences in the preceding six months (June to September 1990) when the number was in the range one to nine per hundred palms(Figure 5.2). The low percentage fruit set in the later part of the year was probably the result of a shortage of male inflorescences in May to August plus a shortage of weevils in May and August.

The annual average fruitset at Hagita improved from 42% in 1990 to 49% in 1991, and similarly at Waigani from 42% to 48%.

Figure 14: Weevil Emergence at Milne Bay in 1991.

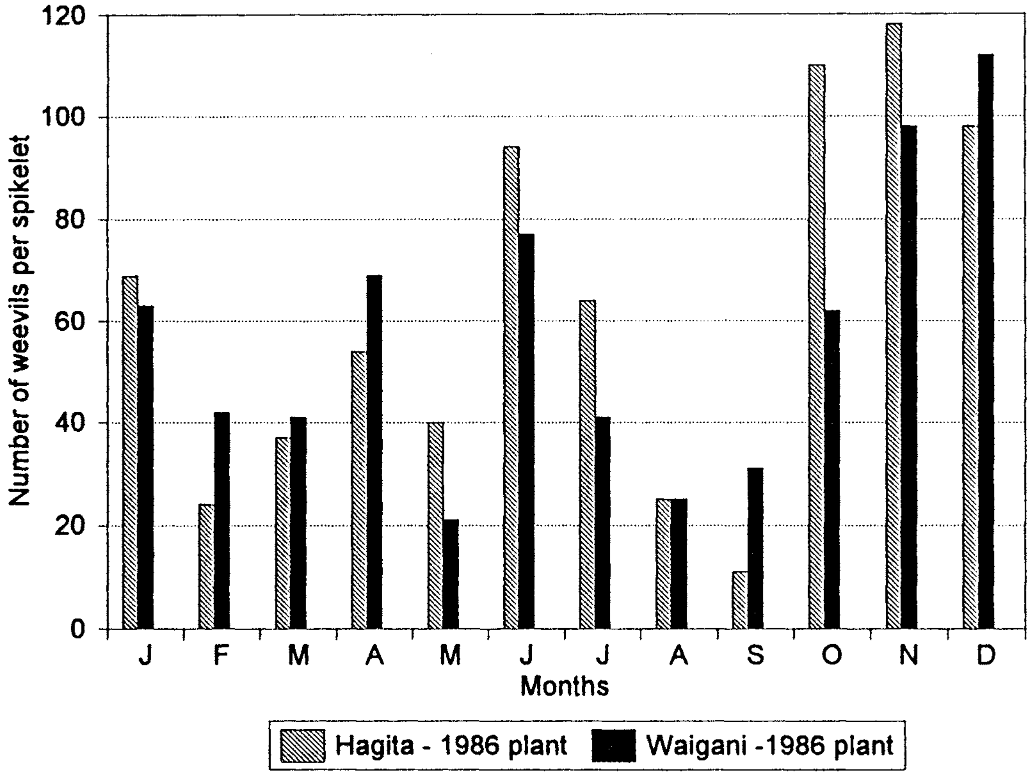


Figure 15: Number of male inflorescences at anthesis (average per day in 100 palms) at Milne Bay in 1990 and 1991.

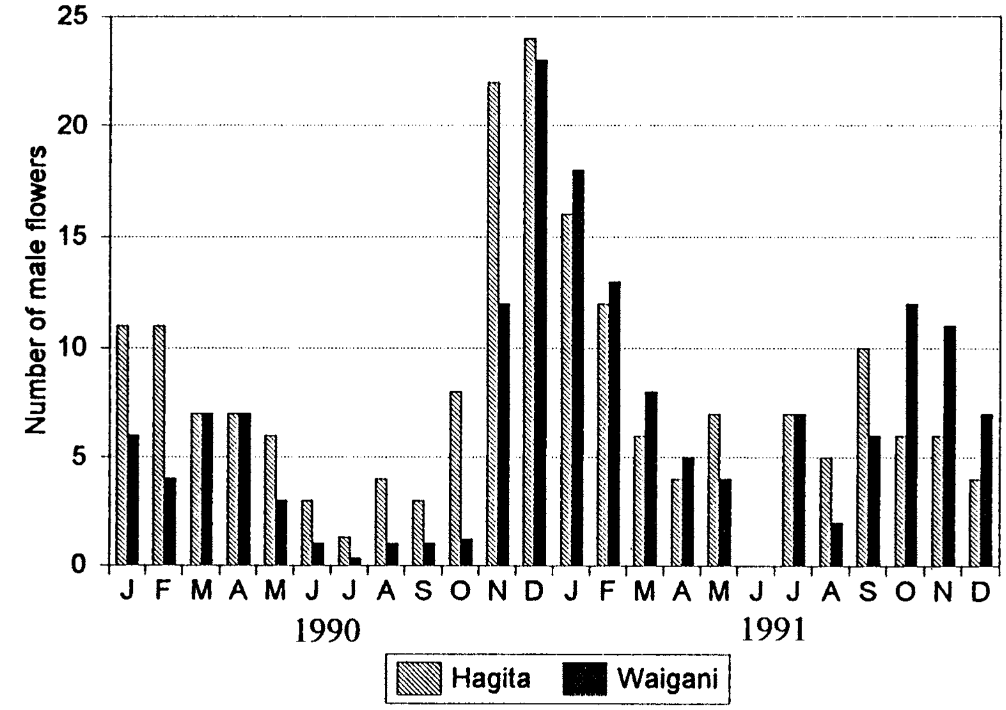
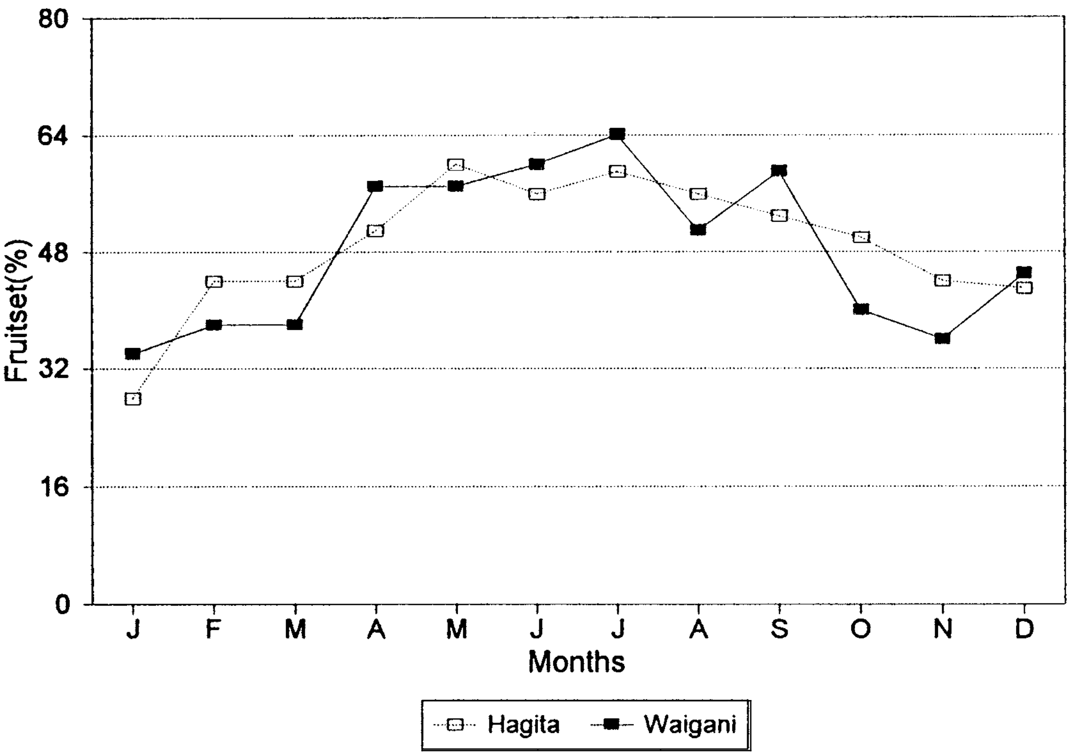


