ANNUAL REPORT

OF

THE PAPUA NEW GUINEA OIL PALM RESEARCH ASSOCIATION

1990

TENTH ANNUAL REPORT

of the

PAPUA NEW GUINEA

OIL PALM RESEARCH ASSOCIATION

1990

1st August 1991

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ABBREVIATIONS

EFB	=	Empty Fruit Bunches
FFB	=	Fresh Fruit Bunches
C.V.%	=	Coefficient of Variation (%)
L.S.D.	=	Lowest Significant Difference
t/ha	=	tonnes per hectare
s.b.w.	=	single bunch weight
VOP	=	Village Oil Palm
SOA	=	Sulphate of ammonia
MOP	=	Muriate of potash
TSP	=	Triple superphosphate
AC	=	Ammonium chloride
DAP	=	Diammonium phosphate
VDM	=	Vegetative dry matter (above ground dry matter estimated from frond petiole cross-section and frond production.)
BDM	=	Bunch dry matter (calculated assuming, dry bunch = 0.53 x fresh bunch, oil/dry bunch = 0.5 and oil energy = 2.1 x carbohydrate energy.)
TDM	=	Total dry matter = VDM + BDM
BI	=	Bunch index = BDM/TDM
LAI	=	Leaf area index = total leaf area/ground area
f	=	fractional interception of energy (estimated from LAI)
e	=	efficiency of energy conversion in g MJ^{-1} (= TDM/fxPARx10, where PAR is the amount of photosythetically active radiation)

NOTE

In all tables, figures in bold type indicate a difference significant at P = 0.05.

MANAGEMENT BOARD

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EXECUTIVE STAFF

DIRECTOR OF RESEARCH	H.L. Foster, M.A., M.Sc., Ph.D.
O-i-C, HIGATURU STATION	A.S. Wilkie, B.Sc., M.Sc.
SOILS AGRONOMIST (DAMI)	I. Orrell, B.Sc.
EXTENSION AGRONOMIST (DAMI)	P. Navus, B.Ag., M.Sc.
ASSISTANT AGRONOMIST (HIGATURU)	A. Oliver, B.Sc.
RESEARCH ASSISTANT (DAMI)	P. Talopa, B.Ag., Dip.Ag.
RESEARCH ASSISTANT (HIGATURU)	J. Silu, B.Sc. (to June)
RESEARCH ASSISTANT (HIGATURU)	J.J. Yambun, B.Ag. (from December)
RESEARCH ASSISTANT	T.M. Solulu, B.Ag. (from December)
SENIOR ENTOMOLOGIST* (DAMI)	R.N.B. Prior, M.Sc.

(* On attachment from Department of Agriculture and Livestock)

NON-EXECUTIVE STAFF

DAMI

SENIOR TECHNICAL ASSISTANT	Sebastian Embupa
SUPERVISOR	Balib Rimandai
SENIOR RECORDER	Blasius Lukara
JUNIOR SUPERVISOR	Topupul Teiga
JUNIOR TRAINEE SUPERVISOR	Patrick Kamo (April to October)
JUNIOR TRAINEE SUPERVISOR	Steven Malagau (April to October)
RECORDERS	Petrus Sokip
	Japson Dapo
	Simon Makai
	Paul Lus
	Jason Yalikua
	Harry Moraki
	Martin Gulan
ASSISTANT RECORDER	Mandako Dungu
DRIVER/HANDYMAN	James Duke
CONFIDENTIAL SECRETARY	Monica Mape (to February)
	Ludwina Mariu (from March)
ACCOUNTS CLERK	Camillus Golu
RECORDS CLERK	Bernadine Bubu
LABORATORY ASSISTANT	Josepha Kameta

HARGY

SENIOR FIELD ASSISTANT	Philip Sio

KAPIURA

JUNIOR SUPERVISOR	Patrick Kamo (from November)

POLIAMBA

JUNIOR SUPERVISOR	Steven Malagau (from November)

HIGATURU

TECHNICAL ASSISTANT	Daniel Tomare
JUNIOR SUPERVISOR	Wawada Kanama
RECORDERS	Graham Bonga
	Adrian Jonah
	Ben Gibson
	Ridon Eruga
	Leonard Dombaka (to February)
CLERK	Ian Ereki (from January)
DRIVER/RECORDER	John Garimopa
	Kasup Walpinum

MILNE BAY

JUNIOR SUPERVISOR	Hilarian Gordon
RECORDER	Tom Rivas (from February)

CHAIRMAN'S STATEMENT

1990 has been an eventful year for the Oil Palm industry in PNG: the fifth major nucleus estate and smallholder venture, Milne Bay Estates, came on stream during the year; Poliamba Plantations Pty Ltd were admitted to membership of the Association, two of the Oil Palm Smallholder stabilisation funds exhausted their reserves and are being assisted with funds from Government; the Commodities Working Group has been deliberating with Oil Palm Processors on a new pricing formula; and the Interim Committee of Oil Palm Industry Corporation has been debating the modus operandi of the proposed new body charged principally with smallholder productivity improvement.

Although FFB production in PNG increased from 581,744 tonnes during 1989 to 659,639 tonnes in 1990, average Palm Oil Prices cif Europe over the same period decreased from US$377 to US$299/tonne. These reduced prices and the financial constraints facing the industry in general, have had their repercussion on OPRA, but, with prudent management, the planned research operations have not been adversely affected. OPRA is grateful for the financial grant of K100,000 made during 1990 by the PNG Department of Agriculture, intended for research into smallholder agronomic oil palm activities, and to the continued financial and logistical inputs of the Oil Palm Companies and their staff who assist in many ways with the day to day operations of OPRA.

The main thrust of OPRA has been to increase FFB yields per hectare, both for plantations and smallholders, through fertilizer trials and subsequent recommendations based on the ever increasing knowledge amassed on the complex interaction between soils, plant nutrient requirements and fertiliser inputs. The number of demonstration plots in smallholder areas has been increased to 51, to enhance the financial returns per unit area by reducing overall production costs that come with greater output from the holdings and throughput in the Oil Mills. This aspect of increased extension activity is the intended aim of the Government's Commodities Working Group and Oil Palm Industry Corporation, and also of the ADB team based at Dami during the year, which has been investigating agro-sociological aspects of smallholders' productivity. Their report is eagerly awaited.

1990 was one of the wettest years on record causing flooding, damage to roads, disrupted FFB production, and reduced sunlight intensity which is likely to have some adverse effect on subsequent yields. Sexava activity in WNB was also at its highest level over recent years. The infestation, gauged by palms treated on smallholdings and plantations alike, was nearly twice as severe as the 1986 outbreak. The entomology unit has been active in providing inspections and advice on pest activity control measures and the release of biological control agents. It is anticipated that this aspect of pest control will receive greater emphasis by OPRA in 1991.

I should like to take this opportunity, on behalf of the Board, to record our appreciation to Dr Foster and his staff for their loyal dedication and hard work, often beyond the call of duty, during times of increased lawlessness, and for the continued co-operation and technical input to OPRA by Government officers and the staff and advisers of the plantation companies, which has continued to enhance the esteem in which OPRA is held by Palm Oil producers.

J. Montgomerie
Chairman, March 9th, 1991

PART 1. ADMINISTRATION AND DEVELOPMENT

MANAGEMENT BOARD AND SCIENTIFIC ADVISORY BOARD

The Association welcomed a new member in July 1990, when Poliamba Pty. Ltd, based in New Ireland, became the sixth plantation company to join PNGOPRA.

The Management Board met twice, at the offices of Harrisons and Crosfield (PNG) Ltd., Lae on 20th March and at the offices of Hargy Oil Palms Pty. Ltd., Bialla, on 4th October. The Ninth Annual General Meeting of the Association was held in Lae on 20th March at which Mr. J. Montgomerie was elected Chairman of the Association. Harrisons and Crosfield (PNG) Ltd were re-appointed as Managing Agents for the ensuing year.

The Scientific Advisory Board met at Hargy Oil Palms Pty. Ltd., on 4th October. This was preceded by workshop meetings between Scientific Advisors and PNGOPRA staff at Mosa Management Centre, New Britain Palm Oil Development Limited, on 2nd and 3rd October and visits to trials on estates and smallholdings on the journey to Bialla, in which most Board members and observers participated.

FINANCE

The research levy of 88 toea per tonne fresh fruit bunches remained unchanged throughout the year and the total cess collected from this source was K582,315. The Government grant received from the Department of Agriculture and Livestock in 1990 was K100,000 compared with K150,000 received the previous year. In addition, grants totalling K60,000 were received from member companies, including those not yet in production and therefore not yet paying any cess. Total income in 1990, including interest and sundry credits amounting to K10,759, was K753,074 which was appreciably below estimate.

Expenditure for the year was tightly controlled and amounted to K812,829, also considerably below the estimate. Expenditure in 1990 thus exceeded income by K59,755 which reduced the Association's accumulated funds to K186,527. This included fixed assets valued at K147,553, so the net current assets at the end of the year were K38,974, compared with K123,994 at the start of the year.

Full details of the Association's Accounts for 1990 and the Auditor's Report are presented in Appendix III.

STAFF

Senior executive staff remained unchanged during 1990. However Mr J. Silu, Assistant Agronomist at Higaturu, resigned before being confirmed in his post, and his position was filled by Mr J. Yambun, recruited in December 1990. A new Assistant Entomologist, Mr T. Solulu, was also recruited at the same time. At the end of the year there were five executive staff at Dami Headquarters (including a Senior Entomologist seconded from the Department of Agriculture and Livestock) and four executive staff at PNGOPRA's mainland station at Higaturu.

Two consultants, Mrs C. Benjamin, Agrosociologist, and Mr H. Harries, Agronomist, arrived at Dami in March 1990 to initiate a one year oil palm smallholder productivity study in West New Britain for the Department of Agriculture and Livestock, sponsored by the Asian Development Bank. PNGOPRA is providing them with full office facilities during the period of their project.

Two trainee Junior Supervisors, Mr Kamo and Mr Malagau, having completed training at Dami, were posted in November 1990 to Kapiura and Poliamba plantations respectively, to supervise trials in these two areas.

The junior staff establishment at the end of 1990 was 17 at Dami, 9 at Higaturu, 2 at Milne Bay and one each at Hargy, Kapiura and Poliamba, making a total strength of 31.

MEETINGS

The Director of Research took part in an ISOPB International Workshop on Yield Potential of the Oil Palm, held at Phuket, Thailand, from 29th - 30th October 1990, where he presented a paper on "Oil palm production in Papua New Guinea".

The Senior Entomologist attended the 3rd International Symposium on Trichogramma and other Egg Parasitoids at San Antonio, Texas, in September 1990.

The Director of Research and the Senior Entomologist respectively attended research advisory meetings of the PNG Cocoa and Coconut Institute and the PNG Coffee Research Institute during the year.

BUILDINGS AND SERVICES

At Dami Headquarters two largely unused rooms have been renovated, one as an office for the use of the ADB Smallholder Project consultants, and the other as a Soils Laboratory to provide analytical facilities for the Soil Assessment Project.

At the Higaturu mainland station an additional covered working space was built during the year and security lights installed.

At each of the four PNGOPRA sub-stations, Hargy, Milne Bay, Kapiura and Poliamba, a new office and house for the PNGOPRA Supervisor has been provided by the plantation company on a rental basis.

A new radio telephone has been installed at Dami Headquarters and facsimile machines are now available at both Dami and PNGOPRA Higaturu, which has considerably improved communications.

The allocation of buildings rented from PNGOPRA member companies in 1990 is detailed in Appendix IV.

VEHICLES

At Dami, the second - hand lorry used for transportation of workers and equipment was replaced by a new Toyota Dyna in January, whilst at Higaturu, the pool motorcycle was replaced in May.

Details of all official PNGOPRA vehicles as at the end of 1990 are given in Appendix V.

EQUIPMENT

Laboratory equipment for the soil N assessment project was received at Dami in August 1990. An analytical balance, UV-VIS spectrophotometer, N distillation apparatus, pH meter, automatic water still, bottle shaker and drying oven have all now been installed in the new soils laboratory at Dami. In addition new drying ovens and de-ionisers, mainly for leaf sample preparation, were obtained for Higaturu, Hargy and Kapiura.

At Dami a tape-back was obtained for the main 386 computer and a new line conditioner was installed to protect all the computer equipment. In addition the 286 portable computer was upgraded with the installation of a 40MB hard disc and a maths Coprocessor, so that it can now run the Genstat Statistics Programme obtained earlier in the year. Towards the end of the year a new 286 desktop computer was purchased for Higaturu to replace the unreliable laptop computer used for data entry.

At Dami headquarters, a new electric typewriter with full word-processing facilities, was purchased for the use of the confidential secretary in October 1990.

VISITORS

To Dami:

Akanda, A., Asian Development Bank, Manila;
Arnison, R., Asian Development Bank Mission;
Barker, P., Prime Minister's Dept., Boroko;
Barnes, A., DAL Kimbe;
Baskett, P., Managing Director, Harrisons and Crosfield (PNG) Ltd., Lae;
Breure, K., Dr., HFAS, London;
Brown, G., Harrisons and Crosfield plc, London;
Brown, N., Analytical Services Ltd., Cambridge, N.Z.;
Clarke, J., Harrisons and Crosfield (PNG) Ltd., Lae;
Clarke, T., Pilbara Laboratories, Lae;
Daipo, R., DAL, Bialla;
Delabu, Y., Price Waterhouse, Lae;
Dias, I.P.S., ADB Agricultural Credit and Rural Savings Study, PNG.;
Duhamel, G., I.R.H.O, Santo, Vanuatu;
Gillbanks, R., Kina Gillbanks & Co., Rabaul;
Honegile, W., Poliamba Pty Ltd., New Ireland;
Johnson, A., Agriculture Bank, Boroko;
Kam, J., National CARIS Centre, DAL, Konedobu;
Kola, J., Dr., Director, PNG CCRI, Kerevat;
Lansbury, J., University of Oxford;
Lawson, R., NBPOD, Mosa;
Lim, K.L., Asian Development Bank, Manila;
Lonai, C., Poliamba Pty Ltd., New Ireland;
McLeod, J., Harrisons and Crosfield plc, London;
Menneer, J., Harrisons and Crosfield (PNG) Ltd., Kimbe;
Morries, P., Remington Office, Lae;
Nelson, S., OPRS Dami;
Notley, D., World Bank, Washington D.C.;
Ochs, R., I.R.H.O, Montpellier, France;
Oliver, A., PNGOPRA, Higaturu;
Ovasuru, T., PNG CCRI, Kerevat;
Paul, G., Chief Executive, Harrisons & Crosfield plc, London;
Percy, H., C.D.C., London;
Perera L.G., ADB Agricultural Credit and Rural Savings Study, PNG.;
Preston, T., Chairman, Harrisons & Crosfield, (PNG) Ltd., Sydney;
Redshaw, M., HFAS, Bah Lias Research Station, Sumatra;
Shedden, B., NBPOD, Mosa;

Sidhu, A., Dr., World Bank, Washington D.C.;
Siggs, J., London Sumatra, Medan, Indonesia;
Simmons, R., DAL, Konedobu;
Southworth, A., P.T. Lonsum, Medan, Sumatra;
Tainole, P., DAL, Nahavio;
Tang, L., Asian Development Bank, Manila;
Tobin, P., Mamba Estates, Higaturu Oil Palms Pty Ltd.;
Tosah, S., Dept. Finance & Planning, Waigani;
Turcan, B., Mr and Mrs, Harrisons and Crosfield plc, London;
Vali, K., DAL, Konedobu;
Vatasan, G., and 11 final year undergraduates, Forestry Dept, Unitech Lae;
Wallace, P., Higaturu Oil Palms Pty Ltd.;
Watson, J., Harrisons and Crosfield (PNG) Ltd., Lae;
Waymark, D., DAL, Konedobu;
Wilkie, S., PNGOPRA, Higaturu;
Woods, T., Landell Mills Associates, Bath, U.K.;
Wykes, Mr and Mrs, Union International, London;

To Higaturu:

Adani, A., National Weather Service, Port Moresby;
Benton, A.A., World Bank, Washington;
Boyer, P., World Bank, Washington;
Brown, N., Analytical Services Ltd., Cambridge, N.Z.;
Chase, L., C.D.C., London;
Darby, C., Analytical Services Ltd., New Zealand;
Dubos, B., I.R.H.O., Higaturu;
Lockwood, R., Dr., C.D.C., London;
Marshall, R., Higaturu Oil Palms Pty. Ltd., Popondetta;
McKee, C., Dr., Rabaul Volcano Observatory;
Memo, A., DAL Quarantine, Popondetta;
Ochs, R., I.R.H.O., Montpellier, France;
Sargeant, C., C.D.C., London;

REVIEW OF RESEARCH

(Dr. H.L. Foster)

I. INTRODUCTION

It is the role of the Papua New Guinea Oil Palm Research Association to carry out research and extension, with the object of increasing the productivity of both estate and smallholder oil palm growers throughout Papua New Guinea. It is thus encouraging to note that FFB yields exceeding 30 t/ha were recorded in 1990 in at least some blocks of all estates, on both the mainland and in West New Britain, which are advised by PNGOPRA. However some blocks in these estates recorded much lower yields and it is the aim of current research to determine how yields in these problem areas can also be raised to similar levels. Inadequate or unbalanced nutrition is believed to be the main factor limiting oil palm yields in estates. Generally the major deficiencies, particularly nitrogen, have been identified and corrected. Current work on nitrogen, involving the newly established soils laboratory, aims to improve the efficiency of its use. In the future more attention will be given to secondary deficiencies, about which we know much less.

The average response to recommended fertilizers in the second year of demonstration trials on smallholdings in the Popondetta area exceeded 50 percent and was thus even more dramatic than the 30 percent response observed in the first year. It is therefore disappointing that average smallholder yields in Papua New Guinea are still poor. PNGOPRA trials clearly demonstrate that there are no major technical factors limiting yields on smallholdings. Interim findings of the Smallholder Productivity Study, currently being carried out in West New Britain by consultants attached to PNGOPRA, indicate that there are attitudinal problems which need to be alleviated if high productivity from smallholders is to be achieved. Now that demonstration trials have been established in most smallholder sub-divisions in the country, PNGOPRA's extension effects will be intensified by holding more frequent field days, to ensure that most farmers are aware of how high productivity can be readily achieved with quite moderate management inputs.

The Association is responsible for providing advice on pest and disease control to the oil palm industry. Current chemical treatment recommendations are effective if efficiently implemented. An upsurge of Sexava damage in West New Britain in 1990 reflects logistical and access problems encountered by treatment teams and emphasises the importance of establishing biological control methods if possible. Thus PNGOPRA is currently establishing a bio-control laboratory dedicated to the mass propagation of parasites of oil palm pests.

In 1990, four **Experiments (110, 115, 116 and 802)** were completed in the Mosa area, whilst four new experiments were established at Mamba **(Experiments 317 and 318)**, Kapiura **(Experiment 402)** and Milne Bay **(Experiment 502)**. Smallholder demonstration trials increased to 49 in 1990: 23 in the Hoskins area, 20 in the Popondetta area, 3 at Alotau, 2 at Bialla and one at Kapiura.

II. NUTRITION

Nitrogen

1. In all the four N systematic trials on first plantings in Mosa estates (**Experiments 108, 116, 117 and 118**) there was a clear FFB yield response to ammonium chloride fertilizer in 1990. However the average response increment in all these trials was in the region of 1 tonne FFB/ha to 1kg A.C. per palm, which is not very efficient. Also yields peaked at intermediate fertilizer rates and the maximum yields were directly proportional to palm age, reaching 26 - 28 t/ha in the younger trials (14 and 16 years old) but no more than 22 t/ha in the older trials (19 and 20 years old). These results all suggest an additional limiting factor apart from N, which increases with age.

2. In the young replant in the factorial **Experiment 107** at Bebere, no significant response to N fertilizer was recorded in 1990. However the control leaf N level (2.4%) was optimum considering the level of total bases and a satisfactory maximum yield of 28 t/ha was obtained in these plots. It is concluded that no response was obtained due to a satisfactory N status in the control plots - which may have been partly due to enrichment from neighbouring plots, considering the high rainfall received at this site. The challenge in this trial in the future is whether a satisfactory yield can be sustained with palm age. With the right combination of N and other fertilizers, it is hoped that the yield decline with age observed in the first planting, can be avoided.

3. In contrast to the previous year, a significant response to N fertilizer was obtained in **Experiment 201** on the ash soil at Hargy, although only in the presence of P fertilizer. This variation in N response from year to year suggests a major influence of the weather on efficiency of fertilizer recovery at this site. Clearly the conditions under which an optimal response is obtained, need to be identified.

4 In the first year of recording in **Experiment 401** on young palms at Kapiura, a significant yield response to N fertilizer was observed, but the effect was small and it is too early to make any conclusions.

5. In the two long running fertilizer **Experiments 305 and 306** at Higaturu on the mainland, N fertilizers (in the presence of chlorine) increased FFB yields by 14 - 15 t/ha in marked contrast to the much more modest gains observed in West New Britain. Specialised analyses will be carried out on both soils from the mainland and New Britain, in the new soils laboratory at Dami, in an attempt to identify soil properties which explain the marked differences in fertilizer response between these two regions.