Figure 16: Percentage fruitset at Milne Bay in 1991



<u>*Poliamba (New Ireland Province)*</u>

Weevil Population

Counting of weevils that emerge from male spikelets will begin in 1992.

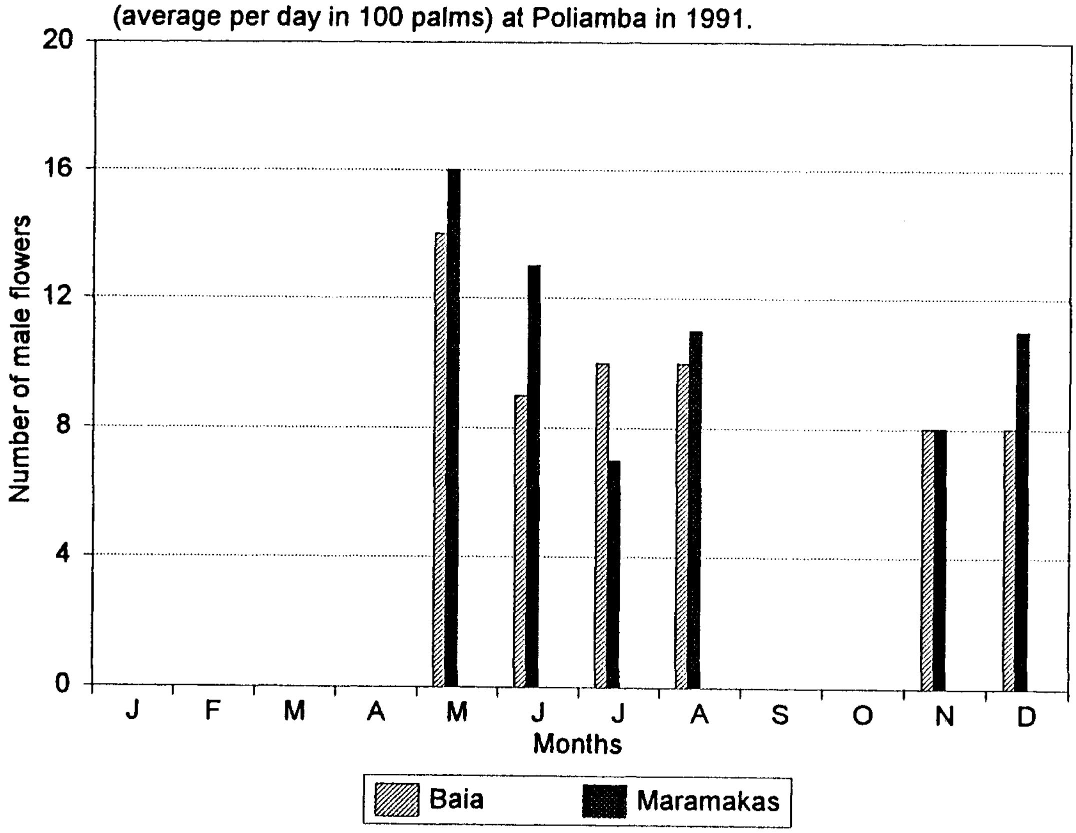
Flower Census

The numbers of anthesing male inflorescences were rather low in June and July (figure 17).

Fruitset

The first measurements of fruitset at Poliamba were made in June 1991, but pollination would have occurred five months earlier, in January, before the introduction of the weevil (April). Fruitset before the introduction of the weevil was 36% at Baia estate, and 52% at Maramakas. Such levels could indicate the presence of other pollinating agents.

Figure 17: Number of male inflorescences at anthesis (average per day in 100 palms) at Poliamba in 1991.



INVESTIGATION 703 FRUITSET IN CLONAL OIL PALMS IN DIFFERENT ENVIRONMENTS

This was planned to investigate the effects of environment on fruitset and weevil behaviour, but was discontinued because of technical problems. This trial will be started again if the Management Board and Scientific Advisory Board agree.

INVESTIGATION 601 CONTROL OF SEXAVA USING CHEMICALS

Purpose

To assist with surveys of damage, to make treatment recommendations, to monitor the chemical control program, and to test any new chemicals that might be effective against sexava.

Background

Sexava is an insect that looks like a grasshopper, and eats the leaves of palms and other monocot species. There are many species of sexava in PNG of which three attack oil palm: *Segestidea defoliaria*, which is the commonest species; *S. novaeguineae* which occurs only in Oro Province; and *Segestes decoratus*, which is sometimes found only as females reproducing parthenogenetically.

Outbreaks of sexava in oil palm can be brought under control by the injection of insecticides (monocrotophos or acephate) into the trunk.

No species of sexava has ever been recorded from the mainland area of Milne Bay Province - but only from an island, on coconuts. In New Ireland two species have been commonly reported on coconuts but not on oil palm.

Progress

In West New Britain there was a marked decrease in the area requiring treatment for sexava. The total area treated in 1991 was 1823 ha compared with 3957ha in 1990. (1990 was the worst year for insect damage during the past 13 years.) The area that was treated in 1991 comprised 235 ha of plantation, and 1588 ha of smallholding (on 398 blocks).

The decrease in the area that needed treatment was the result of continuing efforts by DAL extension staff and OPRA. The release of 2.5 million parasitoids of sexava also helped to control the pest.

At Bialla, where the most severe damage had occurred previously, a separate sexava treatment team was set up, operated by DAL with assistance from OPRA. It has been operating for seven months and appears to be giving a satisfactory service to the smallholders. Heavy rain hindered progress of both survey and treatment.

In West New Britain, *Segestidea defoliaria,* and *Segestes decoratus* were found at Tamba Subdivision and Dami. No chemical treatment was recommended, but parasitoids of the eggs were released.

In Oro Province, moderate damage caused by sexava was seen in April on Hujavasuru VOP and a parasitic Tachinid (fly) was reported to be present. At Bora VOP light damage was reported, and one specimen of sexava (*Segestidea novaeguineae*) was found that was parasitized by the internal parasite *Stichotrema dallatorreanum.* No treatment was recommended in either case.

INVESTIGATION 607 BIOLOGICAL CONTROL OF SEXAVA

Purpose

To find and study biological agents that attack sexava, and rear the most useful parasites for release into infested areas .

Background

Sexava is susceptible to some parasitic insects that can be used to control its population. Two species of wasp that are parasitic on the eggs of sexava are already being reared and released into infested areas (*Leefmansia bicolor*, and *Doirania leefmansi*). Another parasite, *Stichotrema dallatorreanum*, which lives in the body of the sexava is being studied.

Progress

Parasitoids of the sexava egg were reared and released throughout the year (Table 68), mainly in areas where recent outbreaks had occurred. They were sometimes released concurrently with the chemical treatment.

More than 2.5 million parasitoids were released, which is many more than were released last year. In certain areas the numbers released were inundative in order to cause high mortality in sexava eggs, and thus keep the population in check.

There was a plan to try to rear the parasitoids on semi-synthetic media, but the plan was not realised because the senior entomologist moved to the Cocoa and Coconut Research Institute in Rabaul. The work will continue there and the oil palm industry should benefit from any developments.

At present it is possible to raise the parasitoids only on sexava eggs. Consequently when the population of sexava is low there are few eggs to be used, and then if the sexava population suddenly increases there are too few parasitoids 'in stock' to have a significant effect when released. This problem would be overcome if parasitoids could be raised on a medium other than sexava eggs.

Table 68. Numbers of individuals of two species of parasitoid of sexava that were released during 1991 at various sites.

SITE	Number of Parasitoids	
	Leefmansia bicolor	*Doirania leefmansi*
Bialla Subdivision	17 600	44 000
Buluma VOP	-	110 000
Buvussi Subdivision	82 400	478 000
Dami Plantation	194 800	550 000
Gasmata	12 800	62 000
Kaie VOP	17 600	44 000
Kapore Subdivision	-	44 000
Kavui Subdivision	104 800	414 000
Kumbango Plantation	51 600	44 000
Navarai Plantation	17 600	88 000
Sarakolok S/division	48 400	110 000
Tamba Subdivision	13 200	22 000
TOTAL	560 800	2 010 000

Stichotrema dallatorreanum (Strepsiptera:Myrmecolacidae) is a parasite of which the female lives inside the body of the sexava, while the male is free living, and is suspected of parasitising an ant (*Camponotus* sp). The males can fly but the females remain permanently endoparasitic in the sexava. When the males fly they go in search of the females for mating. The parasite causes a reduction in fecundity of its host. The male host is neutered by the presence of the parasite.

This parasite has been identified in sexava species on coconuts in Morobe, and on oil palms in Oro Province.

The purpose of the study is to identify the host of the male, and then to rear the parasite and its hosts in the laboratory.

An ant colony was set up in the laboratory, and young larvae of the parasite (from Popondetta) were introduced into it. The ant colony survived but the parasite did not. The work continues.