6. In both **Experiments 309 and 310** at Higaturu, the introduction of N fertilizers has considerably increased the average yield levels in these trials (from less than 10 t/ha to more than 25 t/ha in the case of Experiment 309), and responses to non-N treatments are now being obtained for the first time. It is now clear that if yields are below 20 t/ha FFB, the N status must first be improved, before it is worth applying other nutrients.

7. In the two **Experiments 311 and 312** on the mainland it was confirmed that N fertilizer application rates can be reduced if empty fruit bunches (EFB) are also applied. In both trials, the same optimal yield was obtained with either 5 kg A.S. per palm per year alone or 2 kg A.S. per palm plus 32 t EFB per hectare per year.

8. In the smallholder demonstration trials in both the Popondetta (**Experiment 314**) and Buvussi (**Experiment 112**) areas, very large responses to moderate rates of N fertilizer (equivalent to 2 kg A.C. per palm) were obtained, exceeding 60 percent on average. In the Popondetta area the highest responses were obtained on the sandy soil group. These results demonstrate the essential need for N fertilizer in most smallholdings, if satisfactory yields are to be obtained. In the research plots of the Popondetta trials, a linear yield response was obtained up to the highest rate of N fertilizer tested (3.75 kg A.S. per palm). The highest yields achieved were on the sandy soils, even though these had the lowest control yields. It will be very instructive to determine why response to N fertilizer is so efficient on these particular soils.

9. In the two new **Experiments 317 and 318** at Mamba in Oro Province, where the soils are much more acid than in the Popondetta area, yield recording had not yet commenced in 1990. However preliminary growth measurements indicated a significant positive effect of N fertilizer at both sites.

10. Only in the fertilizer trials on the alluvial soils at Milne Bay has nitrogen not been found to be the dominant nutrient required. However in the first six months of yield recording in **Experiment 501** at Hagita, N fertilizer increased yields at high K fertilizer rates, as predicted by earlier growth measurements.

11. Ammonium fertilizers have a depressive effect on leaf Mg levels as observed in **Experiments 107, 305 and 306** where ammonium sulphate was applied and **Experiment 108** where ammonium chloride was the N source. However as shown in **Experiment 110** at Bebere and the early results of **Experiment 120** at Dami, the chloride source is less depressive than the sulphate source, and as indicated by **Experiment 110** the positive effect of the chloride ion may under certain circumstances even outweigh the negative effect of the ammonium ion.

12. Future work on N fertilizers will concentrate on elucidating two aspects: the factors which improve efficiency and the influence of the non-N constituents. The new soils laboratory at Dami will provide basic support in these investigations.

Chlorine

1. There was a significant vegetative dry matter and mean bunch weight response to chloride fertilizers in five trials on Higaturu estates on the mainland, including **Experiments 305, 306 and 311** which test different rates of KCl fertilizer, **Experiment 309** which compares KCl and bunch ash and **Experiment 310** which compares sulphate and chloride sources of sodium and potassium salts. However in **Experiment 306** the usual FFB yield increase with KCl was not observed in 1990 due to a depression in bunch numbers (possibly due to an induced Mg deficiency). The results of **Experiments 309 and 310**, in which K was applied in the non-chloride plots, indicates that these responses were due to the Cl and not the K constituent of KCl.

2. In **Experiment 110** at Bebere and **Experiment 119** at Malilimi, both in West New Britain, chloride fertilizers significantly increased FFB yields, in these cases through an increase in bunch number production.

3. In **Experiment 107** at Bebere, there was no significant yield response to NaCl application.

4. In **Experiment 117** at Kumbango, there was a much larger yield response to ammonium chloride compared with urea applied at the same N rate. Leaf N levels were similar for the two fertilizers when applied at the same N rate, but there was a considerable difference in leaf Cl levels. It appears most likely that the poor response to urea was due to a limiting level of chlorine.

5. In all the mainland trials, chloride fertilizers caused a massive increase in chlorine concentration in the rachis which stimulated an equivalent uptake of cations in order to maintain charge balance. This increase in osmotica can be expected to improve moisture status and it is this effect of chloride which it is believed results in the improved vegetative growth and bunch weight observed.

6. In all the trials in which chloride fertilizers were applied, this treatment increased leaflet Ca and depressed leaflet K. It is believed that this is due to the stimulation of cation uptake by chlorine and the preferential retention of Ca in the leaves which in turn depresses K.

7. In **Experiments 107, 110 and 120,** all in West New Britain, leaflet Mg was initially low but was significantly increased by chloride fertilizer application. It is believed that this improvement in magnesium status is the reason for the increase in bunch numbers in **Experiments 110 and 120.** In **Experiment 107,** leaflet data in 1990 indicates movement of chlorine across plot boundaries, which would explain the lack of any yield response to chloride treatment in this year.

8. In the smallholder trials on sandy soils in **Experiment 314** in the Popondetta region there was a marked overall response to KCl fertilizer, which the leaf data indicated was most likely due to the chlorine constituent of the fertilizer.

Potassium

1. There was no yield or growth response to potassium sulphate in **Experiment 107** at Bebere or in **Experiment 310** at Ambogo, or to bunch ash in **Experiment 309** at Ambogo. Thus it is assumed that the responses to KCl fertilizer recorded on volcanic soils in other trials (e.g.**Experiments 305 and 311**), are due to its anionic constituent.

2. In 1990 the ratio of K to total bases in the leaflets of frond 17 in the control plots of all major trials on volcanic soils exceeded 25 per cent, which indicates an adequate K status. However on volcanic soils, leaf K is depressed by chloride fertilizers (as shown in **Experiments 305, 306, 309, 310, 107, 108, 110, 119 and 120**) and in 1990 leaf K fell below 25 per cent of total bases in the higher ammonium chloride plots in **Experiment 108**, which may partly explain the disappointing response to this fertilizer at higher rates. Leaf K was also below 25 per cent of total bases in a number of the smallholder trials in **Experiment 314** in the Popondetta area in 1990, particularly those on "organic" soils; which indicates that response to KCl fertilizer observed in some of these trials may be at least partly due to the cation.

3. In **Experiment 501** on young palms on alluvial soil at Hagita estate, Milne Bay, the first six months of yield recording in 1990 confirmed earlier conclusions based on vegetative measurements, that potassium is the most needed nutrient on this soil type. A new factorial fertilizer trial, including four rates of K fertilizer, was initiated in 1990 on mature palms on a similar soil (characterised by an exceptionally low exchangeable K/Mg ratio) in the neighbouring estate of Waigani.

4. Potassium fertilizer may also be an important amendment on the corranous soils in Poliamba estates in New Ireland, where two new factorial fertilizer trials, including K treatments, are due to be established next year.

Magnesium

1 The effect of kieserite application in all factorial fertilizer trials on volcanic soils (e.g. **Experiments 107, 210, 401, 305 and 306**) on leaf Mg levels is small, indicating the difficulty of improving Mg status on these soils.

2. Nevertheless kieserite application significantly improved bunch weights in **Experiment 107** and bunch numbers in **Experiment 120** in the Mosa area of West New Britain, where leaf Mg levels are generally low.

3. As previously reported, the chlorine and phosphate anions are generally more effective than the magnesium cations in increasing leaf Mg levels. In particular in **Experiment 310** on the mainland, kieserite did not affect rachis or leaflet Mg levels, but magnesium chloride significantly increased both rachis and leaflet Mg. Magnesium chloride was the treatment which had the greatest effect on both leaflet Mg and yield in this trial and is clearly a much better source of Mg than kieserite - unfortunately however it is very hygroscopic and difficult to handle on a plantation scale.

4. Non-Mg chloride fertilizers can be quite effective in improving leaflet Mg levels as shown by sodium chloride in **Experiment 107** and ammonium chloride in **Experiment 110.** However potassium chloride can depress leaflet Mg as observed in **Experiment 306.**

5. Phosphate fertilizers appear to be more effective than chloride in increasing magnesium levels as revealed in **Experiment 108**, where diammonium phosphate outyielded ammonium chloride at higher N rates, apparently due to its ability to maintain a higher Mg level. The beneficial effect of phosphate application on leaf Mg levels is also seen in **Experiment 201** at Bialla, where the significant effect of triple superphosphate on yield is believed to be at least partially due to an improvement in the Mg status.

6. Leaf Mg levels observed in trials on estates indicate that Mg deficiency is likely to be a problem mainly in West New Britain. A number of the smallholder trials in **Experiment 121** in the Hoskins area in West New Britain also showed extremely low leaflet Mg levels ($<0.15\%$) in 1990 and preliminary yield results indicated a tendency for kieserite application to be beneficial at these sites.

7. Mg status in oil palm appears to be more strongly influenced by anions and by competing bases, than by the level of magnesium in the soil or the amount of Mg applied as fertilizer. Thus it may be easier to improve Mg status by reducing the level of other bases, rather than by increasing the magnesium level. The factors which influence the level of other bases, particularly Ca, need to be elucidated. One clear factor is age - leaflet Ca generally declines as palms get older and hence Mg deficiency tends to disappear with time.

<u>Phosphate</u>

1. In 1990 phosphate fertilizer increased yields only in **Experiments 108** and **201** in West New Britain. In both cases both leaf P and Mg were significantly increased, and as discussed above, part of the benefit of the phosphate may be due to its influence on Mg status.

2. In the new **Experiment 318** on a river terrace soil at Mamba in Oro Province, triple superphosphate fertilizer significantly increased vegetative growth in 1990.

3. In general, leaf P levels were fairly reasonable in most trials, and the lack of response to this nutrient may be partly due to an adequate status.

4. The necessity for placing phosphate fertilizer in the planting hole during field planting is being investigated for soils in West New Britain in **Experiment 714**. An initial field trial was established at Dami in 1990 and at least one more field trial will be started in 1991. In addition further soils are being investigated in a nursery pot experiment.

Oil extraction ratios

1. Results of bunch analysis in **Experiment 108** indicate a marked increase in both fruit moisture and kernel content and a corresponding decline in oil/bunch ratio, due to the application of ammonium chloride. In **Experiment 107**, ammonium sulphate (but not sodium chloride) shows a tendency to increase fruit moisture content and depress fruit set.

2. It appears that fruit moisture content is likely to be below average if N or Cl are low. Correction of the status of these nutrients will then increase fruit moisture content and hence reduce the oil extraction ratio. A typical increase of 1.2 percent in fruit moisture content would depress the oil to bunch ratio by about 1 per cent.

3. Excessive rates of N and K fertilizers may also increase the kernel content of the fruit, due to an increase in the K/Mg ratio, which will also depress oil extraction.

4. Lastly excessive rates of N can apparently depress fruit set, presumably through a physiological stress mechanism. As discussed later, a decline in fruit set will also depress percentage oil extraction.

III. SMALLHOLDER EXTENSION

1. In the long-running smallholder fertilizer trials in **Experiment 112** at Buvussi in West New Britain, yield response to fertilizer at 6 out of the 8 trials increased to an average of more than 50 per cent.

2. In the Hoskins area, a total of 15 new fertilizer demonstration trials have now been established in **Experiment 121**, so that there is now at least one site in each sub-division. Yield results in 1990 are too preliminary to allow any conclusions, but leaf analyses suggest that appreciable responses to both N and Mg can be expected in the future.

3. By the end of 1990 a total of 20 smallholder demonstration trials had been established in **Experiment 314** in the Popondetta area. The results of those trials in their second year was even more dramatic than the impressive results recorded in their first year. On average the demonstration plots gave a yield of 19 t/ha compared with 12 t/ha in the control plots a yield response of approximately 60 percent. The research plots confirmed that N is the main requirement in these smallholdings, but KCl fertilizer is also needed to obtain full response at many of the sites. Interestingly the highest yields averaging 25.6 t/ha were obtained on the sandy soils, which had the lowest control plot yields.

In contrast, yields in the control plots of the younger more recently established trials in their first year averaged 30 t/ha and the fertilized plots showed no response. These results show that good yields can be obtained in smallholdings with correct management.

4. In the Popondetta area, at least one field day was held each month at a selected demonstration, where the benefits of correct management and fertilizer application were emphasised to smallholders. Similar field days will be held in the Hoskins area next year, now that demonstrations have been established in all sub-divisions. All field days involving smallholders are jointly organised by PNGOPRA and the Department of Agriculture and Livestock.

5. Other smallholder demonstrations established by the end of 1990 included 3 at Alotau (**Experiment 506**), 2 at Bialla (**Experiment 207**) and one at Kapiura (**Experiment 403**), making a total of 49 throughout the country. Further expansion up to 72 demonstration trials is planned for 1991, including 2 at Kavieng (**Experiment 253**) and 6 at schools in the Hoskins and Bialla areas (**Experiments 124 and 408**).

IV. ENTOMOLOGY

Fruitset

1. In **Experiment 603** fruitset measured over the last few years has indicated an average level exceeding 70% for 17 year old IRHO material at Bialla, an average level of approximately 60% for 11 year old Dami material at Bialla and Hoskins in West New Britain, and 50% for 11 year old Dami material at Popondetta. Differences appear to be due to environment, material and palm age.

2. Fruitset is currently being monitored at Milne Bay and results in 1990 indicated average levels below 50% for most of the year, apparently due to inadequate male flowers in this young planting.

3. Fruitset in the Popondetta area shows a seasonal variation (which is particularly marked in young palms). In **Experiment 603** on 11 year old palms, a moderate fluctuation was observed, levels averaging 55% in the first half of 1990 declining to 45% in the second half of the year. Removal of alternate female inflorescences before anthesis resulted in maintenance of a fruitset of 55% in the second half of the year. Thus yield stress appears to be responsible for seasonal variation in fruitset, but still does not explain the below average fruitset levels in the Popondetta area.

4. The importance of fruitset in oil production at Popondetta was investigated by analysing bunches from **Experiment 603** having a range of fruitset values.. The results indicate that the oil content of the fruit has the most influence on the oil/bunch ratio, but fruitset does have a secondary influence similar to that previously observed in the Mosa area, where a reduction in fruitset of 10 per cent lowered the bunch oil content by 1 per cent. Assuming the energy for fruit production remains unchanged, this result implies that on average there is a gain of a quarter of a tonne of oil per 10% increase in fruitset.

5. Clonal material for **Experiment 703**, designed to compare fruitset in materials from different sources (IRHO and Unifield), is currently in the nurseries at Dami and Higaturu. This material will be planted in trials on the mainland and in West New Britain early next year.

Pest control

1. 1990 was a particularly wet year in West New Britain, which favoured Sexava development and hindered treatment. Thus damage from Sexava in this area was the worst for 13 years. The most serious damage was in the Bialla region where problems of access prevented prompt treatment.

2. In Oro Province in contrast, where the *Stichotrema* internal parasite of Sexava is found, minimal damage from Sexava was recorded.

3. Mass rearing of the Sexava egg parasites *L. bicolor* and *D. leafmansia* continued, and in **Experiment 606** more than 2 million were released in West New Britain during the year.

4. Future plans for the biological control of Sexava include the development of a semi-synthetic medium for more efficient mass rearing of egg parasites and further study of *Stichotrema* with the aim of establishing this parasite in West New Britain. Only the female *Stichotrema* parasite infects Sexava; the host of the male parasite, possibly an ant, has yet to be discovered.

5. The worst outbreak of bagworms seen for 15 years occurred on Mosa plantations in West New Britain this year. However trunk injection of monocrotophos, monitored in **Experiment 606** successfully brought the outbreak under control and there has been no subsequent resurgence.

6. No significant damage to oil palm by *Scapanes* beetles, monitored in **Experiment 608**, was recorded in any area of Papua New Guinea during the year, including underplanted palms in West New Britain. Damage due to *Oryctes* in New Ireland was far less than expected, apparently due to the success of the *Oryctes* virus in controlling the larvae.

7. Minor damage due to stick insects and rats was recorded during the year. Otherwise there was little damage observed due to other pests.

V. PATHOLOGY

1. Once again no serious disease problems arose in Papua New Guinea during the year, although isolated cases of spear rot and stem rot were recorded.

2. In **Experiment 801** in the Mosa area of West New Britain, in which oil palm seedlings had been planted close to old oil palm stumps, no *Ganoderma* infection has been noted during eight years of close observation, and this trial has now been closed.

I. AGRONOMY TRIALS

ISLAND PROVINCES

(I. Orrell & P. Talopa)

TRIAL 107, FACTORIAL FERTILIZER EXPERIMENT ON MATURE REPLANTED PALMS, BEBERE PLANTATION.

PURPOSE:

To provide fertilizer response information that will be useful in developing recommendations concerning fertilizer usage.

SITE DETAILS:

LOCATION; Bebere Plantation, Field D8 & D9.

GENETIC MATERIAL; Dami commercial DxP crosses.

SOIL DESCRIPTION; Young coarse textured freely draining soil formed on alluvially redeposited andesitic pumiceous sands gravel and volcanic ash.

PLANTING DATE; January 1983.

PLANTING DENSITY; 135 palms/ha.

DESIGN AND TREATMENTS:

DESIGN;

This experiment consists of a mixed series $3^2 2^3$ factorial design (N,P,K,Mg and Cl). Each plot consists of 36 palms of which the central 16 are recorded. The recorded palms are of 16 different progenies arranged in the same spatial configuration in each plot. Five of these progenies were selected from high bunch number (HBN) families and eleven from families with medium sex ratio (MSR).

TREATMENTS;

Except for nitrogen, no fertilizers were applied during the first two years following planting. At three months, all plots received 0.25kg sulphate of ammonia per palm and an additional 1kg sulphate of ammonia per palm was applied at 12 months as a treatment (establishment nitrogen). The other treatment applications commenced in February 1985. Fertilizers are applied as two equal split doses per year. Annual fertilizer application rates until the end of 1988 were as follows;

LEVEL	0	1	2
FERTILIZER	kg/palm/year		
Sulphate of Ammonia	0.0	1.0	2.0
Triple Superphosphate	0.0	0.5	1.0
Sulphate of Potash	0.0	1.8	---
Kieserite	0.0	2.0	---

In 1989 the fertilizer treatments were amended as follows;

LEVEL	0	1	2
FERTILIZER	kg/palm/yr		
Sulphate of Ammonia	0.0	2.0	4.0
Triple Superphosphate	0.0	1.0	2.0
Sulphate of Potash	0.0	3.6	---
Kieserite	0.0	3.0	---
Sodium Chloride	0.0	4.0	---

The sodium chloride treatment was introduced to increase the palm tissue chlorine levels. This treatment was included to determine whether low chlorine levels were limiting yield or whether the low chlorine levels were affecting responses to the other fertilizers. The sodium chloride is applied orthogonally over the earlier "establishment nitrogen" treatment. This inclusion means that the original blocking is no longer valid.

RESULTS:

FFB Production data for January to December 1990 and January 1988 to December 1990 are presented in Tables 1 and 2 respectively.

The FFB production data for 1990 alone, shows no significant effects of the fertilizer treatments on FFB yield or numbers of bunches produced. Kieserite treatment does increase single bunch weight ($p=0.002$). The chloride treatment also produces an increase in single bunch weight, but this main effect is only significant at $p=0.08$.

The three years FFB production data (1988-1990) shows no significant effects of fertilizer treatment on FFB yield and numbers of bunches produced. Although both Ammonium sulphate and Kieserite treatments show a non-significant trend of increasing FFB production which in the 1987-89 analysis proved significant. The Kieserite treatment has produced a significant ($p=0.01$) increase in single bunch weight.

Table 1: Trial 107, FFB Yield & Yield Components, Jan-Dec 1990.

Main Effects	FFB Yield (t/ha/yr)	No. of Bunches (No/ha/yr)	Bunch Wgt. (kg/bunch)
N_0	27.86	1715	16.32
N_1	28.56	1746	16.40
N_2	28.12	1706	16.54
P_0	28.24	1737	16.28
P_1	27.78	1708	16.34
P_2	28.53	1722	16.64
K_0	28.06	1729	16.28
K_1	28.30	1716	16.56
Mg_0	28.15	1754	**16.09**[1]
Mg_1	28.21	1690	**16.75**
Cl_0	28.25	1744	16.25
Cl_1	28.11	1700	16.59
cv%	8.4	11.3	4.9
$LSD_{.05}$(N&P)	1.42	117.0	0.49
$LSD_{.05}$(K,Mg&Cl)	1.16	95.5	0.40

Table 2: Trial 107, FFB Yield & Yield Components, Jan88-Dec90.

Main Effects	FFB Yield (t/ha/yr)	No. of Bunches (No/ha/yr)	Bunch Wgt. (kg/bunch)
N_0	26.67	1999	13.37
N_1	27.42	2033	13.50
N_2	27.41	2023	13.57
P_0	27.16	2011	13.52
P_1	27.09	2036	13.32
P_2	27.25	2009	13.60
K_0	27.28	2037	13.42
K_1	27.05	2000	13.55
Mg_0	26.88	2027	**13.29**
Mg_1	27.45	2010	**13.68**
cv%	5.7	7.4	4.3
$LSD_{.05}$(N&P)	0.92	90.3	0.35
$LSD_{.05}$(K,Mg&Cl)	0.76	73.6	0.28

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

Frond 17 leaflet sampling and analysis was carried out in October 1990. The results of the tissue analysis are presented in Table 3.

Table 3: Trial 107, Frond 17 Leaflet Nutrient Analysis, October 1990.

Main Effects	Frond 17 Leaflet Nutrient Levels (calculated on a dry matter basis)						
	N (%)	P (%)	K (%)	Mg (%)	Ca (%)	Na (ppm)	Cl (%)
N 0	2.402	0.151	0.833	**0.157**	0.802	36.7	0.283
N 1	2.432	0.150	0.828	**0.144**	0.785	34.6	0.258
N 2	2.439	0.149	0.820	**0.149**	0.784	34.3	0.267
P 0	2.419	0.149	0.834	0.152	0.788	35.8	0.249
P 1	2.424	0.150	0.826	0.153	0.801	36.7	0.286
P 2	2.430	0.150	0.821	0.146	0.782	33.0	0.273
K 0	2.431	0.150	0.826	0.151	0.790	36.0	0.270
K 0	2.418	0.150	0.828	0.149	0.790	34.3	0.269
Mg 0	2.410	0.149	0.830	**0.144**	**0.802**	36.4	0.276
Mg 1	2.439	0.150	0.825	**0.156**	**0.779**	34.0	0.262
Cl 0	2.427	0.151	0.826	0.149	**0.780**	34.0	**0.237**
Cl 1	2.422	0.148	0.828	0.151	**0.801**	36.4	**0.301**
cv%	3.4	3.4	6.5	7.7	4.3	43.2	26.9
$LSD_{.05}$(N&P)	0.050	0.003	0.033	0.007	0.021	9.1	0.044
$LSD_{.05}$(K,Mg&Cl)	0.041	0.003	0.027	0.006	0.017	7.5	0.036

None of the fertilizer treatments had a significant effect on the frond 17 leaflet nitrogen, phosphorus and potassium levels. The ammonium sulphate treatments generally decreased the leaflet magnesium levels ($p=0.021$ linear effect, $p=0.008$ quadratic effect). Kieserite treatment significantly ($p<0.001$) increased the leaflet magnesium levels, but only by 0.012% from 0.144%. The sodium chloride treatment increased the leaflet chlorine level ($p=0.002$).

The leaflet tissue analysis at this site indicates that the only seriously yield limiting nutrient is magnesium. Unfortunately the kieserite treatment is not raising the leaflet magnesium level by very much and the leaflet magnesium status is not reaching a 'sufficiency' level. This is probably the reason for the lack of treatment response at this site.

Throughout 1990 and continuing in 1991, bunches have been selected at random from all plots and analysed for oil content and physical characteristics at the bunch analysis facility on Dami Research Station. Analysis results collected as of May 1991 are presented in Table 4.

Table 4: Trial 107, Bunch Analysis 1990/91.

Main Effects	NOSP	BW	FFB	FB	FRWT	WMF	DMF	SHF	KF	DMWM	ODM	FS	OWM	OB	KB
N0	143.1	17.68	67.71	68.40	11.98	76.72	48.16	12.66	10.62	62.79	79.86	**66.02**	50.19	26.33	7.19
N1	149.8	17.77	67.65	68.46	12.00	78.80	49.22	11.39	9.80	62.39	79.44	**64.43**	49.63	26.86	6.64
N2	150.7	17.57	65.85	66.62	14.58	77.71	48.37	12.62	9.66	62.31	79.42	**61.07**	49.52	25.63	6.41
P0	**143.6**	17.99	67.31	68.13	12.11	78.77	48.55	11.60	9.62	61.55	79.72	63.88	49.12	26.40	6.53
P1	**146.2**	16.80	67.52	68.34	11.60	78.24	49.37	11.78	9.97	63.06	79.62	65.10	50.25	26.97	6.72
P2	**153.8**	18.23	66.37	67.01	14.84	76.21	47.82	13.29	10.49	62.87	79.38	62.54	49.97	25.45	7.00
K0	**143.8**	17.16	67.52	68.29	13.87	77.22	48.30	12.83	9.95	62.60	**79.14**	63.59	49.60	26.14	6.74
K1	**151.9**	18.19	66.61	67.36	11.83	78.27	48.86	11.62	10.10	62.39	**80.00**	64.09	49.96	26.40	6.75
Mg0	149.2	16.94	67.94	68.68	13.49	77.74	49.07	12.29	9.96	63.17	79.72	65.17	50.42	26.96	6.77
Mg1	146.6	18.41	66.20	66.97	12.21	77.75	48.09	12.17	10.09	61.81	79.42	62.51	49.14	25.59	6.73
Cl0	146.7	17.37	67.89	68.48	11.81	78.17	48.82	12.11	9.71	62.40	79.53	64.61	49.68	26.66	6.62
Cl1	149.0	17.97	66.25	67.18	13.90	77.32	48.34	12.34	10.34	62.59	79.61	63.07	49.88	25.89	6.88
cv%	11.2	20.6	5.8	5.6	57.4	7.1	8.7	31.4	22.7	5.4	2.2	10.6	7.1	12.8	22.7
$LSD_{.05}$(N&P)	9.85	2.17	2.31	2.26	4.40	3.31	2.51	2.29	1.36	2.01	1.03	4.03	2.09	2.00	0.91
$LSD_{.05}$ (K,Mg & Cl)	7.86	1.74	1.84	1.81	3.51	2.65	2.00	1.87	1.09	1.61	0.82	3.22	1.67	1.60	0.73

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

The ammonium sulphate application has significantly (for linear response component p=0.02) depressed fruit set. Application of ammonium chloride and diammonium phosphate in Trial 108 also depressed the fruit set in the bunch analysis carried out in 1991.

Vegetative measurements were made in October 1990 at the same time that leaflet tissue sampling was being carried out. The estimated physiological parameters calculated from these measurements are presented in Table 5.

Table 5: Trial 107, Physiological Parameters, October 1990.

Main Effects	Leaf Area Index	Fractional Energy Interception	Efficiency of Energy Conversion (g MJ^{-1})	Vegetative D.M. Production (t/ha/yr)	Bunch D.M. Production[2] (t/ha/yr)	Bunch Index
N0	**6.257**	**0.914**	1.484	18.12	22.85	0.558
N1	**6.537**	**0.923**	1.497	18.27	23.42	0.561
N2	**6.509**	**0.922**	1.483	18.25	23.06	0.558
P0	**6.278**	**0.915**	1.491	18.05	23.16	0.561
P1	**6.357**	**0.917**	1.478	18.18	22.78	0.556
P2	**6.669**	**0.927**	1.494	18.41	23.39	0.560
K0	6.414	0.919	1.481	18.10	23.01	0.560
K1	6.454	0.921	1.494	18.32	23.21	0.558
Mg0	6.445	0.920	1.483	18.12	23.08	0.560
Mg1	6.424	0.919	1.493	18.31	23.13	0.558
Cl0	6.372	0.918	1.490	18.13	23.17	0.561
Cl1	6.496	0.922	1.486	18.30	23.05	0.557
CV%	4.9	1.1	5.3	5.8	8.4	5.0
$LSD_{.05}$(N&P)	0.188	0.006	0.048	0.63	1.16	0.017
$LSD_{.05}$ (K,Mg&Cl)	0.154	0.005	0.039	0.52	0.95	0.014

The ammonium sulphate applications have significantly increased both leaf area index (p=0.01) and the fractional energy interception (p=0.009).

The Triple Superphosphate applications have also increased both the leaf area index (p<0.001) and fractional energy interception (p<0.001).

These increases in leaf area index and fractional energy interception show a very similar trend to the data collected in 1989, although in 1989 these effects were not significant

[2]Bunch dry matter is calculated using carbohydrate equivalent, where oil energy = 2.1 x carbohydrate.

due to larger errors. Between 1989 and 1990 there has been a marked increase in leaf area index and fractional energy interception. In 1989 the overall plot means for leaf area index and fractional energy interception were **5.458** and **0.899** respectively, in 1990 these had risen to **6.434** and **0.920**. Unrecorded observations at the trial site show a marked reduction in vegetative ground cover during 1989 and 1990 (ground cover assessments were started in 1991).

The physiological parameters calculated in 1989 showed that the ammonium sulphate applications had significantly increased the values for efficiency of energy conversion, vegetative dry matter production and bunch dry matter production. In the 1990 assessment, these effects were not evident. In 1990 the values of these parameters are higher than in 1989. From 1989 to 1990, the overall mean for efficiency of energy interception has risen from **1.408** to **1.488** g/MJ, vegetative dry matter production has risen from **15.80** to **18.21** t/ha/yr and bunch dry matter production has risen from **22.43** to **23.11** t/ha/yr. Bunch index has dropped from **0.586** in 1989 to **0.559** in 1990.

TRIAL 108, SYSTEMATIC NITROGEN FERTILIZER TRIAL, KUMBANGO PLANTATION.

PURPOSE:

To provide fertilizer response information that will be useful in developing recommendations concerning fertilizer usage.

SITE DETAILS:

LOCATION; Kumbango Plantation, Fields E7 and F8.

GENETIC MATERIAL; Dami commercial DxP crosses.

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

PLANTING DATE; 1972.

PLANTING DENSITY; 120 palms/ha.

DESIGN AND TREATMENTS:

DESIGN; Two sources of nitrogen are compared in systematically increasing levels of 8 equal steps, replicated four times. 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. Two replicates of this arrangement were placed in a block mulched with 30 t ha^{-1} empty bunches in March 1985 and two replicates placed in an unmulched one. There is a total of 64 plots, each plot consisting of the two rows on either side of a harvesting path (twin row) and on average consisting of 33 palms. There are no guard rows between levels but the two sources are guarded from each other and the end rows are guarded.

TREATMENTS; The annual fertilizer applications to this experiment are as follows:

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

At each level of fertilizer application, both nitrogen sources supply the same quantity of nitrogen.

Due to evidence indicating the development of magnesium deficiency in this trial application of Kieserite at 4.0 kg/palm/yr began in November 1989.

RESULTS:

FFB Yield and yield component data for Jan to Dec 1990 and Jan88 to Dec90 are presented in Tables 6 and 7 respectively.

Table 6: Trial 108, FFB Yield & Yield Components, Jan-Dec 1990.

N_Level	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	17.01	17.95	738	778	23.12	23.09
1	18.61	17.78	795	776	23.46	22.92
2	20.35	20.08	841	831	24.22	24.20
3	20.85	20.73	805	864	26.05	23.98
4	19.22	22.21	767	908	25.03	24.45
5	19.38	23.90	769	1003	25.17	23.90
6	19.32	23.60	812	987	23.82	23.93
7	20.44	20.74	809	839	25.23	24.74

During 1990 the yield response to ammonium chloride application has declined, largely through a reduction in the numbers of bunches produced at the higher ammonium chloride application rates. Diammonium phosphate continues to show a marked rate response in terms of FFB production. Up to 3.6 kg DAP/palm/yr, the DAP increased FFB yield by 1.5 t FFB/ha/yr for every kg DAP/palm/yr.

Table 7: Trial 108, FFB Yield & Yield Components, Jan88-Dec90.

N_Level	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	16.48	15.81	730	742	22.53	21.34
1	17.12	16.42	749	743	22.84	22.10
2	19.03	17.97	794	776	23.97	23.19
3	19.31	18.43	759	784	25.49	23.44
4	18.28	20.81	718	836	25.42	24.95
5	19.50	21.10	747	868	26.13	24.35
6	19.44	21.05	785	856	24.77	24.68
7	19.72	19.01	757	765	26.05	24.89

Beginning in 1990 a kieserite treatment was superimposed on the trial to overcome the suspected magnesium deficiency in part induced by the nitrogen fertilizer applications. In 1990 this treatment had no significant effect on FFB production.

FFB yield and yield component data for Jan-Dec 1990 and fitted quadratic regression models are illustrated in Figures 1 to 3.

The three years FFB production data January 1988 to December 1990 shows marked treatment rate responses in terms of FFB yield for both nitrogen sources. The ammonium chloride treatment response though has been flattened as a result of the lack of response in 1990.

The treatment rate response can not now be regarded as solely a nitrogen rate response. The depression of the ammonium chloride rate response is probably due to the depression of magnesium status which is more pronounced in the ammonium chloride treatments.

FFB yield and yield component data for 1988 to 1990 and fitted quadratic response models are illustrated in Figures 4 to 6.

Figure 1: Trial 108, FFB Yield, Jan-Dec 1990.

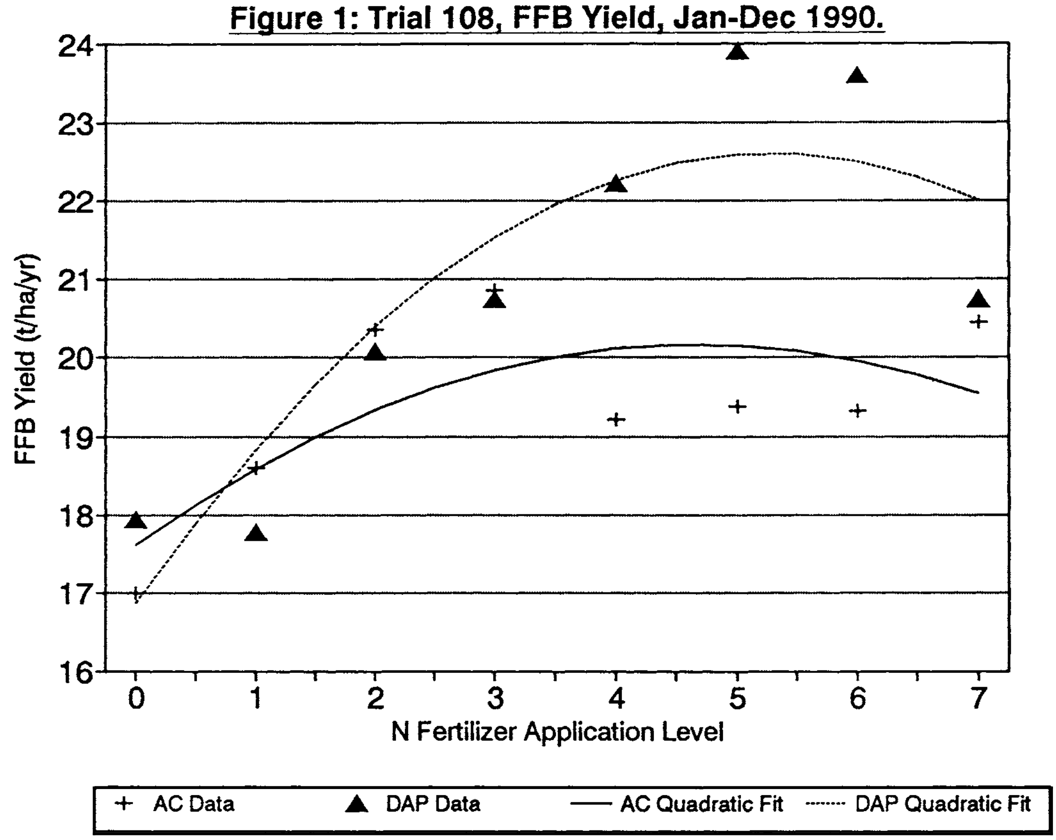


Figure 2: Trial 108, No. of Bunches, Jan-Dec 1990.

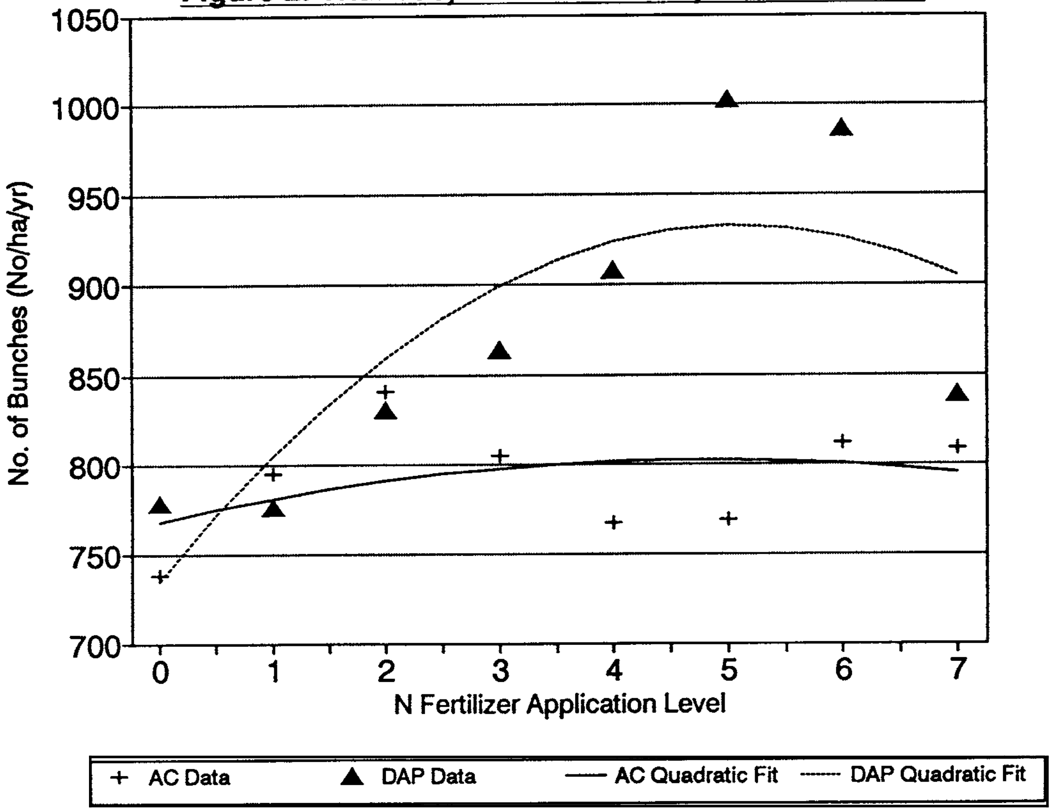
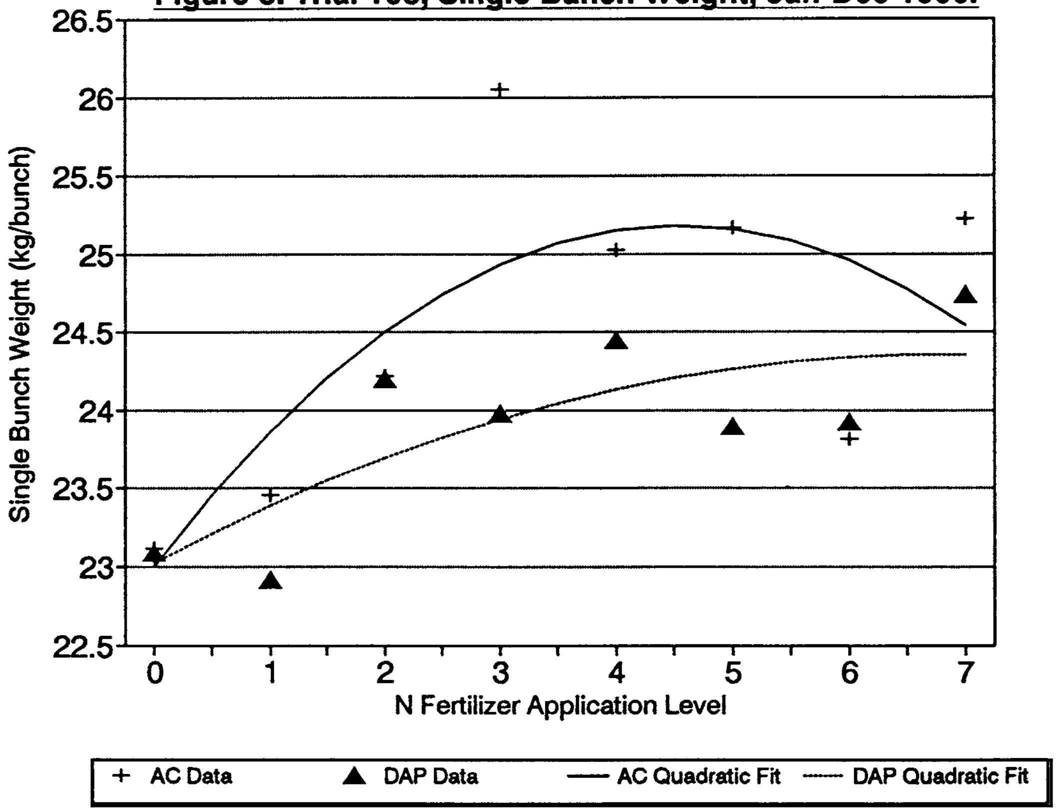


Figure 3: Trial 108, Single Bunch Weight, Jan-Dec 1990.