INVESTIGATION 606 CONTROL OF BAGWORM (*LEPIDOPTERA:PSYCHIDAE*)

Purpose

To monitor the amount and distribution of damage to oil palm caused by bagworms; to identify factors linked with high levels of parasitism of bagworms, and to formulate control measures.

Background

Bagworms are caterpillars of various species of moth, that stick to the underside of oil palm leaves, inside bags that are made of pieces of leaf stuck together by silk. The caterpillar eats holes in the leaf. The adult male moth flies and mates with the female (which does not fly) while she is still in the bag. The female dies in the bag and her body becomes the egg-case of the newly fertilised eggs. When the eggs hatch the new caterpillars come out of the bag.

There are several species of bagworm that attack oil palm, but all are susceptible to attack by parasites and pathogens which usually keep the population under control.

Progress

In Oro Province, *Mahasena corbetti*, *Clania* sp. and the 'ice cream cone' bagworms were reported from Embi and the New Warisota plantations. They are still present, but damage remains light and of no economic significance. Samples taken every month show a fluctuating but relatively high natural mortality, reaching 73 percent, with 21 percent due to parasitism by Diptera and Hymenoptera. Predation, especially by birds, is reported to have increased during the year.

No treatment was recommended, and monitoring of the widespread infestation will continue.

At Poliamba light but localised damage was reported in early April.

In West New Britain and Milne Bay no significant outbreaks of bagworms were reported.

INVESTIGATION 605 OBSERVATIONS ON OTHER PESTS

Purpose

To determine for minor pests of oil palm, levels of damage, life cycles, wild or natural host plants, distribution in Papua New Guinea and records of its pest status overseas, and to formulate control measures.

Progress

At Bebere plantation in West New Britain a new pest of oil palm caused light damage. Holes about 1 cm square were cut from the leaf surface on both 3-4 year old palms and adjacent 12-15 year old palms. The damage resembled that caused by bagworms.

The cause of the damage was a lepidopteran (a moth), but the identity is not yet known. The caterpillar of the moth is light brown, about 12mm long, and lies along or adjacent to the central midrib, covered by a tent of silk. The majority of larvae were parasitized by a Braconid (wasp) and only a few pupae could be found. Specimens have been sent via DAL to CSIRO, Australia, for identification.

In Oro Province, reports of damage by the stick insect, *Eurycantha insularis* in January led to 6 blocks being recommended for treatment by trunk injection at Koropata VOP. In July two parasitic Tachinid flies were bred from *E. insularis* , but unfortunately they did not survive.

At Higaturu, an unidentified grey weevil was reported causing light damage by chewing small holes in the leaf centre.

In Oro Province, 16 smallholder blocks at Igora Subdivision reported light to moderate rat damage in January. The smallholders' concern was more with the damage to their food crops than to the oil palm. It was recommended to use commercial rat baits for a while throughout the Igora area. A further recommendation was to improve block hygiene and to encourage the rats' natural predators such as hawks, owls and snakes.

In Milne Bay light rat damage has been continuously reported on male inflorescences and black bunches.

INVESTIGATION 608 CONTROL OF SCAPANES AND ORYCTES

Purpose

To determine if underplanting or leaving poisoned palms or felled trunks in the field causes an increase in attack by rhinoceros beetle, and to decide whether any changes in plantation practice should be recommended.

Background

The adult rhinoceros beetles (*Oryctes rhinoceros* and *Scapanes australis*) attack palms, including oil palms, by tunnelling in through the frond rachis and the unemerged developing fronds. The larvae live in decaying vegetable matter such as the trunks of dead or felled palms and bunch refuse. When oil palms are replanted from earlier oil palm or from coconuts the old trunks should be covered by a fast growing legume to hide them so that the beetles do not lay their eggs there. Rhinoceros beetles from neighbouring jungle can attack palms on the edges of plantations . *Scapanes* is widely distributed in PNG, but *Oryctes* is only in East New Britain and New Ireland.

Progress

At Poliamba (New Ireland) no further significant damage to the young palms has been recorded, even though both *Oryctes rhinoceros* and *Scapanes australis* were recorded in significant numbers following a large scale replanting from coconuts. A virus is present that is pathogenic to *Oryctes* and we suspect that this decreased the threat of serious damage. The virus is not effective against *Scapanes*.

At Milne Bay no significant *Scapanes* attack was recorded.

In West New Britain, isolated but obvious *Scapanes* damage was observed on young fronds and fresh fruit bunches at Kapiura. This is the first time that damage to bunches caused by *Scapanes* has been recorded.

PATHOLOGY

In Oro Province, several palms were reported collapsing both in estate and smallholder blocks. In Arehe estate four palms were reported to have collapsed after being affected by basal stem rot, (possibly caused by *Ganoderma*), and in Ambogo estate two palms were found with basal stem rot. At Iseveni estate ten palms were reported infected with *Phellinus noxius* and one suffering from upper stem rot due to *Armillariella mellea*.

In smallholder blocks, sixteen palms were reported rotting, most having upper stem rot caused by *Phellinus noxius*. One such palm collapsed at Sorovi. A block at Awowota reported one palm having *Ganoderma* symptoms.

In all cases, the recommendation was to fell and burn the affected palms.

At Rikau VOP, in West New Britain, one palm was reported having mild spear rot disease.

PUBLICATIONS

Foster, H.L., Wilkie, A.S. & Orrell, I. (1991). The effect of chloride fertilisers applied to oil palms on volcanic soils in Papua New Guinea. Proceedings of PORIM International Palm Oil Conference 1991.

APPENDICES

APPENDIX I

METEOROLOGICAL DATA

Table 67 Rainfall (mm) At All Sites In 1991.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
W.N.B.Province													
Dami	515	677	910	249	108	94	244	214	3	100	144	248	3507
Bebere	416	535	765	289	209	110	239	278	8	179	217	114	3359
Kumbango	565	632	917	269	212	95	261	290	15	137	295	189	3877
Malilimi	428	359	591	292	231	145	NR	406	NR	327	199	385	
Togulo	623	717	112	384	209	96	280	822	209	250	212	484	4398
Navarai	644	459	856	175	133	91	NR	163	28	19	53	729	
Kautu	568	326	847	220	354	203	467	367	25	176	188	196	3937
Hargy	556	1158	1439	378	238	207	294	333	9	268	260	358	5498
Navo	379	1060	1163	204	159	336	260	294	36	337	136	281	4645
Oro Province													
Arehe	421	330	180	233	60	169	117	79	42	345	236	310	2522
Ambogo	291	286	182	224	47	135	55	244	106	253	135	283	2241
Isavene	473	211	147	206	120	162	166	167	46	361	276	357	2692
OPRA Higaturu	365	252	167	289	69	157	103	110	74	350	290	355	2581
Milne Bay Province													
Hagita	134	182	23	292	349	165	141	316	56	174	117	81	2030
Waigani	181	221	39	314	432	178	164	316	4	205	154	123	2331
GiliGili	167	193	66	345	118	160	105	455	3	160	79	49	1900
New Ireland Province													
Lakurumau	325	604	295	82	281	118	300	208	173	196	197	262	3041

Table 68 Metereological Data from Dami, 1970-91.

	Rainfall (mm)		Rainy Days (per month)		Sunshine (hrs/mnth)	
	1970-91	1991	1970-91	1991	1970-91	1991
January	626	515	25	25	115	119
February	633	677	24	21	110	80
March	540	910	24	26	121	78
April	348	249	21	19	149	175
May	223	108	17	13	166	152
June	158	94	15	7	161	168
July	190	244	16	18	150	105
August	162	214	15	16	176	107
September	167	3	13	1	177	172
October	181	100	16	30	175	153
November	241	144	18	15	174	191
December	432	248	22	18	126	142
Total	3901	3507	227	209	1800	1644

Table 69 Metereological Data from Higaturu, 1981-91.

	Rainfall (mm)		Rainy Days (per month)		Sunshine (hrs/mnth)	
	1981-91	1991	1981-91	1991	1981-91	1991
January	291	365	19	21	154	164
February	268	252	19	17	126	117
March	305	167	20	16	162	193
April	279	289	19	19	164	183
May	177	69	16	11	170	155
June	171	157	15	7	147	168
July	114	103	11	13	164	155
August	107	110	13	14	171	109
September	169	74	14	14	171	199
October	252	350	19	18	180	178
November	230	290	16	18	184	174
December	315	355	20	20	152	206
Total	2676	2580	201	188	1944	2001

APPENDIX II

SOIL ANALYSIS DATA

National Agricultural Chemistry Laboratory
Department of Agriculture and Livestock
Kila Kila, Port Moresby

Table 70 Soil Analysis Summary, Islands Provinces Trials, 1990.

Trial	Depth (cm)	pH	Extractable Bases (me%)				CEC (me%)	Olsen P (mg/kg)	P Retention (%)	pH in NaF	Organic C (%)	Total N (%)	C/N ratio	PSDA (%)		
			Ca	Mg	K	Na								Sand	Silt	Clay
Hoskins																
107	0-20	6.3	4.70	0.46	0.19	0.13	8.0	4.7	53	9.7	1.73	0.18	10	52	35	13
	40-60	6.6	7.90	0.92	1.88	0.40	13.2	4.7	40	8.8	0.65	0.07	9	54	20	27
108	0-20	6.4	5.00	0.27	0.58	0.28	9.3	2.7	67	9.8	1.34	0.15	9	52	35	14
	40-60	6.4	5.10	0.24	0.61	0.38	9.9	2.8	65	9.9	1.27	0.13	10	52	33	15
110	0-20	6.3	3.50	0.27	0.22	0.11	6.3	2.5	51	9.8	1.30	0.13	10	54	35	11
	40-60	6.5	5.90	0.53	1.44	0.34	10.4	2.7	49	9.4	0.80	0.09	10	62	23	17
117	0-20	6.1	3.50	0.17	0.38	0.07	6.2	2.9	53	10.0	1.31	0.15	9	53	38	9
	40-60	6.3	5.80	0.35	0.78	0.58	10.9	4.4	62	9.8	1.09	0.12	10	55	36	10
118	0-20	5.9	4.90	0.25	0.34	0.06	7.2	3.3	57	9.9	1.68	0.19	9	52	38	10
	40-60	6.2	5.50	0.35	0.93	0.39	8.9	5.3	52	9.6	0.81	0.09	9	62	23	15
119	0-20	6.1	3.90	0.39	0.18	0.09	6.3	3.6	56	9.7	1.35	0.13	10	46	38	16
	40-60	6.0	3.40	0.26	0.15	0.08	5.1	3.5	49	9.8	0.84	0.10	8	49	37	14
120	0-20	6.0	7.90	0.60	0.77	0.22	10.7	9.7	26	8.7	1.87	0.17	12	69	17	14
	40-60	6.5	3.10	0.36	0.84	0.14	5.4	6.0	17	8.8	0.24	0.02	12	82	10	9
Bialla																
201	0-20	5.9	10.50	0.74	0.10	0.06	18.2	3.0	92	10.5	4.95	0.53	9	43	37	20
	40-60	6.3	4.30	0.28	0.07	0.06	10.1	1.4	92	10.4	1.41	0.17	8	44	39	17
Kapiura																
401	0-20	6.2	18.50	3.17	0.63	0.08	24.3	2.4	52	9.3	2.16	0.22	10	40	35	25
	40-60	6.1	16.40	3.20	0.52	0.12	36.4	4.1	42	8.7				47	27	27

Methods Used:pH (1:5 soil:distilled water); Phosphorus (Olsen extraction); CEC and cations (ammonium acetate pH 7 method); Organic C (Walkley-Black); Total N (Kjeldahl); P retention (Saunders method); pH in NaF (1:50 soil:sat. NaF soln); PSDA (hydrometer).