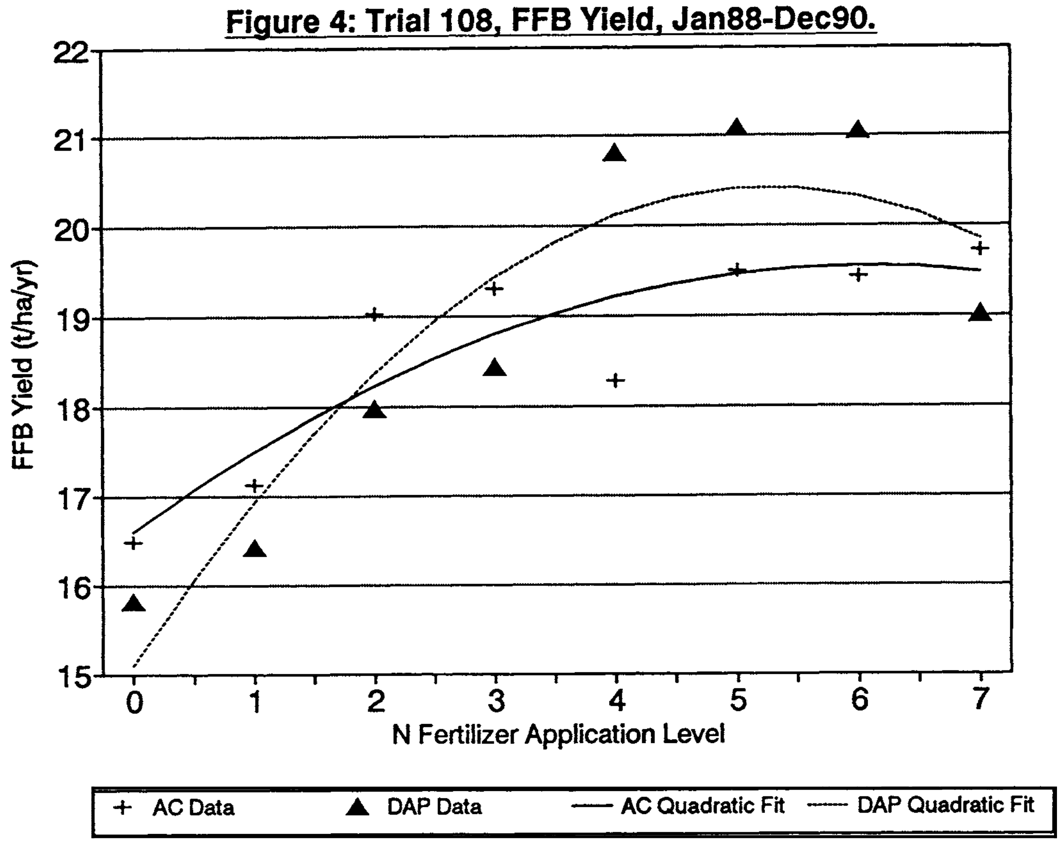


Figure 4: Trial 108, FFB Yield, Jan88-Dec90.
FFB Yield (t/ha/yr)
22
21
20
19
18
17
16
15
0
1
2
3
4
5
6
7
N Fertilizer Application Level
AC Data
DAP Data
AC Quadratic Fit
DAP Quadratic Fit

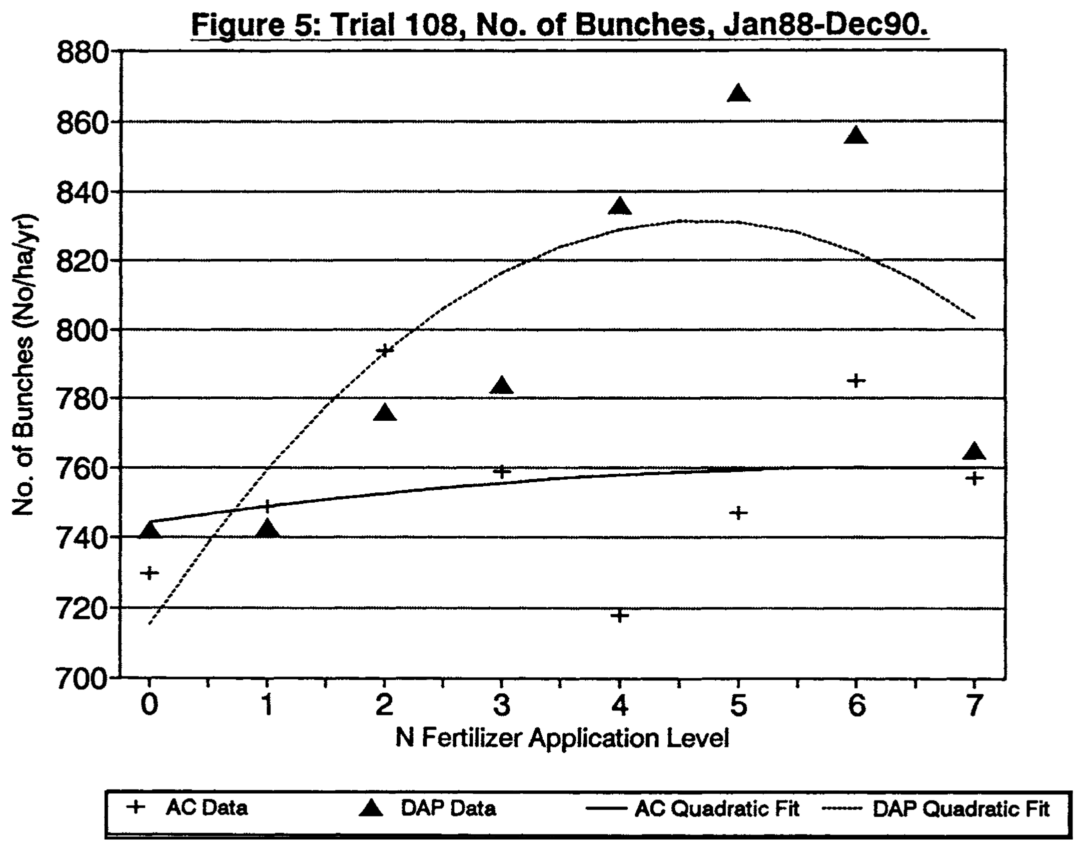
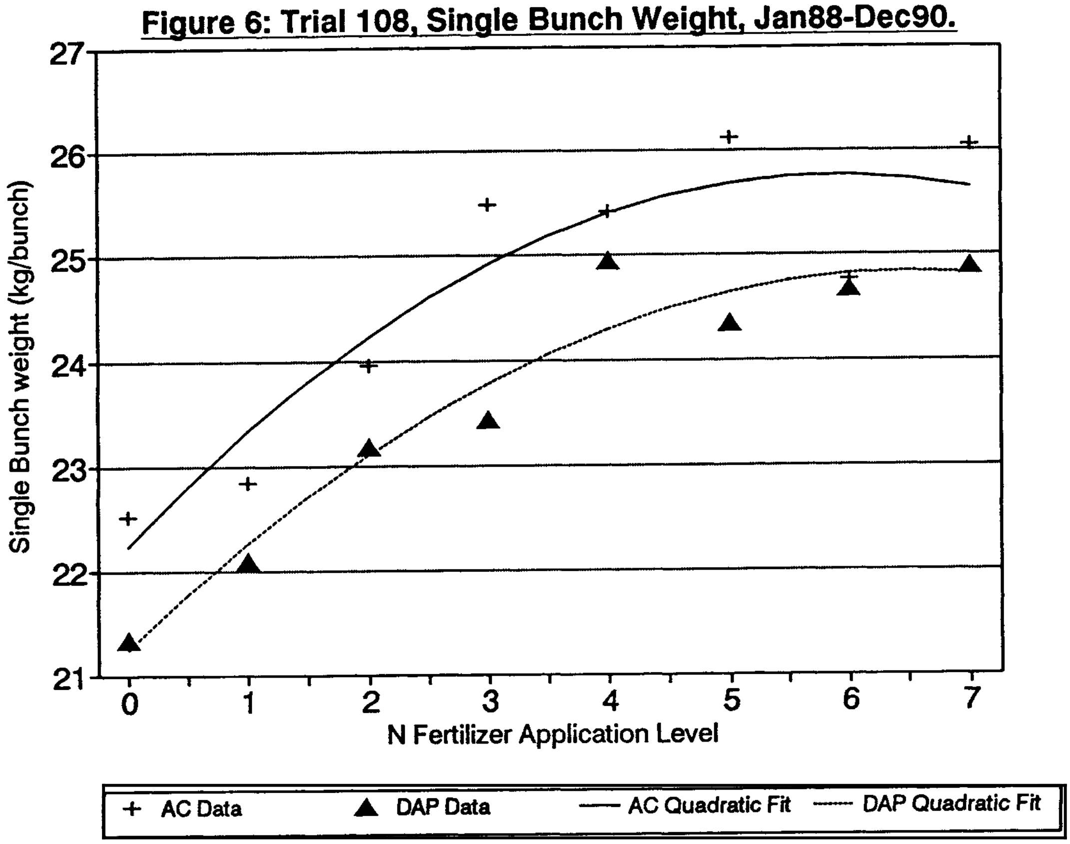


Figure 5: Trial 108, No. of Bunches, Jan88-Dec90.
No. of Bunches (No/ha/yr)
880
860
840
820
800
780
760
740
720
700
0
1
2
3
4
5
6
7
N Fertilizer Application Level
AC Data
DAP Data
AC Quadratic Fit
DAP Quadratic Fit



Since the large nitrogen response in 1987, the magnitude of the nitrogen response seems to be declining. The monthly FFB yields and yield components were calculated from the time of the first fertilizer treatment application in August 1985 to the present in order to more clearly illustrate any trend in nitrogen response. Figure 7 illustrates the monthly FFB yield response for fertilizer application levels 1,3 and 6. Monthly response in terms of numbers of bunches produced and single bunch weight are illustrated in figures 8 and 9 respectively.

Both ammonium chloride and diammonium phosphate produced a marked FFB yield response approximately 9 months after the first fertilizer application. Since that initial large response there has been a decline in FFB yield response with time. The greater the N fertilizer application level, the greater the slope of the decline in response. The decline in FFB yield response since the high responses in 1987 is largely due to a decline in the numbers of bunches produced.

The response in terms of numbers of bunches produced reached a low plateau towards the beginning of 1989 in which all but the highest fertilizer application levels showed no effective increase in numbers of bunches produced due to nitrogen fertilizer application.

The response in terms of single bunch weight developed rapidly with the ammonium chloride fertilizer, the response developed approximately 6 months after the first fertilizer application and remained at about the same level until about the beginning if 1990. Since the beginning of 1990 there has been a decline in the bunch weight response. The single bunch weight response of diammonium phosphate shows quite different characteristics to those of ammonium chloride. The diammonium phosphate response developed slowly reaching a peak 3.5 to 4 years after the first fertilizer application. As with the ammonium chloride response, the diammonium phosphate response started to decline around the beginning of 1990.

Figure 7: Trial 108. The Effect of Treatment and Time on FFB Yield Response.

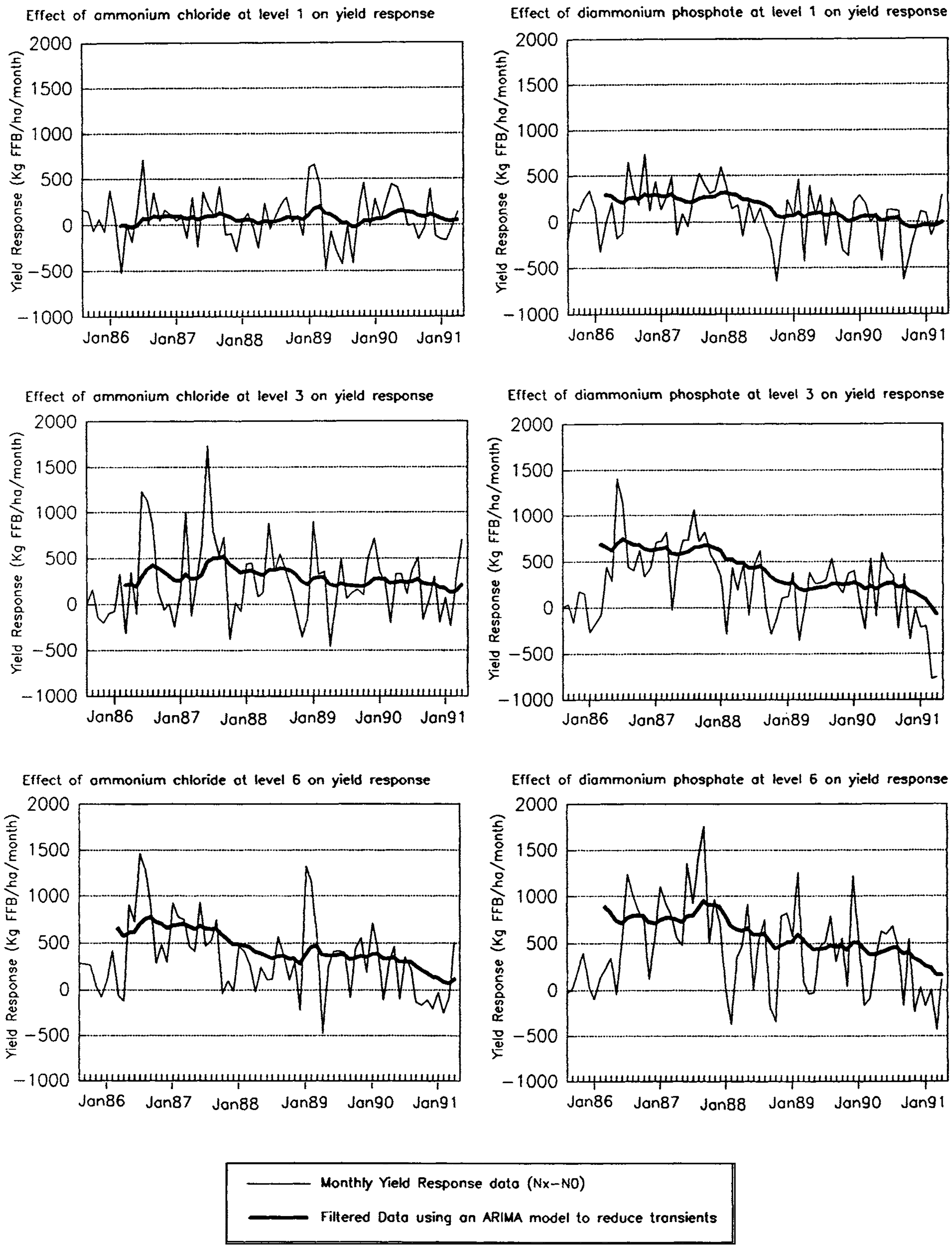


Figure 8: Trial 108. The Effect of Treatment and Time on Bunch Number Response

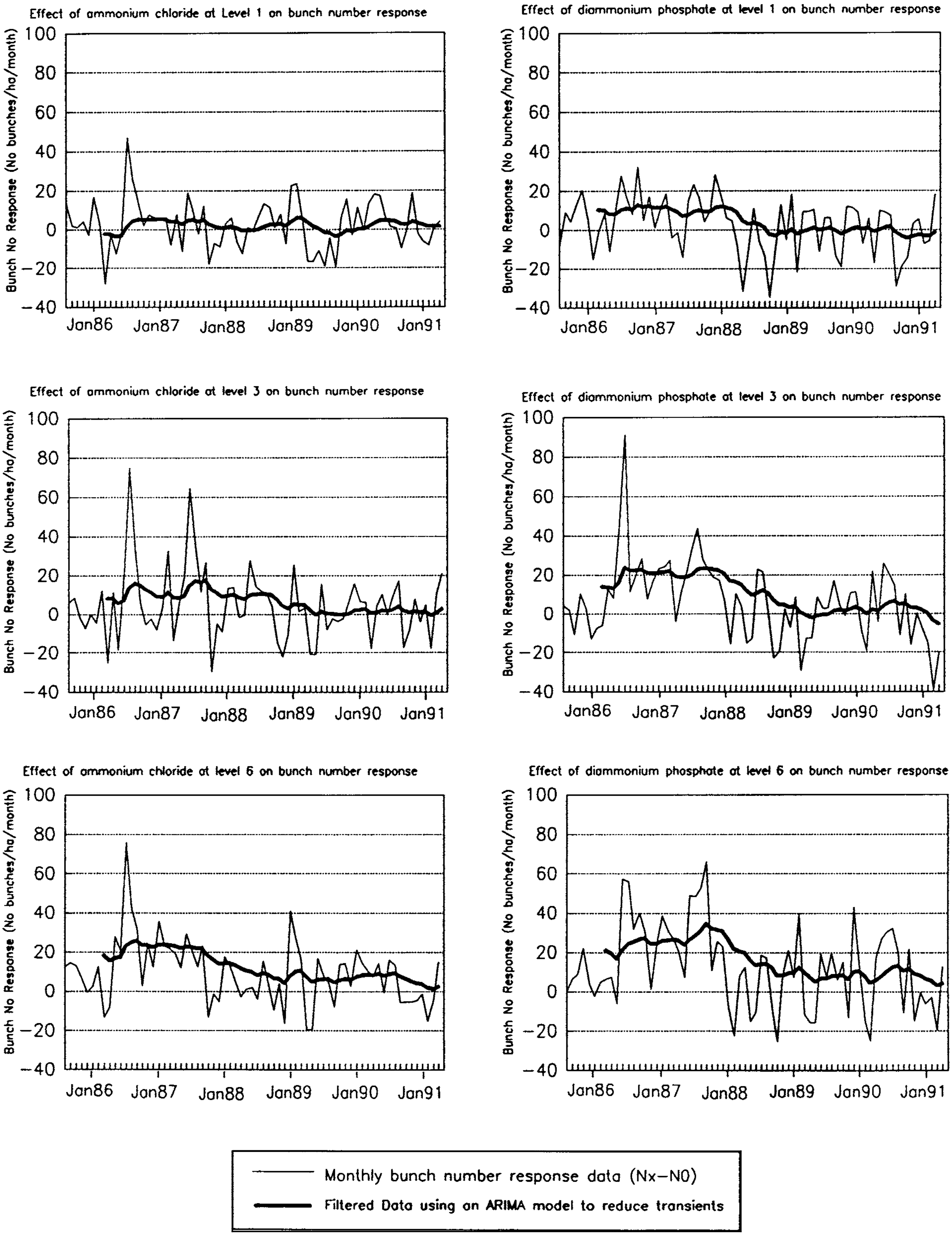
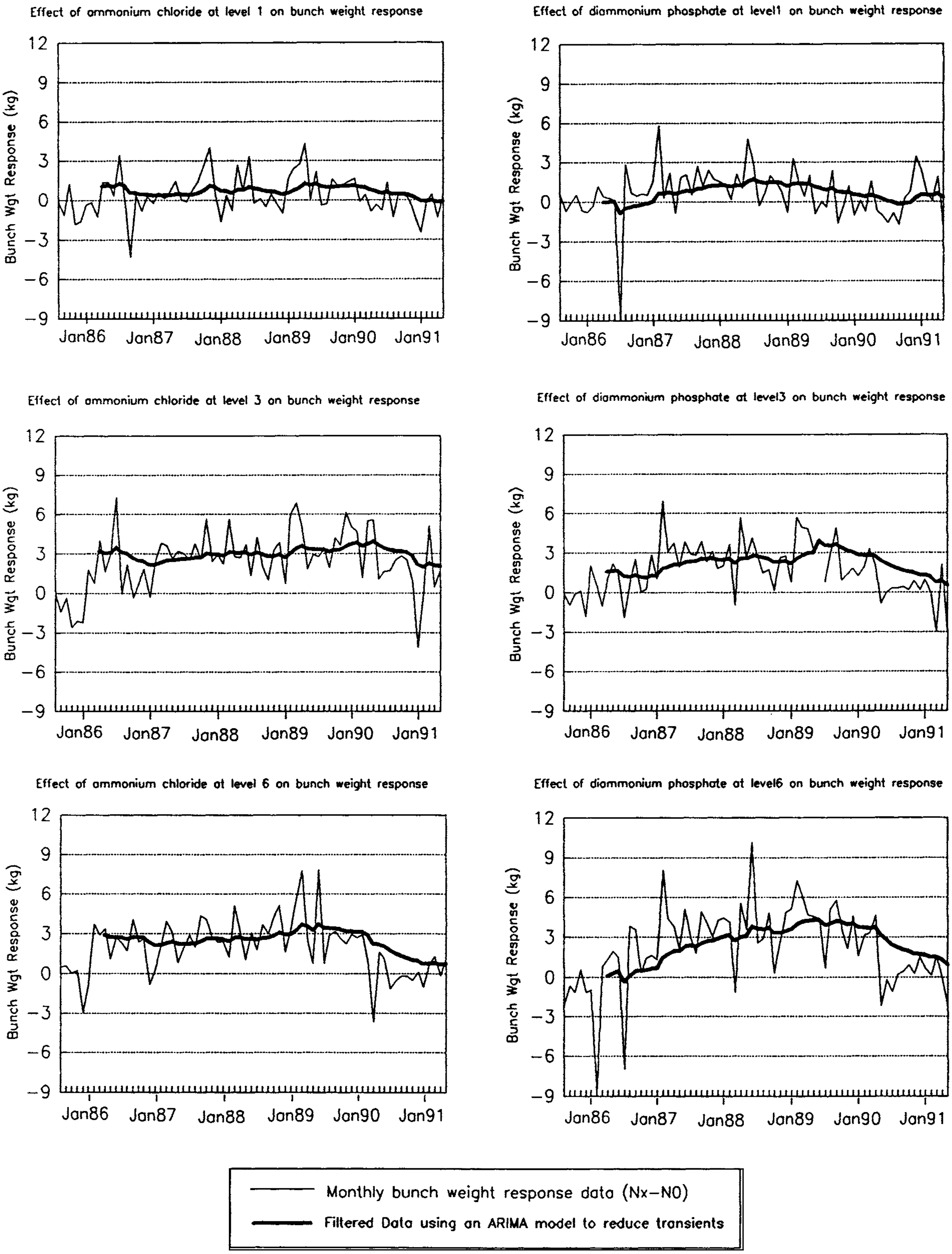


Figure 9: Trial 108. The Effect of Treatment and Time on Bunch Weight Response.