Table 71 Soil Analysis Summary, Mainland Provinces Trials, 1990.

Trial	Depth (cm)	pH	Extractable Bases (me%)				CEC (me%)	Olsen P (mg/kg)	P Retention (%)	pH in NaF	Organic C (%)	Total N (%)	C/N ratio	PSDA (%)		
			Ca	Mg	K	Na								Sand	Silt	Clay
HIGATURU																
305	0-20	6.2	9.3	0.94	0.13	0.02	11.0	7.0	22	8.2	2.02	0.21	10	58	22	20
	40-60	6.4	8.8	2.13	0.24	0.11	11.8	6.3	47	8.9	0.54	0.06	10	44	14	42
306	0-20	6.2	10.1	2.63	0.11	0.03	12.9	10.1	17	7.8	1.97	0.19	10	57	28	15
	40-60	6.3	2.9	1.70	0.16	0.12	4.2	4.3	6	7.5	0.14	0.02	7	83	10	7
309	0-20	6.0	4.6	1.24	0.37	0.04	14.5	8.6	50	NA	3.10	0.26	12	65	24	11
	40-60	6.2	0.9	0.21	0.10	0.03	3.1	4.3	12	NA	0.22	0.03	8	82	12	6
310	0-20	6.3	9.5	1.72	0.16	0.04	13.0	12.6	28	NA	2.10	0.21	10	62	23	16
	40-60	6.5	1.8	0.95	0.08	0.02	3.2	5.4	9	NA	0.15	0.02	7	81	13	6
311	0-20	6.0	7.2	1.20	0.43	0.03	11.4	6.5	27	NA	1.98	0.22	9	63	20	17
	40-60	6.2	7.6	1.83	0.28	0.09	11.2	5.9	41	NA	0.42	0.05	8	49	10	41
312#	0-20	6.1	8.0	2.23	0.62	0.03	13.1	10.0	40	9.1	2.82	0.26	11	58	36	6
	40-60	6.3	2.2	0.75	0.24	0.03	3.6	4.4	12	8.0	0.22	0.03	9	72	25	3
MAMBA																
317	0-20	5.3	1.8	0.17	0.09	0.03	14.9	11.0	83	NA	5.04	0.52	10	65	22	14
	40-60	5.5	0.6	0.05	0.03	0.02	6.9	11.0	74	NA	1.64	0.19	9	67	23	10
318	0-20	4.8	0.7	0.13	0.08	0.01	8.5	12.9	42	*8.8	2.41	0.25	10	52	29	19
	40-60	5.6	0.2	0.03	0.03	0.01	3.1	7.7	26	*8.9	0.45	0.07	7	69	19	13
MILNE BAY																
501	0-20	6.2	31.7	12.35	0.13	0.54	45.2	7.2	38	NA	2.51	0.24	10	22	40	38
	40-60	6.7	29.2	11.48	0.05	0.70	40.4	2.0	30	NA	0.34	0.05	8	43	26	31
502	0-20	6.2	34.2	14.54	0.15	0.63	47.1	5.2	47	NA	3.36	0.31	11	16	40	44
	40-60	6.8	33.8	13.80	0.07	0.66	46.4	1.5	40	NA	0.74	0.09	9	21	36	43

Results from replicate samples only

* Results from only 1 of 10 samples

APPENDIX III

THE ASSOCIATION'S ACCOUNTS FOR 1991.

Auditors' Report To The Members Of The Papua New Guinea Oil Palm Research Association Inc.

We have audited the financial statements as set out on pages 4 to 8 in accordance with International Auditing Guidelines.

In our opinion the balance sheet and statements of income and expenditure, together with the statement of source and application of funds, give a true and fair view of the state of affairs of the Association at 31st December 1991 and its income and expenditure and the changes in financial position for the year ended on that date, and are properly drawn up in accordance with Papua New Guinea Accounting Standards.

Price Waterhouse
Port Moresby
24th July 1992

BALANCE SHEET AT 31 DECEMBER 1991

	Notes	1991 K	1990 K
ACCUMULATED FUNDS		257,766	186,527
FIXED ASSETS	2	117,438	147,553
CURRENT ASSETS			
Cash at bank and on hand		433	9,240
Debtors	3	322,756	167,512
		323,189	176,752
CURRENT LIABILITIES			
Bank overdraft		17,818	-
Trade creditors		122,578	120,483
Other creditors and accruals		42,465	17,295
		182,861	137,778
Net current assets/(liabilities)		140,328	38,974
		257,766	186,527

The accompanying notes form part of these accounts.

STATEMENT OF CHANGES IN FINANCIAL POSITION FOR THE YEAR ENDED 31 DECEMBER 1991

	1991	1990
	K	K
SOURCE OF FUNDS		
Surplus/(deficit) from operations	71,239	(59,755)
Plus/(less)		
Depreciation	49,491	56,082
Loss/(profit) on disposal of fixed assets	2,848	(2,700)
Funds from/(for) operations	123,578	(6,373)
OTHER SOURCES		
Proceeds from disposal of fixed assets	-	2,700
	123,578	(2,700)
APPLICATION OF FUNDS		
Purchase of fixed assets	22,224	81,347
	101,354	(85,020)
CHANGES IN WORKING CAPITAL		
Bank overdraft	(17,818)	-
Cash at bank & on hand	(8,807)	(97,755)
Debtors	155,244	60,814
Other creditors & accruals	(25,170)	16,054
Trade creditors	(2,095)	(64,133)
	(101,354)	(85,020)

The accompanying notes form part of these accounts.