Bunches were sampled in January from ammonium chloride treatments only. Bunches were collected from all four replicates of three ammonium chloride application levels; 0 (0 kg A.C. $palm^{-1}$ $year^{-1}$), 3 (2.7 kg A.C. $palm^{-1}$ $year^{-1}$) and 6 (5.7 kg A.C. $palm^{-1}$ $year^{-1}$). Five bunches were randomly sampled from each plot. Therefore 20 bunches were analysed for each treatment level. Bunches were analysed at NBPOD's Dami Research Station using their standard methodology.

Table 8: Trial 108, Bunch Analysis of Selected plots, January 1990.

	Ammonium chloride Level			F Probability	
	0	3	6	Linear Term	Deviation from Linearity
Bunch Wgt (kg)	24.85	32.18	29.82	0.023	0.011
No Spikelets/Bunch	191	206	210	0.087	NS
% Fruit Set	78.70	80.45	80.15	NS	NS
% Fert. Fruit to Bunch	70.59	69.71	70.35	NS	NS
% Fruit to Bunch	71.59	69.71	70.35	NS	NS
Single Fruit Wgt (g)	9.75	9.10	9.41	NS	NS
% Wet Mesocarp to Fruit	76.21	75.53	73.25	0.029	NS
% Dry Mesocarp to Fruit	51.22	48.59	46.61	0.007	NS
% Shell to Fruit	13.35	13.94	15.07	0.054	NS
% Kernel to Fruit	10.43	10.52	11.68	0.074	NS
% Multiple Kernels	9.51	7.14	6.50	NS	NS
% Mesocarp Moisture	67.18	64.21	63.57	0.035	NS
% Oil to Dry Mesocarp	82.02	82.59	81.92	NS	NS
% Oil to Wet Mesocarp	55.10	53.09	52.09	0.052	NS
% Oil to Bunch	30.08	27.98	26.81	0.004	NS
% Kernel to Bunch	7.36	7.27	8.16	NS	NS

There has been a significant increase in bunch weight due to ammonium chloride addition.

The decline in oil to bunch is due to the decline in dry mesocarp to fruit. The other factors affecting oil to bunch, namely fruit to bunch and oil to dry mesocarp, show no significant changes due to ammonium chloride addition.

The decline in dry mesocarp to fruit appears to be due to both a higher mesocarp moisture content and a larger nut (kernel plus shell).

The higher mesocarp moisture content was expected as a consequence of applying chloride. The lower dry mesocarp content is not normally associated with increases in frond 17 leaflet magnesium level has dropped markedly with time and with ammonium chloride application. Particularly in treatments receiving ammonium chloride, Trial 108 is severely magnesium deficient. The drop in dry mesocarp content is likely to be due to magnesium stress. As plantation fertilizer recommendations include magnesium amelioration where necessary, it is recommended that the above effects are not included in an economic analysis.

Vegetative measurements were made in January 1990 at the same time as Frond 17 leaflet samples were taken for nutrient analysis. The estimated physiological parameters calculated from these measurements are presented in Table 9.

Table 9: Trial 108, Physiological Parameters, January 1990.

Fertilizer and Level	Leaf Area Index	Fractional Energy Interception	Efficiency of Energy Conversion ($g\ MJ^{-1}$)	Vegetative D.M. Production (t/ha/yr)	Bunch D.M. Production[1] (t/ha/yr)	Bunch Index
AC 0	5.760	0.873	1.161	16.68	13.95	0.455
AC 1	5.377	0.855	1.260	17.25	15.26	0.468
AC 2	5.750	0.873	1.333	18.46	16.69	0.474
AC 3	5.872	0.878	1.351	18.73	17.10	0.475
AC 4	6.060	0.887	1.313	19.36	15.76	0.447
AC 5	6.017	0.884	1.350	20.05	15.89	0.440
AC 6	5.752	0.873	1.326	19.12	15.84	0.453
AC 7	5.760	0.872	1.363	19.04	16.76	0.468
DAP 0	5.618	0.867	1.193	16.54	14.72	0.471
DAP 1	5.753	0.874	1.157	15.93	14.58	0.478
DAP 2	5.698	0.871	1.288	17.42	16.47	0.485
DAP 3	5.927	0.880	1.327	18.28	17.00	0.482
DAP 4	6.185	0.891	1.406	19.51	18.22	0.480
DAP 5	6.110	0.889	1.431	18.80	19.60	0.511
DAP 6	6.195	0.892	1.456	19.88	19.35	0.492
DAP 7	5.895	0.879	1.369	19.33	17.00	0.469

Both nitrogen sources have tended to increase leaf area index and fractional energy interception. The diammonium phosphate has increased these parameters to a greater degree than ammonium chloride. Both nitrogen sources have also markedly increased the efficiency of energy conversion which in combination with a slightly greater light interception due to larger leaf area, has increased both vegetative and bunch dry matter production. Diammonium phosphate has produced a greater increase in bunch dry

[1] Bunch dry matter is calculated using carbohydrate equivalent, where oil energy = 2.1 x carbohydrate.

matter production than ammonium chloride as indicated in the FFB yield responses illustrated in Figure 1.

Frond 17 leaflet sampling and analysis were carried in January/February 1990. The results of the tissue analysis are presented in Table 10.

Table 10: Trial 108, Frond 17 Leaflet Nutrient Analysis, January 1990.

Fertilizer and Level	Frond 17 Leaflet Nutrient Levels (as % of Dry Matter)					
	N	P	K	Mg	Ca	Cl
AC 0	2.220	0.144	0.730	0.148	0.870	0.295
AC 1	2.178	0.141	0.728	0.153	0.835	0.290
AC 2	2.225	0.143	0.725	0.160	0.895	0.310
AC 3	2.245	0.145	0.648	0.145	0.990	0.343
AC 4	2.288	0.149	0.620	0.143	1.005	0.355
AC 5	2.316	0.150	0.635	0.140	0.995	0.358
AC 6	2.333	0.149	0.630	0.128	0.983	0.363
AC 7	2.375	0.151	0.650	0.133	0.998	0.360
DAP 0	2.153	0.141	0.728	0.158	0.853	0.270
DAP 1	2.163	0.143	0.760	0.165	0.855	0.230
DAP 2	2.138	0.145	0.765	0.175	0.813	0.230
DAP 3	2.213	0.148	0.778	0.168	0.820	0.208
DAP 4	2.245	0.150	0.755	0.153	0.793	0.205
DAP 5	2.315	0.151	0.725	0.148	0.815	0.193
DAP 6	2.328	0.152	0.745	0.150	0.805	0.173
DAP 7	2.395	0.153	0.738	0.153	0.770	0.193

Both nitrogen sources increase leaflet nitrogen levels from about 2.2% and less, which would be regarded as nitrogen deficient, to just under 2.4%, which would not be regarded as nitrogen deficient in these circumstances. The low FFB yields particularly at the higher nitrogen application rates are probably due to deficiency of nutrients other than nitrogen, probably magnesium. The increase in FFB yield relative to the increase in leaflet nitrogen content due to diammonium phosphate application is about at the level that would be expected ie. a 0.1% increase in leaflet N corresponds to an increase of about 2.4 t FFB/ha/yr. The FFB response relative to the increase in leaflet nitrogen content due to ammonium chloride application is less than expected ie. about 1.0 t FFB/ha/yr. The lower than expected FFB yield response from ammonium chloride application is probably due to the inhibitory effects of the magnesium and possibly potassium deficiencies.

The diammonium phosphate applications have increased leaflet phosphorus levels.

Interestingly, the higher ammonium chloride application rates also seem to have increased the leaflet phosphorus levels.

As expected the ammonium chloride applications have increased leaflet chlorine levels. The diammonium phosphate application seems to have depressed leaflet chlorine levels.

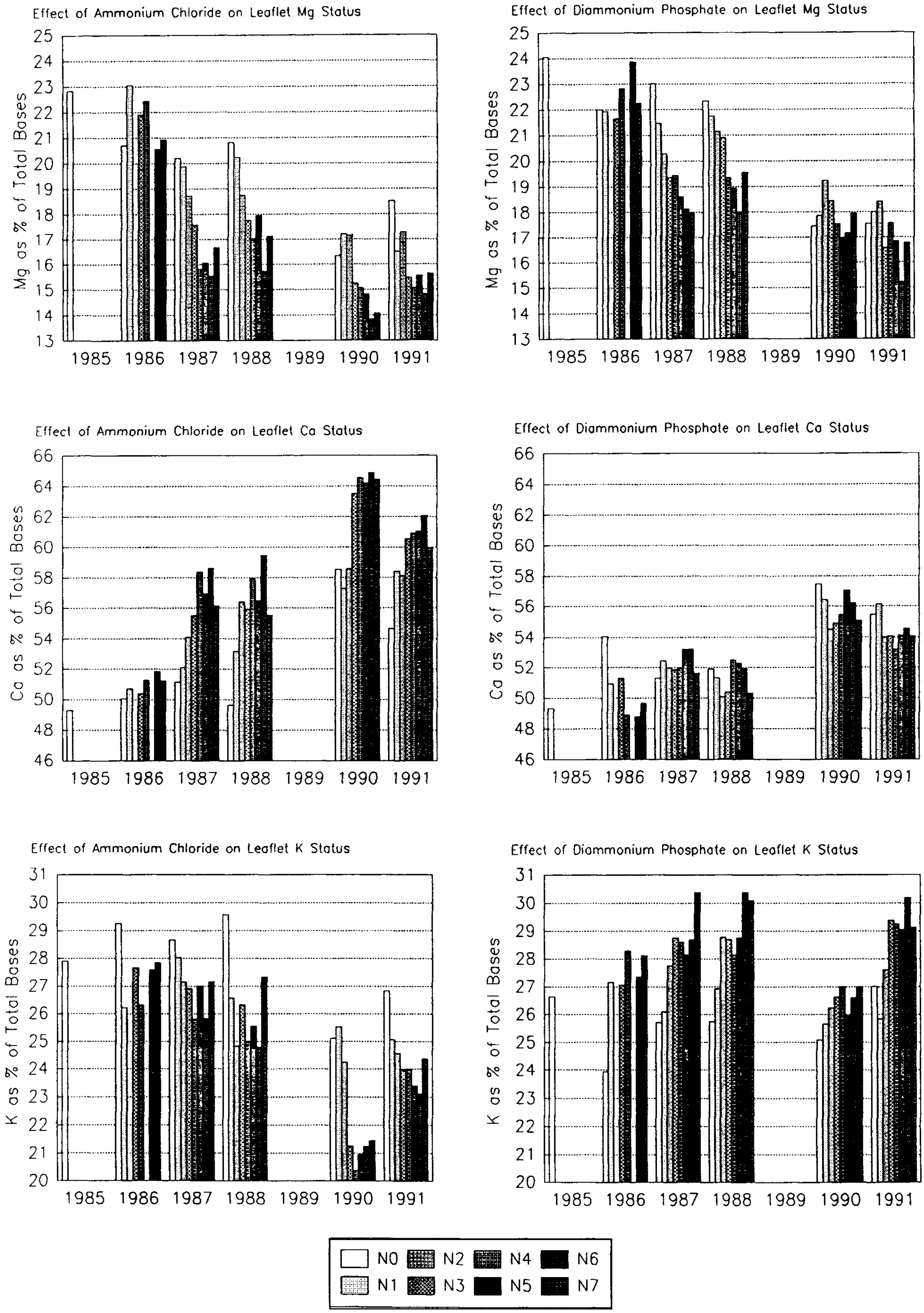
Although there is no marked change in the level of total bases (Ca+Mg+K) in the leaflet tissue due to application of these ammonium fertilizers, both fertilizers change the base composition. The effects of the two ammonium fertilizers and of time on leaflet base status is illustrated in Figure 10.

Both ammonium chloride and diammonium phosphate depress leaflet magnesium levels. The magnesium status is also declining with time. At the present time, the whole of Trial 108 is probably magnesium deficient with the deficiency being increased as nitrogen application rate is increased.

Ammonium chloride application increases the leaflet calcium level and in the case of the ammonium chloride treated plots, the leaflet calcium level increases markedly with time. The diammonium phosphate application has little effect on leaflet calcium status. The calcium level in the diammonium phosphate treated plots is increasing with time but not to the same degree as the ammonium chloride treated plots.

Ammonium chloride application is depressing leaflet potassium levels. The ammonium chloride treated plots also show a decrease in leaflet potassium status with time. In 1990 the leaflet potassium status of palms receiving the higher ammonium chloride application rates was probably at a sufficiently low level to be regarded as limiting. This potential potassium deficiency at the higher ammonium chloride application rates also suggests why the ammonium chloride yield response is depressed relative to the diammonium phosphate. The diammonium phosphate applications tend to increase the leaflet potassium level. The potassium status of the plots receiving diammonium phosphate fertilizer is also increasing with time.

Figure 10: Trial 108. The Effect of Treatment and Time on Leaflet Cation Status.



TRIAL 110, NITROGEN/ANION EXPERIMENT ON YOUNG REPLANTED PALMS, BEBERE PLANTATION.

PURPOSE:

To determine the effect of the anions chloride, sulphate and phosphate, which are commonly present in the nitrogenous fertilizers that are used on Oil Palm, on Oil Palm growth and yield. Such information will provide guidance in developing fertilizer recommendations.

SITE DETAILS:

LOCATION; Bebere Plantation, Fields B11 and B12.

GENETIC MATERIAL; Dami commercial DxP crosses.

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

PLANTING DATE; February 1984.

PLANTING DENSITY; 135 palms/ha.

DESIGN AND TREATMENTS:

DESIGN;

The experiment consists of 24 treatments, in 3 replicates of completely randomised blocks. Blocking was based on petiole WxT measurements.

TREATMENTS;

Fertilizer treatment application rates are as follows.

Treatment	Non-N Anion and Level		kg Fertilizer/palm/year	
			Non-N Anion Source	Additional Ammonium Nitrate
1	Chloride	0	0.0	1.6
2	Chloride	1	0.5	1.2
3	Chloride	2	1.0	0.8
4	Sulphate	0	0.0	1.6
5	Sulphate	1	1.25	0.8
6	Sulphate	2	2.5	0.0
7	Phosphate	0	0.0	1.6
8	Phosphate	1	1.4	0.8
9	Phosphate	2	2.8	0.0
10	Nil	0	0.0	0.0
11	Nil	0	0.0	0.0
12	Nil	0	0.0	0.0
Treatments 13 to 24, as above but mulched.				

Apart from the 'Nil' treatments, all treatments and levels receive the same amount of nitrogen, the only difference between them being the type and level of accompanying non-nitrogenous anion (either chloride, sulphate or phosphate). Plots receiving treatments 1 to 12 are unmulched, plots receiving treatments 13-24 were mulched with about 100 kg of empty bunches (EFB) per palm in April and May 1984. Application of fertilizer started in June 1985 and was continued at half yearly intervals. The above rates are those used since June 1986, the two applications prior to this time were at half these rates.

RESULTS:

FFB yield and yield component data for January to December 1990 and January 1988 to December 1990 are presented in Tables 11 and 12 respectively. The FFB yield and yield component data for January to December 1990 is illustrated in Figures 11 to 13 and the data for January 1988 to December 1990 is illustrated in Figures 14 to 15.

Table 11: Trial 110, FFB Yield & Yield Components, Jan-Dec 1990.

Tot N Appl. plm/yr	Non-N Anion & Level		FFB Yield (t/ha/yr)		No. Bunches (No./ha/yr)		Bunch Wgt. (kg/bunch)	
			-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch
580g		0	26.95	27.35	2213	2093	12.18	13.08
580g	Chloride	1	29.81	27.88	2282	2134	13.07	13.12
580g		2	27.24	28.89	2065	2045	13.30	14.11
580g		0	26.95	27.35	2213	2093	12.18	13.08
580g	Sulphate	1	27.25	28.53	2060	2219	13.30	12.86
580g		2	25.90	28.47	2012	2072	12.91	13.75
580g		0	26.95	27.35	2213	2093	12.18	13.08
580g	Phosphate	1	29.31	28.50	2275	2034	12.89	13.97
580g		2	30.31	26.63	2399	1997	12.65	13.37
0.0	No Fert.		27.12	27.35	2145	2120	12.72	12.97
580g	MEAN (+N)		27.85	27.88	2192	2086	12.74	13.38

Table 12: Trial 110, FFB Yield & Yield Components, Jan88-Dec90.

Tot N Appl. plm/yr	Non-N Anion & Level		FFB Yield (t/ha/yr)		No. Bunches (No./ha/yr)		Bunch Wgt. (kg/bunch)	
			-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch
580g		0	25.43	27.08	2441	2496	10.41	10.86
580g	Chloride	1	28.39	28.12	2564	2586	11.08	10.91
580g		2	27.77	28.44	2541	2480	10.95	11.47
580g		0	25.43	27.08	2441	2496	10.41	10.86
580g	Sulphate	1	26.70	27.14	2363	2540	11.32	10.68
580g		2	25.91	28.12	2386	2508	10.86	11.22
580g		0	25.43	27.08	2441	2496	10.41	10.86
580g	Phosphate	1	27.15	27.42	2490	2367	10.91	11.57
580g		2	28.45	26.63	2681	2394	10.62	11.14
0.0	No Fert.		26.77	26.83	2490	2490	10.76	10.78
580g	MEAN (+N)		26.74	27.46	2483	2485	10.78	11.06

Figure 11: Trial 110, FFB Response to Chloride, Jan-Dec 1990.

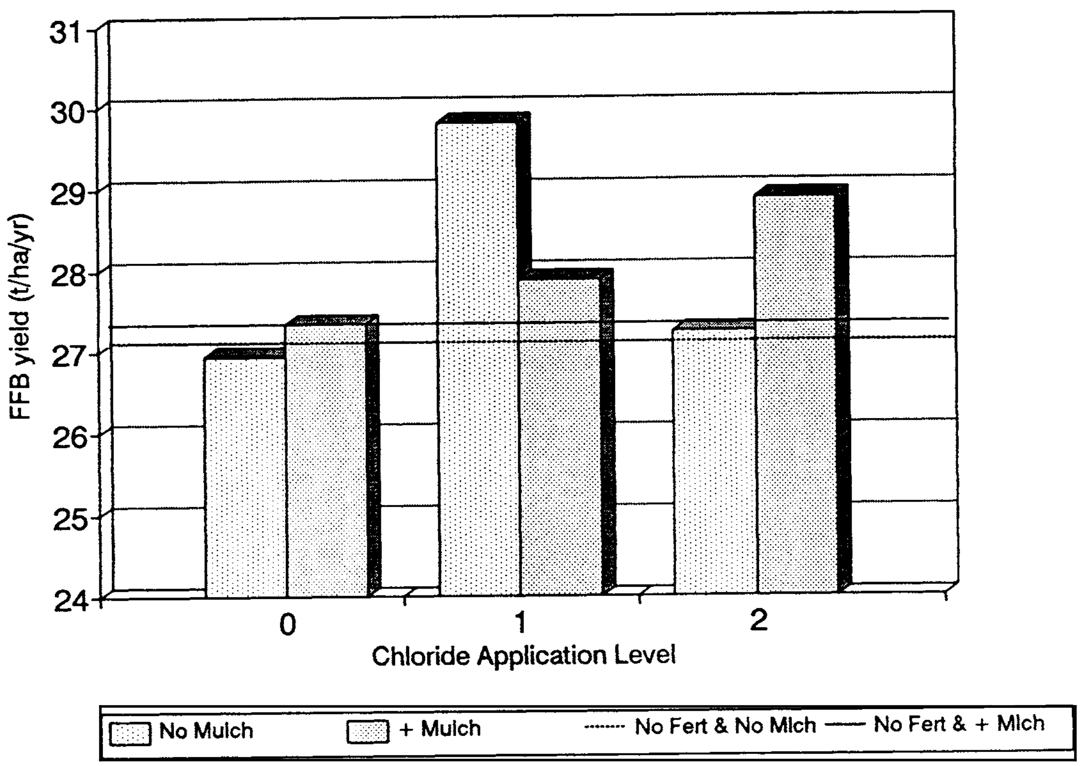


Figure 12: Trial 110, FFB Response to Sulphate, Jan-Dec 1990.