STATEMENT OF INCOME AND EXPENDITURE FOR THE YEAR ENDED 31 DECEMBER 1991

	1991	1990
	K	K
INCOME		
FFB Levy	691,559	582,315
Profit on disposal of fixed assets	-	2,700
Interest received	5,731	7,215
Government Grant received	200,000	100,000
Member Grants received	20,000	60,000
Sundry income	3,393	844
	920,683	753,074
EXPENDITURE		
Bank charges	372	633
Depreciation	49,491	56,082
Direct experiment costs	338,659	323,361
Bad debts expense	-	10,000
Electricity, water and gas	19,609	28,261
Insurance	11,984	8,127
Laboratory	1,322	2,185
Legal and other professional fees	15,023	28,895
Medical	6,174	4,227
Motor Vehicle	13,524	10,271
Office expenses	26,463	19,481
Rentals and accommodation costs	113,778	91,486
Repairs and maintenance - buildings	14,958	21,982
Salaries, wages and allowances	199,239	192,549
Staff recruitment	17,725	3,220
Staff training	1.392	20
Travel and entertainment	19,733	12,043
	849,444	812,829
SURPLUS/(DEFICIT) FOR THE YEAR	71,239	(59,755)
ACCUMULATED FUNDS BROUGH FORWARD	186,527	246,282
ACCUMULATED FUNDS CARRIED FORWARD	257,766	186,527

The accompanying notes form part of these accounts.

NOTES TO AND FORMING PART OF THE ACCOUNTS AT 31 DECEMBER 1991

1. STATEMENT OF ACCOUNTING POLICIES

(a) Basis of accounting

The accounts have been prepared on the basis of historical costs and do not take into account changing money values or current valuations of non-current assets.

(b) Fixed assets and depreciation

Fixed assets are recorded at cost. Depreciation is calculated by the straight line method at rates considered adequate to write off the assets over their estimated economic lives.
Current rates of depreciation are:-

Furniture & equipment	10% per annum
Motor vehicles	33.33% per annum

(c) Direct experiment costs

Costs in relation to experiments are written off as direct experiment costs in the year they are incurred.

2. FIXED ASSEST

	1991 K	1990 K
Household, office and laboratory furniture and equipment at cost	158,881	141,136
Accumulated depreciation	58,829	38,168
	100,052	102,968
Motor vehicle at cost	119,965	119,965
Accumulated depreciation	102,579	75,380
	17,386	44,585
Total written down value	117,438	147,553

3. DEBTORS

	1991 K	1990 K
Sundry debtors	33,383	32,149
Provision for doubtful debts	(10,000)	(10,000)
	23,383	22,149
Trade debtors	299,373	145,363
	322,756	167,512

4. CAPITAL COMMITMENTS

Capital expenditure authorised and contracted for at 31 December 1991 totalled K Nil 1990 KNil).

5. COMPARATIVE BALANCES

Certain comparative balances have been revised to conform with the disclosure format in the 1991 accounts.

MANAGEMENT BOARD'S STATEMENT AT 31 DECEMBER 1991

We, I Dickson and J Wijnand, being two of the members of the Management Board of the Papua New Guinea Oil Palm Research Association Inc., hereby state that in our opinion the accompanying balance sheet and statements of income and expenditure and changes in financial position are drawn up so as to exhibit a true and fair view of the state of affairs of the Association at 31 December 1991 and of the results of the business of the Association for the year ended on that date.

For and on behalf of the Board

I Dickson

J Wijnand

Port Moresby
24 July, 1992

SECRETARY'S STATEMENT

I, Cosmas Kaue, Secretary of the Papua New Guinea Oil Palm Research Association Inc., do hereby state that the accompanying balance sheet and statements of income and expenditure and changes in financial position are, to the best of my knowledge drawn up so as to exhibit a true and fair view of the state of affairs of the Association as at 31 December 1991 and of the results for the year ended on that date.

C. Kaue
Secretary

Port Moresby
24 July, 1992

APPENDIX IV

ALLOCATION OF RENTED BUILDINGS

NEW BRITAIN PALM OIL DEVELOPMENT LTD.

Offices and laboratory (7 rooms)	1
Entomological building	1
Store rooms (3)	1
"SM" houses	1
"A" houses	3
"AR" houses	1
Guest house - Dami	1
"IB" houses	5
"JG" houses	6
"DLQ" houses	2
"SMQ" houses	1

HARGY OIL PALMS PTY LTD.

Office	1
Intermediate house	1

HIGATURU OIL PALMS PTY LTD.

Agronomy and main office	1
Entomological office	1
Insectory	1
Executive duplex	1
Griffiths house	1
Supervisor's houses	2
Intermediate	2
Labour houses	4

MILNE BAY ESTATES PTY LTD.

Office	1
Intermediate house	1

KAPIURA PLANTATIONS PTY LTD

Office (1 room)	1
"IB" house	1

POLIAMBA PLANTATIONS PTY LTD.