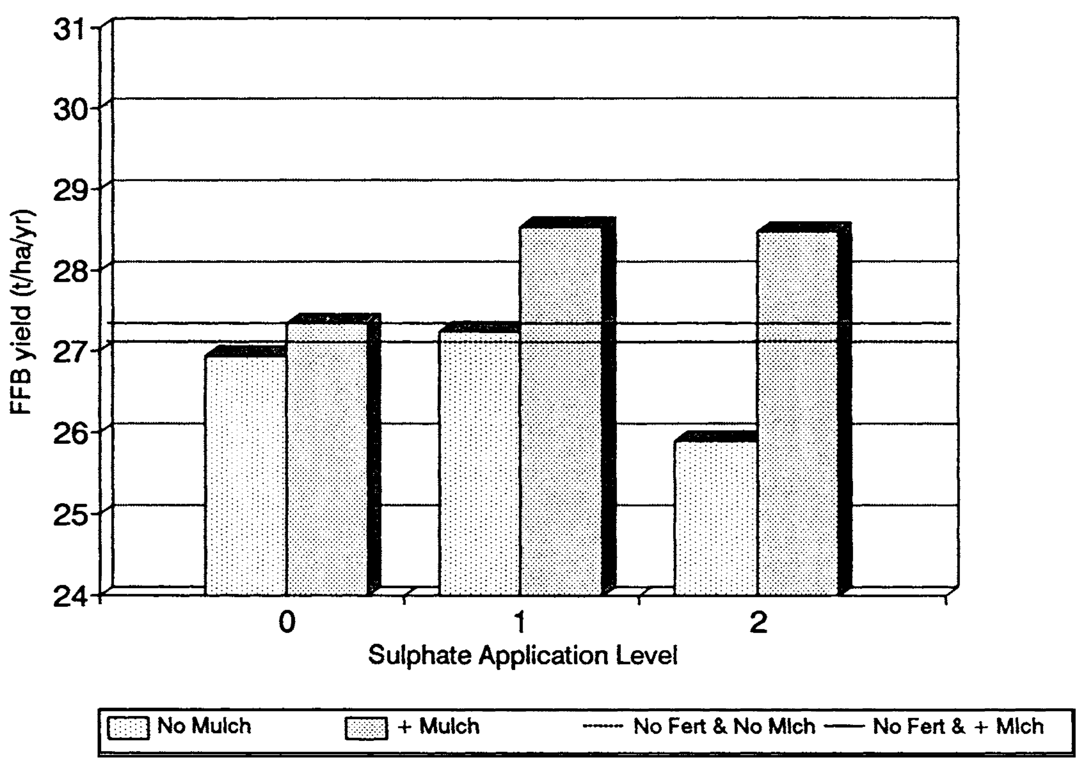


Figure 13: Trial 110, FFB Response to Phosphate, Jan-Dec 1990.

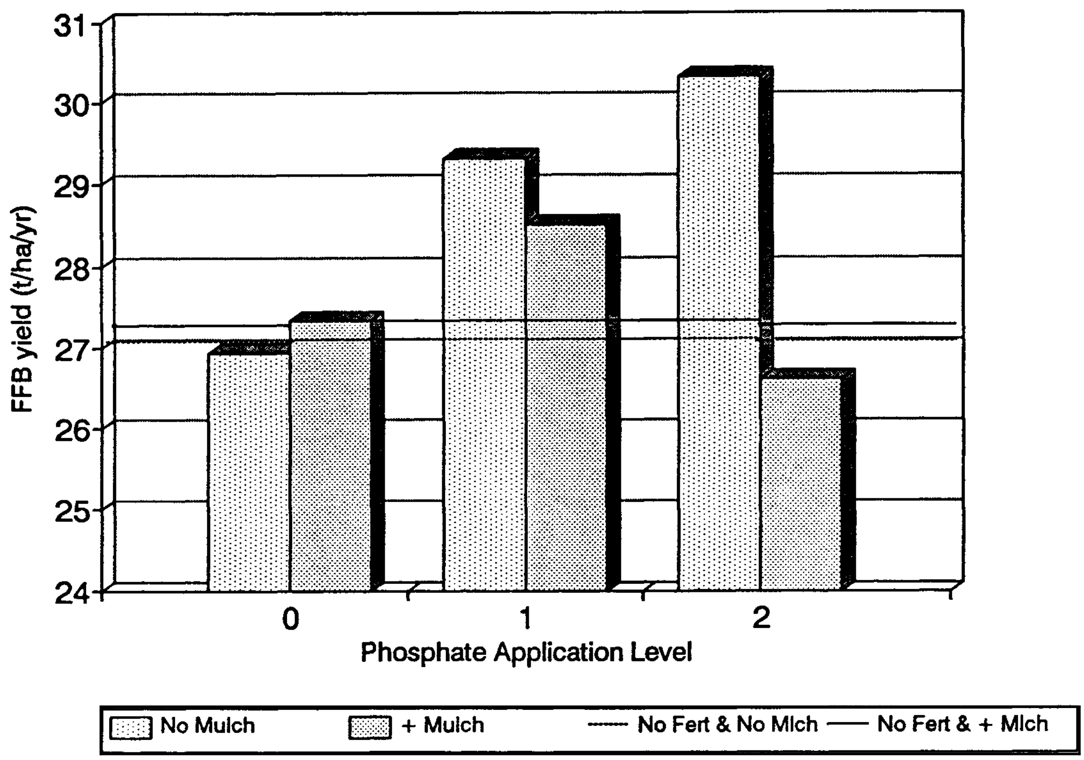


Figure 14: Trial 110, FFB Response to Chloride, Jan88-Dec90.

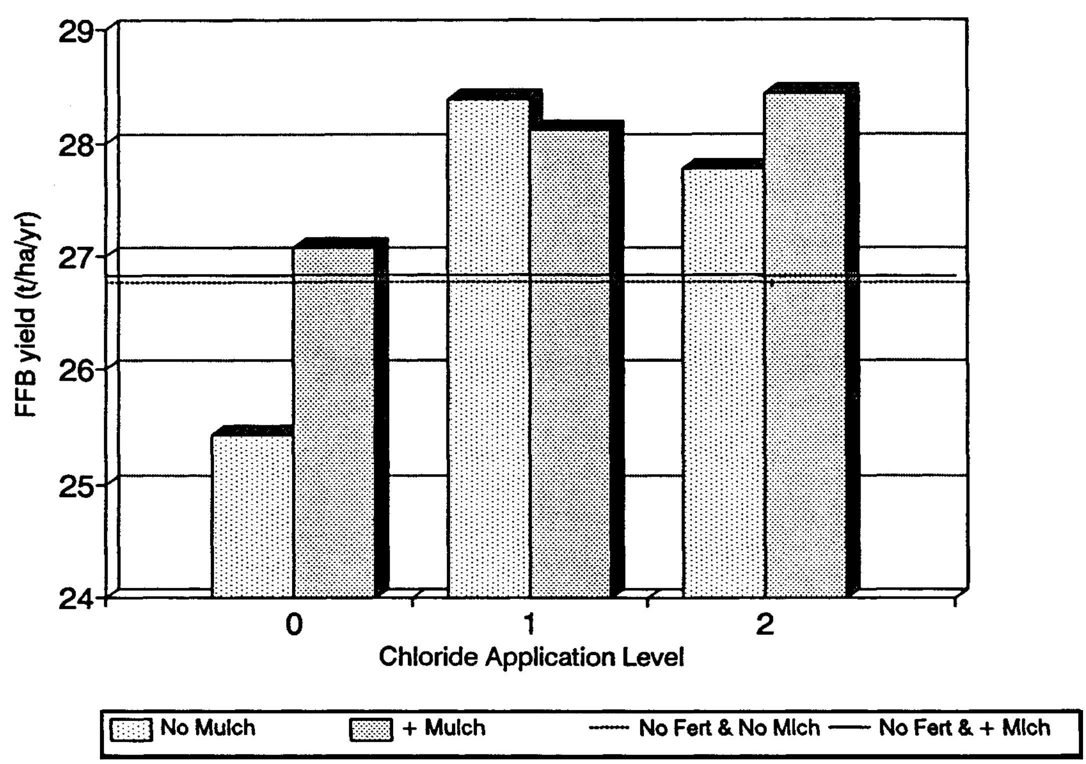


Figure 15: Trial 110, FFB Response to Sulphate, Jan88-Dec90.

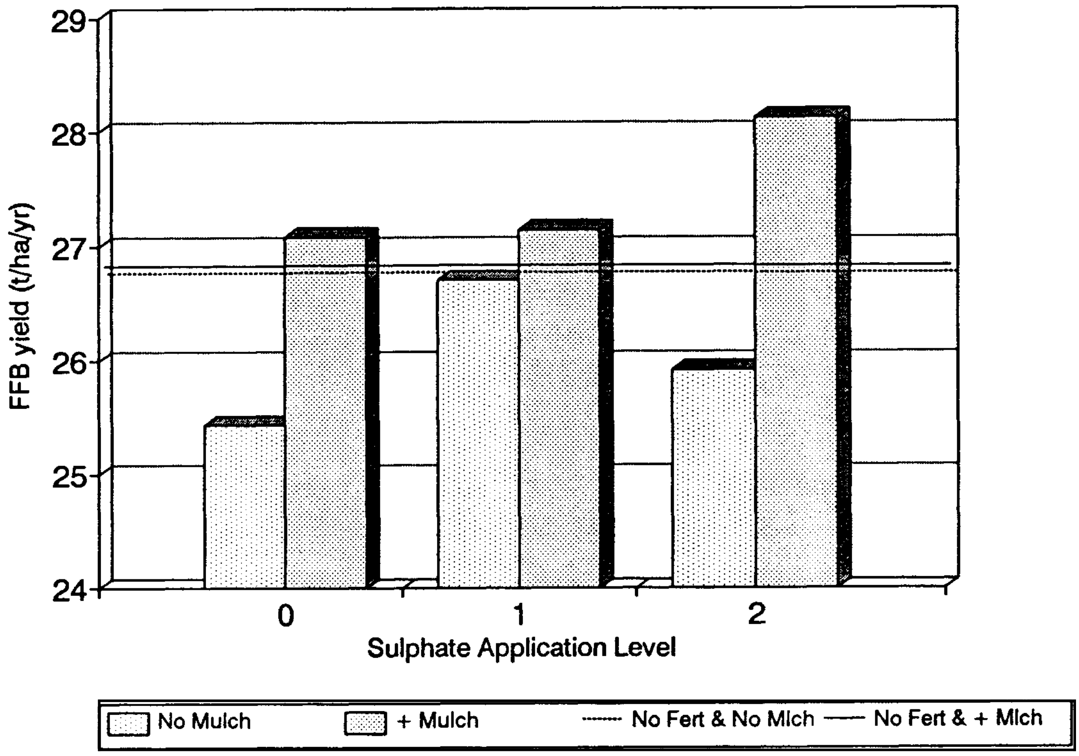
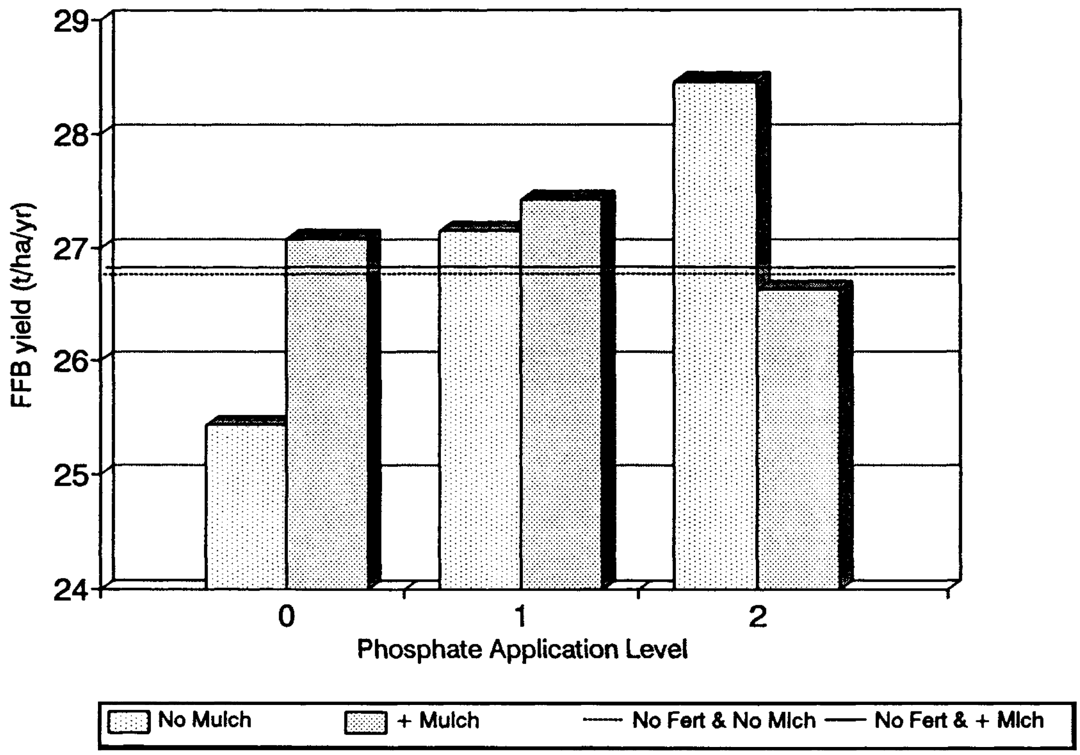


Figure 16: Trial 110, FFB Response to Phosphate, Jan88-Dec90.



It appears that in the absence of the EFB mulch that was applied in 1984, both the phosphate and the chloride treatments increased FFB yield. The phosphate response is now greater than the chloride response.

In the presence of EFB mulch, there is no FFB yield response to non-nitrogenous anion treatment.

In comparing treatments comprising nitrogen additions and treatments with no nitrogen fertilizer additions, fertilizer nitrogen application appears to have little effect of FFB yield.

Vegetative measurements were made in June 1990 at the same time that frond 17 leaflet samples were taken for nutrient analysis. The estimated physiological parameters calculated from these measurements are presented in Table 13.

Table 13: Trial 110, Physiological Parameters, June 1990.

Tot N Appl. plm/yr	Non-N Anion & Level		Leaf Area Index		Fractional Energy Interception		Efficiency of Energy Conversion (g MJ^{-1})	
			-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch
580g		0	4.914	5.541	0.867	0.898	1.421	1.409
580g	Chloride	1	5.027	5.205	0.874	0.883	1.508	1.532
580g		2	5.167	5.330	0.881	0.888	1.435	1.520
580g		0	4.917	5.541	0.867	0.898	1.421	1.409
580g	Sulphate	1	4.963	3.823	0.868	0.702	1.424	2.233
580g		2	4.723	5.945	0.856	0.914	1.419	1.478
580g		0	4.917	5.541	0.867	0.898	1.421	1.409
580g	Phosphate	1	5.110	5.203	0.878	0.881	1.482	1.478
580g		2	5.203	5.445	0.882	0.895	1.506	1.380
0.0	No Fert.		4.791	4.970	0.854	0.861	1.450	1.474
580g	MEAN (+N)		4.993	5.286	0.871	0.873	1.449	1.539

Table 13 *continued*: Trial 110, Physiological Parameters, June 1990.

Tot N Appl. plm/yr	Non-N Anion & Level	Vegetative Dry Matter Production (t/ha/yr)		Bunch Dry Matter Production (t/ha/yr)		Bunch Index	
		-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch
580g	0	15.10	16.19	22.10	22.04	0.593	0.576
580g	Chloride 1	15.36	16.76	24.44	24.08	0.614	0.590
580g	2	15.77	17.07	22.33	23.69	0.586	0.581
580g	0	15.10	16.19	22.10	22.04	0.593	0.576
580g	Sulphate 1	14.97	16.64	22.34	23.39	0.599	0.585
580g	2	15.46	17.01	21.24	23.78	0.577	0.583
580g	0	15.10	16.19	22.10	22.04	0.593	0.576
580g	Phosphate 1	15.27	15.95	24.03	23.37	0.612	0.592
580g	2	15.27	15.97	24.85	21.32	0.620	0.572
0.0	No Fert.	14.98	15.63	22.23	22.49	0.597	0.590
580g	MEAN (+N)	15.27	16.44	22.84	22.86	0.599	0.581

In the absence of mulch both the chloride and phosphate treatments seem to increase leaf area index and fractional energy interception. In both the presence and absence of mulch, the addition of nitrogen increases leaf area index and fractional energy interception.

Phosphate application in the absence of mulch increases the efficiency of energy conversion. There is also an indication that chloride also increases the 'e' value in the presence and absence of mulch. These increases in 'e' values, as with FFB yield, seem to be a recovery of a low value induced by nitrogen application in the absence of non-nitrogenous anion when compared with the nil fertilizer control.

The addition of nitrogen increases the vegetative and bunch dry matter production in the presence and absence of mulch. Chloride treatments in the presence and absence of mulch seem to have increased vegetative dry matter production. Phosphate treatment in the absence of mulch and sulphate in the presence of mulch have increased bunch dry matter production.

The phosphate treatment in the absence of mulch appears to have increased the bunch index.

In June 1990 Frond 17 leaflet sampling was carried out on selected plots. The results of the nutrient analysis of these samples is presented in Table 14.

Table 14: Trial 110, Frond 17 Tissue Analysis, 1990.
(non mulched treatments unless specified)

Total N Application palm/yr	Non-N Anion & Level		Nitrogen(%)		Phosphorus(%)		Potassium(%)	
			Leaflet	Rachis	Leaflet	Rachis	Leaflet	Rachis
580g		0	2.401	0.250	0.148	0.047	0.843	1.261
580g	Chloride	1	2.503	0.253	0.151	0.049	0.777	1.287
580g		2	2.453	0.250	0.151	0.049	0.817	1.313
580g		0	2.401	0.250	0.148	0.047	0.843	1.261
580g	Sulphate	1	2.397	0.247	0.143	0.042	0.870	1.273
580g		2	2.373	0.263	0.143	0.045	0.863	1.337
580g		0	2.401	0.250	0.148	0.047	0.843	1.261
580g	Phosphate	1	2.447	0.263	0.150	0.057	0.850	1.353
580g		2	2.503	0.250	0.152	0.050	0.837	1.190
580g	Non-N anion + Mulch	0	2.422	0.234	0.146	0.043	0.870	1.218
0.0	No Fertilizer		2.441	0.251	0.147	0.045	0.874	1.231
0.0	No Fertilizer + Mulch		2.414	0.251	0.146	0.046	0.840	1.316

Table 14 *continued:* Trial 110, Frond 17 Tissue Analysis, 1990.
(non mulched treatments unless specified)

Total N Application palm/yr	Non-N Anion & Level		Magnesium(%)		Calcium(%)		Chlorine(%)	
			Leaflet	Rachis	Leaflet	Rachis	Leaflet	Rachis
580g		0	0.131	0.036	0.926	0.449	0.217	0.126
580g	Chloride	1	0.140	0.040	0.963	0.487	0.327	0.317
580g		2	0.163	0.040	0.963	0.477	0.363	0.377
580g		0	0.131	0.036	0.926	0.449	0.217	0.126
580g	Sulphate	1	0.130	0.033	0.873	0.427	0.250	0.133
580g		2	0.127	0.033	0.873	0.460	0.247	0.130
580g		0	0.131	0.036	0.926	0.449	0.217	0.126
580g	Phosphate	1	0.150	0.033	0.927	0.447	0.293	0.200
580g		2	0.153	0.037	0.903	0.400	0.253	0.117
580g	Non-N anion + Mulch	0	0.144	0.032	0.864	0.396	0.230	0.096
0.0	No Fertilizer		0.152	0.037	0.907	0.440	0.248	0.138
0.0	No Fertilizer + Mulch		0.144	0.034	0.853	0.393	0.231	0.116

The chloride treatment in the absence of mulch and presence of applied nitrogen increased the levels of potassium in the rachis and magnesium in the leaflet. The sulphate treatment has also increased the level of potassium in the rachis. The phosphate treatment has increased leaflet levels of magnesium, phosphorus and nitrogen and depressed rachis calcium.

Comparing fertilizer treatments with the non fertilized control, leaflet chlorine levels are increased by chloride application while the sulphate application depresses leaflet calcium. Both nitrate (non-nitrogenous anion level0) and sulphate depress magnesium levels while chloride and phosphate have little effect on magnesium levels. The chloride applications noticeably depress leaflet potassium levels and nitrate and phosphate slightly depress leaflet potassium.

Both the chloride and phosphate non-nitrogenous anion treatments have resulted in improvements in FFB yield. This improvement in FFB yield is possibly due to the effect of these anions in increasing leaflet magnesium levels which are very low in this trial. Both these anions increase leaflet nitrogen levels but the nitrogen treated plots compared to the nil fertilized plots show no benefit in terms of FFB yield derived from nitrogen fertilizer application.

TRIAL 116, SYSTEMATIC NITROGEN FERTILIZER TRIAL, BEBERE PLANTATION.

PURPOSE:

To provide fertilizer response information that will be useful in developing recommendations concerning fertilizer usage.

SITE DETAILS:

LOCATION; Bebere Plantation, Fields E3 and E4.

GENETIC MATERIAL; Dami commercial DxP crosses.

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

PLANTING DATE; 1971.

PLANTING DENSITY; 120 palms/ha.

DESIGN AND TREATMENTS:

Design; This experiment comprises a systematic design of 8 replicates of 7 treatments (5 treatment rates). 4 replicates receive 1 year's ammonium chloride application and 4 replicates receive continuous ammonium chloride application. Each replicate contains 5 treatment rates of ammonium chloride increasing systematically in one direction. This dose rate gradient in one replicate abuts a second replicate with the dose rate gradient in the opposite direction. There is a total of 56 plots, each plot consisting of the two rows of palms on either side of a harvesting path (twin row) and containing about 30 palms. There are no guard rows between different treatment application rates.

Treatments: Fertilizer application rates are as follows;

LEVEL	0	0	0	1	2	3	4
TREATMENT	kg Fertilizer/palm/year						
Ammonium chloride, one years application only.	0.0	0.0	0.0	1.5	3.0	4.5	6.0
Ammonium chloride, continuous application.	0.0	0.0	0.0	1.5	3.0	4.5	6.0

Annual fertilizer application rates are split into 2 applications per year.

Fertilizer applications commenced in April 1987.

Due to fire damage, this trial was canceled in August 1990.

RESULTS:

FFB yield and yield component data for Jan to Aug 1990 and Jan 1988 to Aug 1990 are presented in Tables 15 and 16 respectively. The data from these tables together with fitted quadratic regression models are presented in Figs 17 to 22.

Table 15: Trial 116, FFB Yield & Yield Components, Jan-Aug 1990.

A.C. Appl. Rate (kg/palm/yr)	FFB Yield (t/ha)		No. Bunches (No./ha)		Bunch Wgt. (kg/bunch)	
	87 Appl	Cont Appl	87 Appl	Cont Appl	87 Appl	Cont Appl
0.0	12.37	14.07	482	553	25.82	25.54
1.5	12.12	14.84	454	509	26.73	29.08
3.0	11.68	16.44	444	582	26.05	28.24
4.5	13.99	17.19	543	580	25.84	29.58
6.0	13.55	13.57	507	482	26.74	27.99

Table 16: Trial 116, FFB Yield & Yield Components, Jan 1988 - Aug 1990.

A.C. Appl. Rate (kg/palm/yr)	FFB Yield (t/ha/yr)[1]		No. Bunches (No./ha/yr)[1]		Bunch Wgt. (kg/bunch)	
	87 Appl	Cont Appl	87 Appl	Cont Appl	87 Appl	Cont Appl
0.0	13.59	15.20	570	627	23.94	24.33
1.5	14.24	16.77	564	638	25.25	26.43
3.0	15.68	18.85	640	690	24.25	27.31
4.5	16.99	19.37	687	696	24.74	27.84
6.0	18.31	18.14	706	661	25.92	27.38

The '1987 only' ammonium chloride treatments now show little evidence of a rate response in 1990. In this trial therefore the FFB yield benefit of applying ammonium chloride had disappeared about 2 years after cessation of the ammonium chloride applications.

The continuous ammonium chloride application continues to produce a marked rate response.

[1] The Jan-Aug 1990 component was transformed to approximate 12 months production.

Figure 17: Trial 116, FFB Yield Response, Jan-Dec 1990.

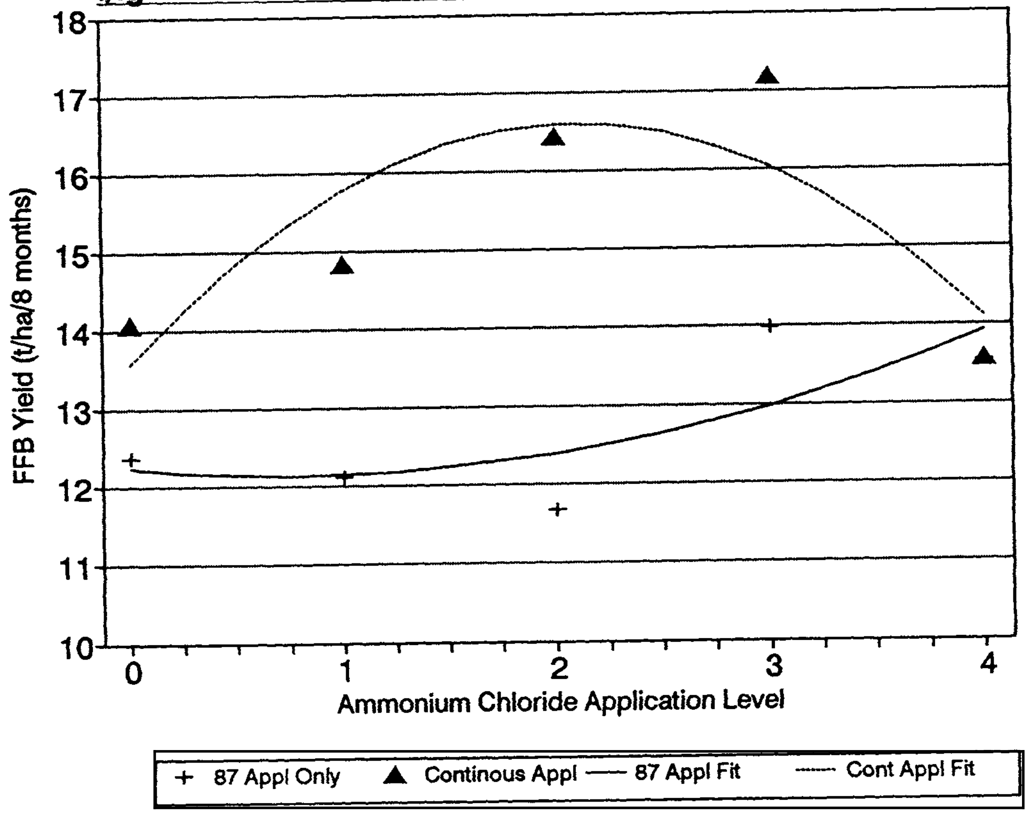


Figure 18: Trial 116, Bunch Number Response, Jan-Aug 1990.

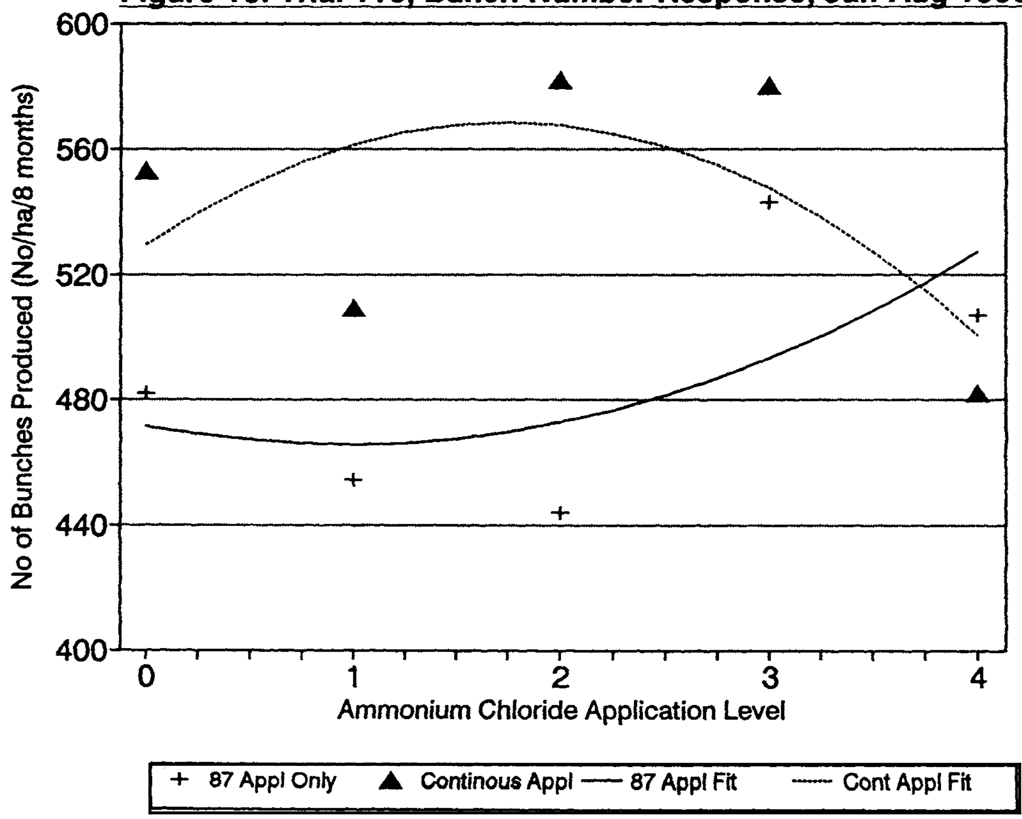


Figure 19: Trial 116, Bunch Weight Response, Jan-Aug 1990.

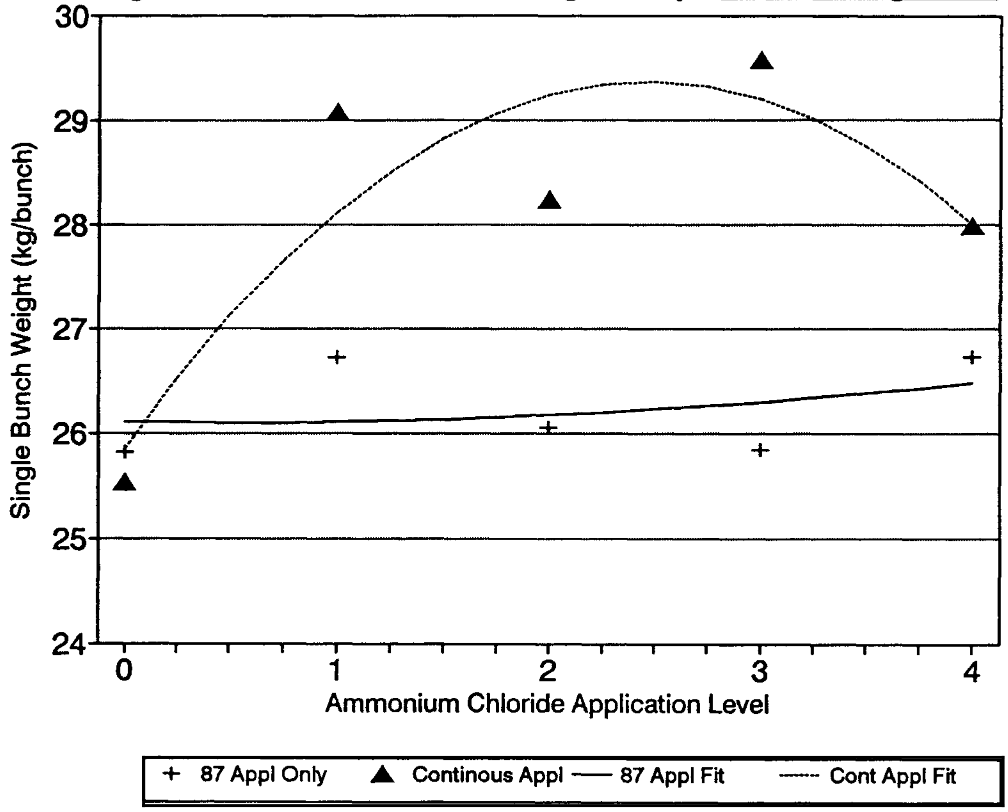


Figure 20: Trial 116, FFB Yield Response, Jan88-Aug90.

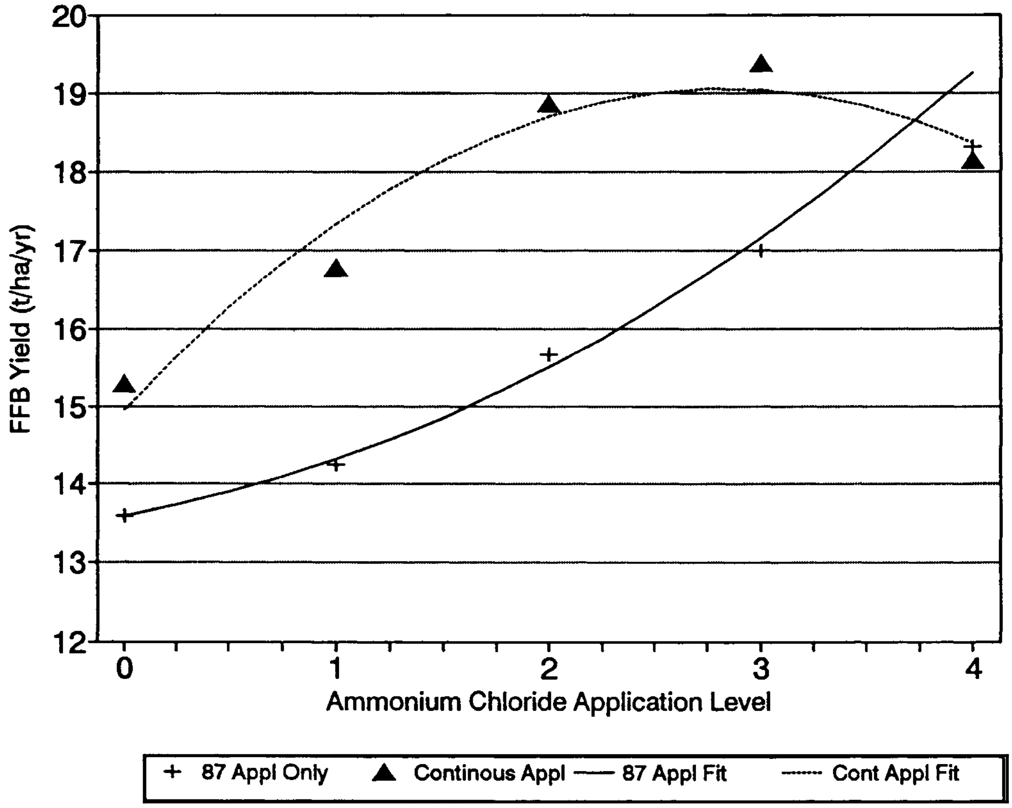


Figure 21: Trial 116, Bunch Number Response, Jan88-Aug90.

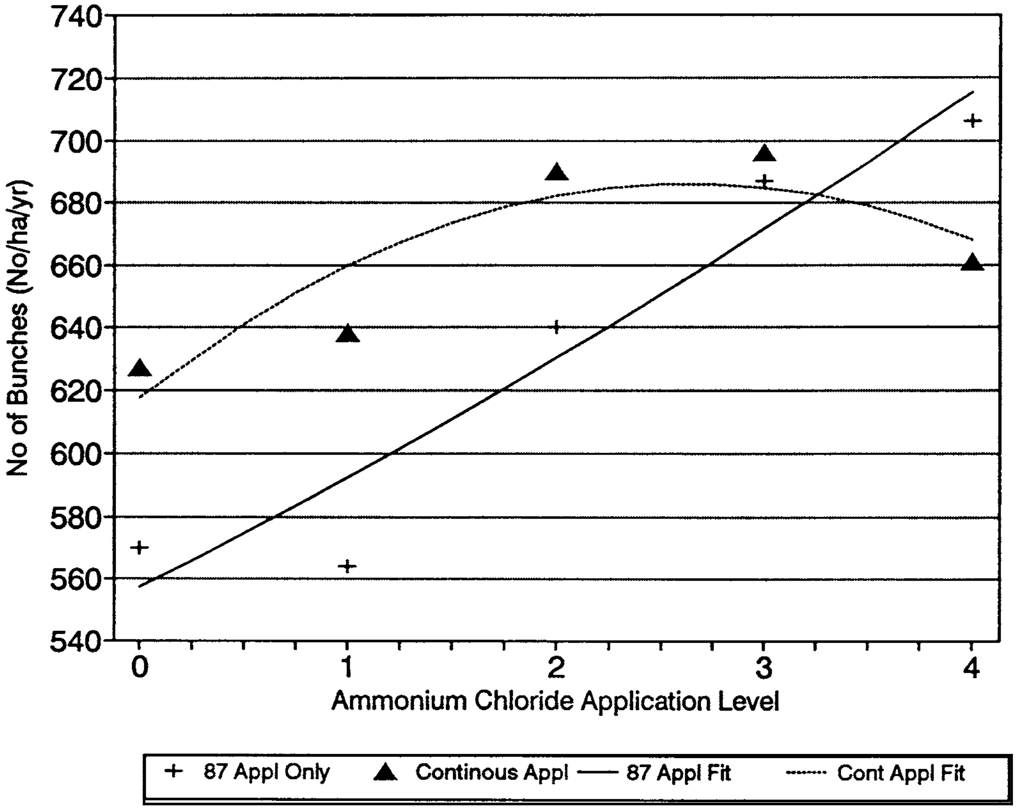
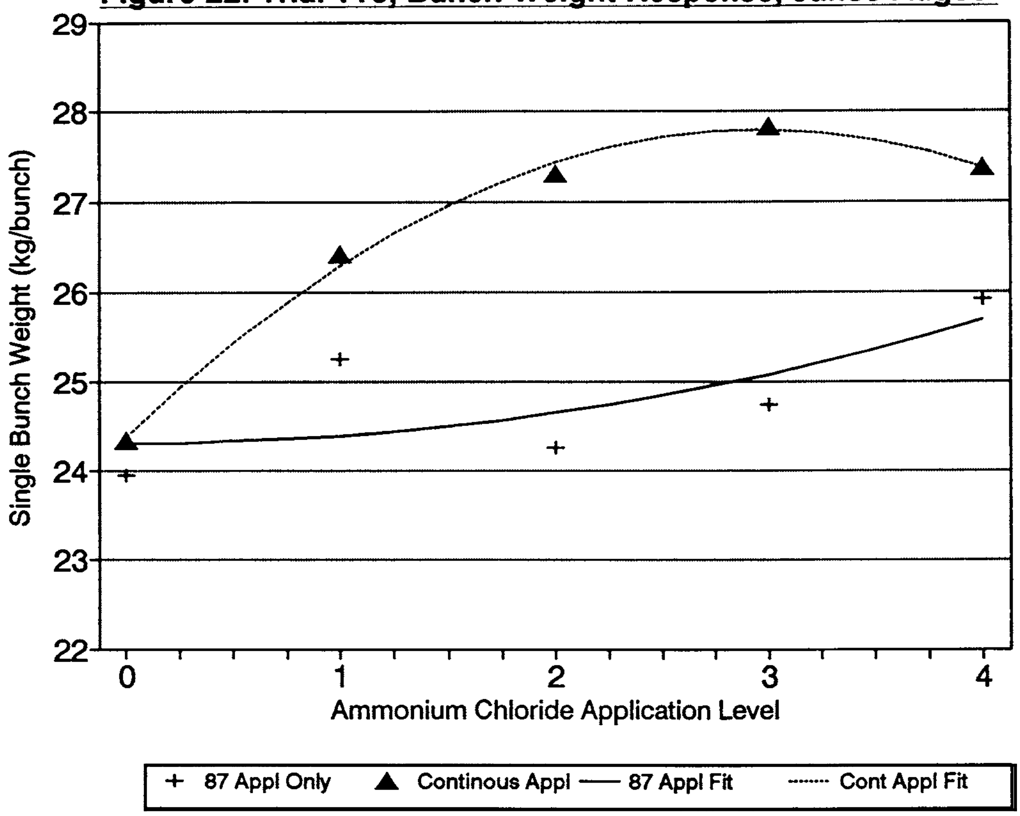


Figure 22: Trial 116, Bunch Weight Response, Jan88-Aug90.



In January 1990 frond 17 leaflet sampling and analysis was carried out. The results of the tissue analysis are presented in Table 17.

Table 17: Trial 116, Frond 17 Leaflet Tissue Analysis, January 1990.

A.C. Appl. Rate (kg/palm/yr)	Frond 17 Leaflet Nutrient Levels (calculated on dry matter basis)											
	% Nitrogen		% Phosphorus		% Potassium		% Calcium		% Magnesium		% Chlorine	
	1987 Appl	Cont Appl	1987 Appl	Cont Appl	1987 Appl	Cont Appl	1987 Appl	Cont Appl	1987 Appl	Cont Appl	1987 Appl	Cont Appl
0.0	2.192	2.225	0.151	0.153	0.762	0.778	0.858	0.849	0.189	0.179	0.316	0.338
1.5	2.175	2.325	0.149	0.155	0.735	0.765	0.825	0.845	0.173	0.175	0.378	0.428
3.0	2.125	2.300	0.146	0.160	0.665	0.703	0.923	0.900	0.188	0.175	0.390	0.518
4.5	2.025	2.350	0.150	0.158	0.695	0.728	0.898	0.893	0.178	0.178	0.413	0.543
6.0	1.975	2.375	0.152	0.157	0.690	0.725	0.860	0.910	0.175	0.180	0.410	0.528

The continuous ammonium chloride application increases frond 17 leaflet nitrogen level. Comparing the rise in leaflet nitrogen level with the rise in FFB yield, a 0.1% increase in frond 17 leaflet nitrogen level corresponds to a 2.6 t FFB/ha/yr increase in yield. This rise in FFB yield with rise in leaflet nitrogen level is at a level that would be expected and is similar to that observed in the diammonium phosphate treatments of trial 108. In the 1987 only ammonium chloride application, the old nitrogen applications seem to have induced a reduction in leaflet nitrogen levels in 1990.

The ammonium chloride applications seem to have had little effect in leaflet phosphorus levels.

Both the continuous and 1987 only ammonium chloride treatments appear to have depressed leaflet potassium levels slightly.

The ammonium chloride treatments, particularly the continuous application, has increased leaflet calcium levels.

The ammonium chloride treatments have had little effect on leaflet magnesium levels.

Both continuous and 1987 only ammonium chloride treatments have increased leaflet chlorine levels as expected. The single years application of ammonium chloride in 1987 has produced a significantly elevated leaflet chlorine level 4 years later in 1990. This indicates that chlorine leaflet levels will be well maintained several years after elevation of chlorine levels by application of chlorine containing fertilizer.

TRIAL 117, SYSTEMATIC NITROGEN FERTILIZER TRIAL, KUMBANGO PLANTATION.

PURPOSE:

To provide fertilizer response information that will be useful in developing recommendations concerning fertilizer usage.