Office	1
Intermediate house	1

APPENDIX V

ALLOCATION OF VEHICLES

Vehicle	Reg.No.	User	Acquired	Km run
Toyota Landcruiser	AGJ 170	DOR	8/91	41,759
Toyota Hilux 4WD (twin)	AFL 659	Agronomist, Dami	3/88	88,262
Toyota Hilux 4WD (single)	AFH 562	Agronomist, Higaturu	5/88	
Toyota Hilux 4WD (single)	AFF 235	Agronomist, MBE	8/87	
Toyota Hilux 4WD (single)	AHA 967	Entomologist, Dami	6/89	123,028
Suzuki Samurai	AGC 752	Ext. Agronomist	10/89	44,999
Toyota Dyna	AGG 068	Driver, Dami	1/90	120,034
Toyota Dyna	AGC 505	Driver, Higaturu	8/89	
Honda 125 M/C	AP 201	Asst. Agronomist, Hig.	5/90	

APPENDIX VI

LIST OF INVESTIGATIONS

Number	Location	Title	Initiated	Concd.
AGRONOMY (West New Britain)				
101a	Bebere	NKMgMnP factorial fertilizer trial	1968	1982
101b	Bebere	Leaf nutrient monitoring plots	1982	1984
102a	Dami	Density/fertilizer trial	1970	1989
102b	Dami	Pot test experiments	1988	1988
103	Kumbango	Sources of potash fertilizer	1976	1983
104	Bebere	Thinning trial	1978	1984
105	Bebere	Thinning trial	1979	1984
106	Bebere	Replanting establishment trial	1982	1988
107	Bebere	Replanting fertilizer trial	1982	
108	Kumbango	Mature palm nitrogen/anion systematic trial	1985	
109a	Bebere	Factory-waste manurial trial	1984	1988
109b	Bebere	Factory-waste manurial trial	1985	1988
110	Bebere	Nitrogen/anion trial on young replanted palms	1985	1990
111	Malilimi	Nitrogen and phosphate fertilizer trial	1985	1987
112	Buvussi	Nitrogen & phosphate fertilizer trial	1985	
113	W.Nakanai	Smallholder N fertilizer & food crop demos	1985	1988
114	Togulo	Discoloured frond investigation	1985	1986
115	Kumbango	Frond placement trial	1987	1990
116	Bebere	Systematic nitrogen fertilizer trial	1987	1990
117	Kumbango	Second systematic nitrogen fertilizer trial	1987	
118	Kumbango	Third systematic nitrogen fertilizer trial	1987	
119	Malilimi	Nitrogen/Anion Fertilizer trial	1989	
120	Dami	Nitrogen/Anion Fertilizer trial	1989	
121	Hoskins	Smallholder demonstration trials	1989	
122	Kumbango	Nitrogen & crop residue trial	1991	
201	Hargy	NPKMg Fertilizer trial	1982	
202	Hargy	Refuse manurial trial	1984	1988
203	Navo	Effect of establishment phosphate	1986	1988
204	Navo	NPKMg Fertilizer Trial	1989	
207	Bialla	Smallholder demonstration trials	1990	
401	Kautu	NPKMg Fertilizer Trial	1989	
402	Bilomi	NPKMg Fertilizer Trial	1990	
403	Kapiura	Smallholder demonstration trials	1990	

Number	Location	Title	Initiated	Concd.
AGRONOMY (Mainland)				
301	Higaturu	Monitoring plots	1977	1982
302	Higaturu	Monitoring plots	1977	1982
303	Higaturu	Monitoring plots	1978	1983
304	Higaturu	Sources of potash & nitrogen trial	1979	1982
305	Arehe	NPKMg factorial fertilizer experiment	1981	
306	Ambogo	NPKMg factorial fertilizer experiment	1983	
307	Popondetta	Smallholder fertilizer trials	1984	1987
308	Arehe	Mill effluent manurial trial	1985	1987
309a	Ambogo	Bunch refuse manurial trial	1984	1988
309b	Ambogo	Sources of potassium trial	1988	
310	Ambogo	Fertilizer frequency and anion trial	1986	
311	Isavene	NK/EFB factorial fertilizer trial	1988	
312	Ambogo	NK/EFB factorial fertilizer trial	1988	
313	Higaturu	Soil assessment trial	1988	1989
314	Popondetta	Smallholder demonstration Trials	1988	
315	Popondetta	Smallholder rehabilitation trials	1988	
316	Higaturu	Cover Crop Investigations	1988	1988
317	Mamba	Lower terrace fertilizer trial	1990	
318	Mamba	River terrace fertilizer trial	1990	
321	Ambogo	Thinning Observation	1989	
501	Hagita	Establishment fertilizer trial	1986	
502	Waigani	NPK/EFB fertilizer trial	1990	
503	Hagita	Nursery fertilizer trial	1987	1988
504	Sagarai	Agro-genetic trial	1991	
505	Waigani	Trace element trial	1988	1988
506	Milne Bay	Smallholder demonstration trials	1989	
508	Hagita	Leaf nutrient fluctuations	1990	

Number	Title	Initiated	Concd.
ENTOMOLOGY			
601	Sexava: chemical control	1981	
602	Pollinators: introductions	1980	
603	Pollinators: field studies	1981	
604	Sexava: field studies	1981	
605	Other pests: general studies	1981	
606	Bagworms: general studies	1982	
607	Sexava: biological control	1983	
608	Rhinoceros beetles	1986	
GENERAL AND BASIC			
701	Flower fertility project	1979	1981
702	Effects of competition	1981	1986
703	Botany of Pollination and fruitset	1985	
704	Soil moisture relations project	1985	1985
705	Arehe Clone and density trial	1986	1989
706	Continuous flowering census	1981	1986
707	Continuous vegetative growth study	1980	1986
708	Continuous leaf nutrient study	1981	1988
709	Arehe Progeny Experiment	1987	1989
714	Phosphate requirement at planting	1990	
PATHOLOGY			
801	Incidence of Ganoderma disease at Bebere	1982	1990
802	Treatment of oil palm stumps with AMS	1983	1985
803	Ganoderma spp. tests of pathogenicity	1983	
WEED CONTROL			
901	Weed control project	1986	1986