SITE DETAILS:

LOCATION; Kumbango Plantation, Fields D8 and D9.

GENETIC MATERIAL; Dami commercial DxP crosses.

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

PLANTING DATE; 1975.

PLANTING DENSITY; 120 palms/ha.

DESIGN AND TREATMENTS:

DESIGN;

Two sources of nitrogen are compared in a systematically increasing level of application rate. Treatments are replicated four times. A systematic set of application rates for a nitrogen source abuts a second set with it rates increasing in the opposite direction. There is a total of 56 plots, each plot consisting of the two rows of palms on either side of a harvesting path (twin row) and containing about 35 palms. There are now guard rows between different treatment application rates.

TREATMENTS;

Fertilizer application rates are as follows;

LEVEL	0	0	0	1	2	3	4
TREATMENT	kg Fertilizer/palm/year						
Ammonium chloride	0.0	0.0	0.0	1.5	3.0	4.5	6.0
Urea	0.0	0.0	0.0	0.85	1.7	2.55	3.4

For a given application level, both sources supply the same quantity of nitrogen.

Annual fertilizer application rates are split into 2 applications per year.

Fertilizer application commenced in April 1987.

RESULTS:

FFB yield and yield component data for Jan to Dec 1990 and Jan 1988 to Dec 1990 are presented in Tables 18 and 19 respectively. The data in these tables together with fitted quadratic regression models are illustrated in Figures 23 to 28.

Table 18: Trial 117, FFB Yield & Yield Components, Jan-Dec 1990.

A.C. Appl. Rate (kg/palm/yr)	FFB Yield (t/ha/yr)		No. Bunches (No./ha/yr)		Bunch Wgt. (kg/bunch)	
	A.C.	UREA	A.C.	UREA	A.C.	UREA
0.0	21.49	20.94	886	896	24.26	23.60
1.5	21.72	21.02	870	876	24.97	24.10
3.0	24.98	22.79	963	966	25.91	23.63
4.5	24.38	21.86	950	972	25.73	22.48
6.0	26.02	22.96	994	963	26.29	23.80

Table 19: Trial 117, FFB Yield & Yield Components, Jan88-Dec90.

A.C. Appl. Rate (kg/palm/yr)	FFB Yield (t/ha/yr)		No. Bunches (No./ha/yr)		Bunch Wgt. (kg/bunch)	
	A.C.	UREA	A.C.	UREA	A.C.	UREA
0.0	20.10	20.09	850	865	23.74	23.45
1.5	21.21	20.86	859	875	24.68	23.90
3.0	22.31	20.74	898	903	24.89	23.01
4.5	23.79	21.03	930	930	25.67	22.64
6.0	23.27	21.05	918	898	25.45	23.43

The ammonium chloride treatments produce clear rate responses in terms of FFB yield through increases in both numbers of bunches produced and single bunch weight.

The Urea treatments have little effect on FFB yield. Although urea appears to increase the numbers of bunches produced, there is a corresponding reduction in single bunch weight.

Figure 23: Trial 117, FFB Yield Response, Jan-Dec 1990.

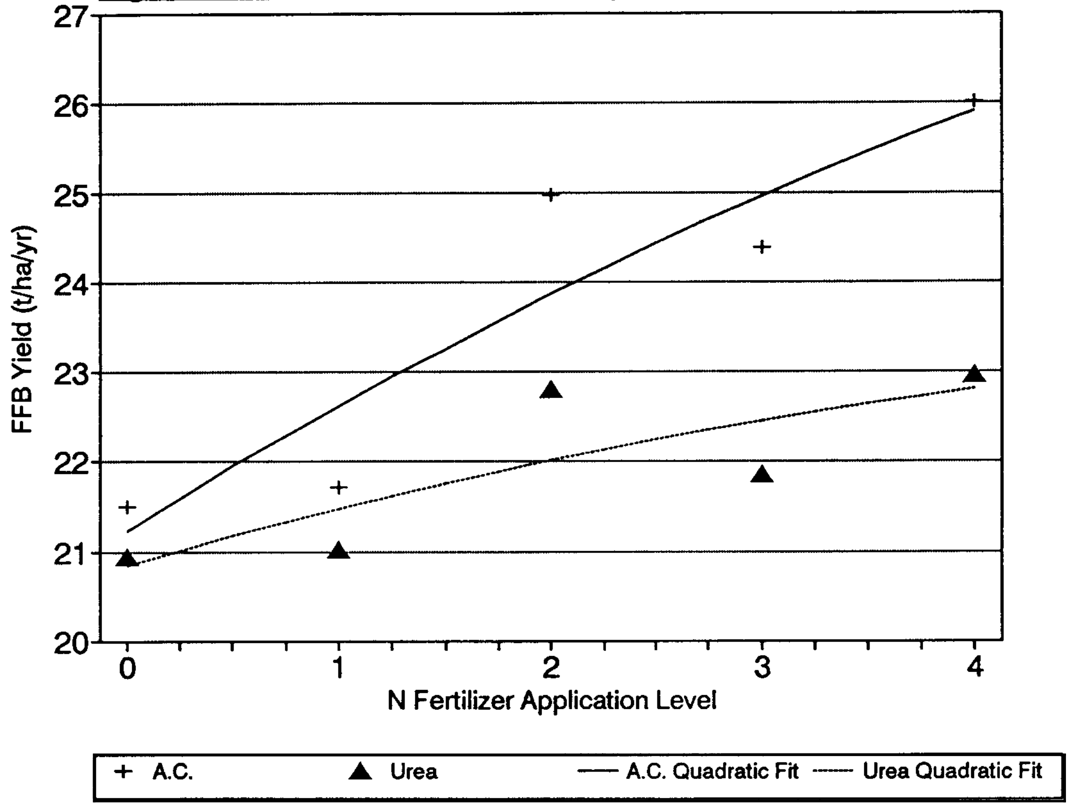


Figure 24: Trial 117, Bunch Number Response, Jan-Dec 1990.

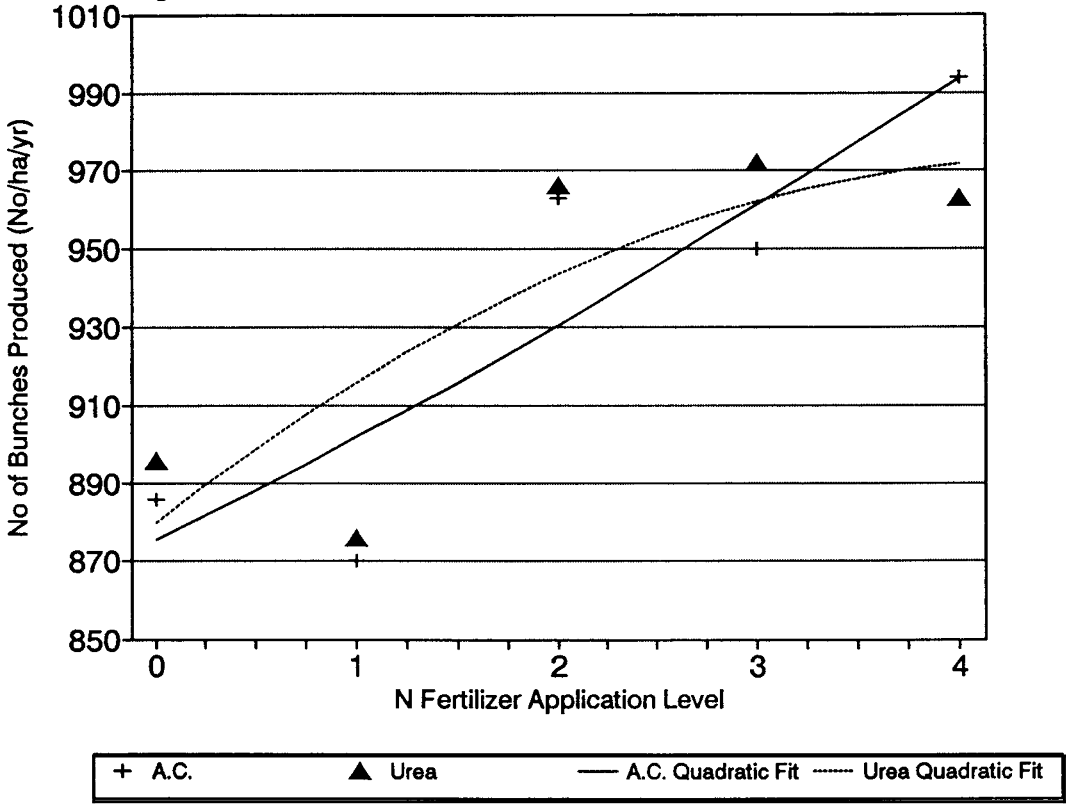


Figure 25: Trial 117, Bunch Weight Response, Jan-Dec 1990.

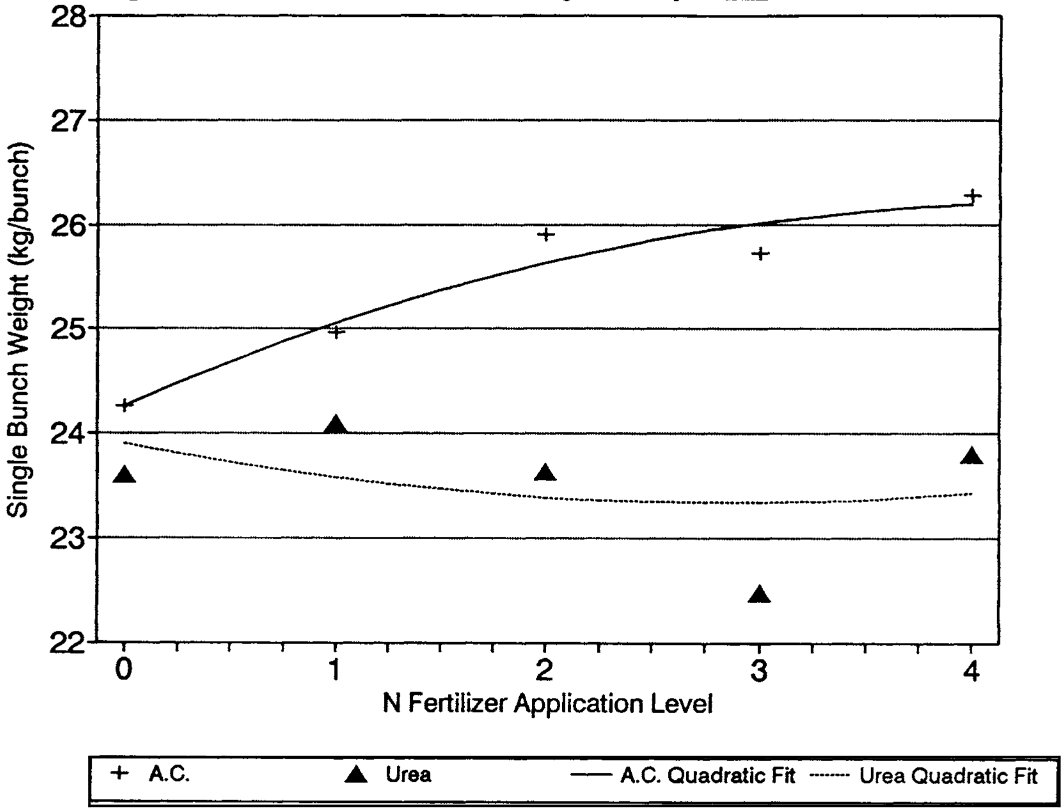


Figure 26: Trial 117, FFB Yield Response, Jan88-Dec90.

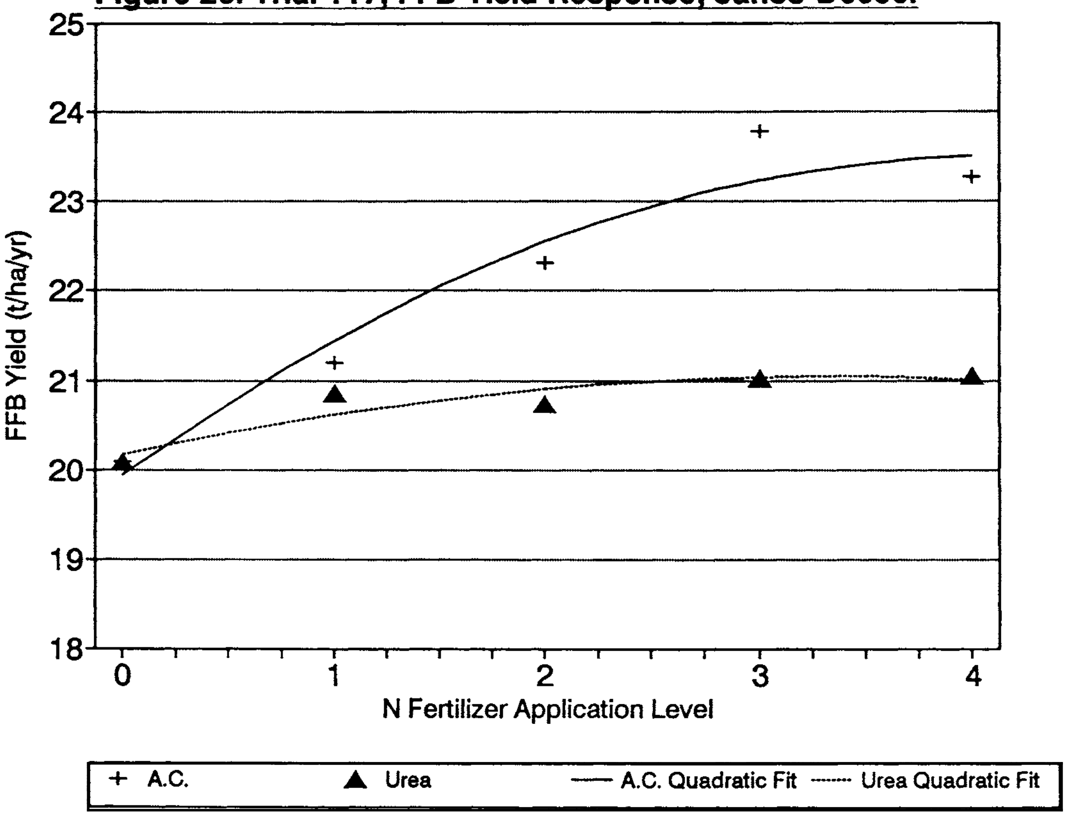


Figure 27: Trial 117, Bunch Number Response, Jan88-Dec90.

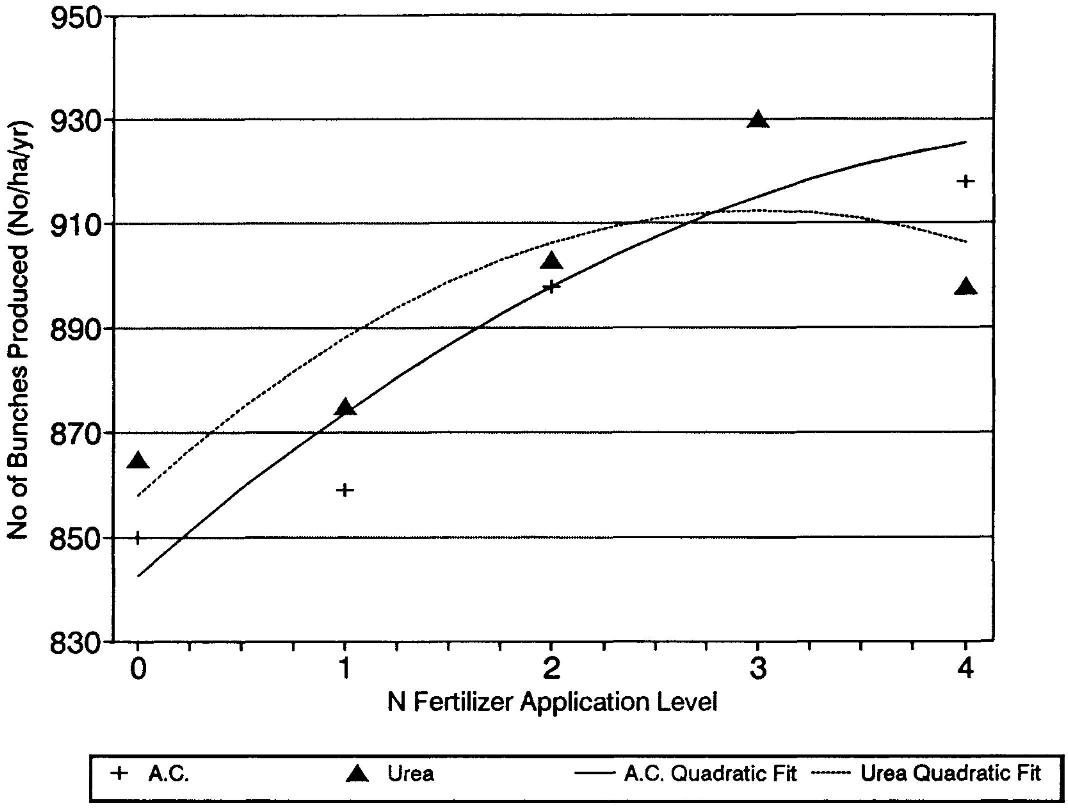
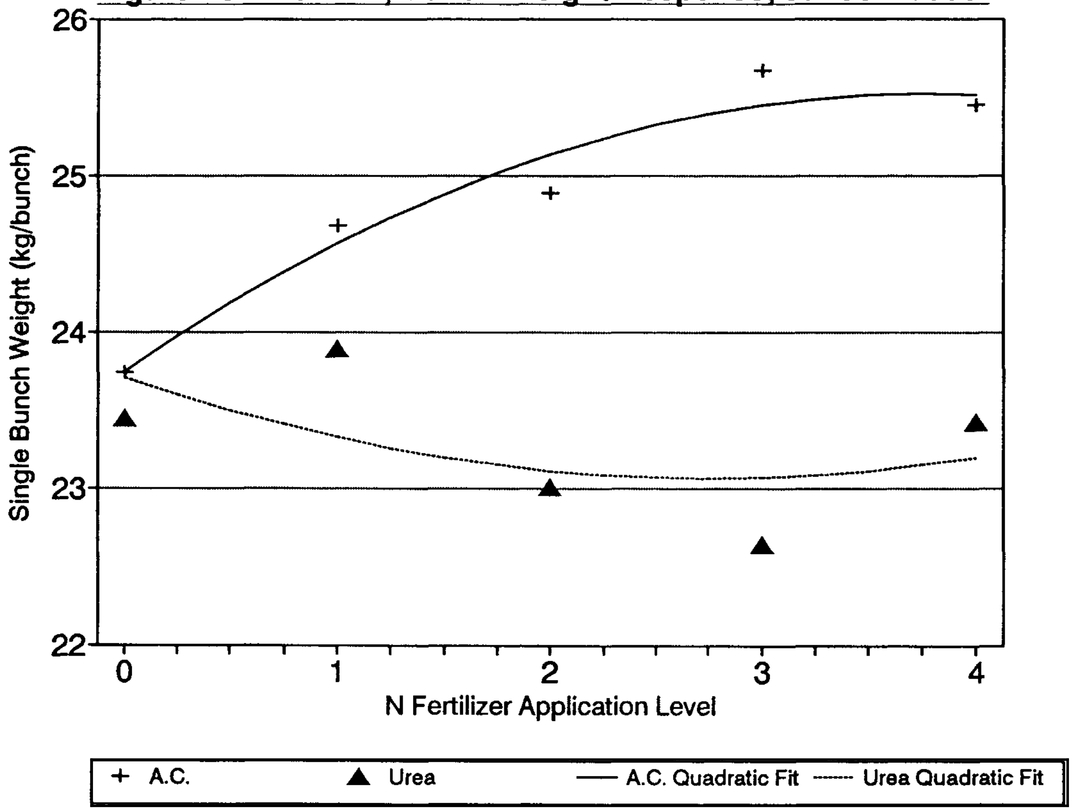


Figure 28: Trial 117, Bunch Weight Response, Jan88-Dec90.



Vegetative measurements were made in January 1990 at the same time that leaflet tissue sampling was being carried out. The estimated physiological parameters calculated from these measurements are presented in Table 20.

Table 20: Trial 117, Physiological Parameters, January 1990.

Fertilizer Application Level	Leaf Area Index		Fractional Energy Interception		Efficiency of Energy Conversion (g MJ^{-1})		Vegetative Dry Matter Production (t/ha/yr)		Bunch Dry Matter Production (t/ha/yr)		Bunch Index	
	A.C.	UREA	A.C.	UREA	A.C.	UREA	A.C.	UREA	A.C.	UREA	A.C.	UREA
0	6.120	6.135	0.888	0.888	1.239	1.147	15.59	13.57	17.62	17.17	0.529	0.557
1	6.193	6.070	0.892	0.887	1.273	1.163	16.45	13.90	17.81	17.24	0.522	0.554
2	6.715	5.985	0.910	0.884	1.370	1.199	17.16	13.30	20.49	18.69	0.547	0.586
3	6.495	5.660	0.902	0.869	1.413	1.193	18.49	13.40	20.00	17.92	0.521	0.572
4	6.305	6.407	0.896	0.899	1.474	1.205	18.55	13.89	21.33	18.83	0.536	0.575

Table 21: Trial 117, Frond 17 Leaflet Tissue Analysis, January 1990.

Fertilizer Application Level	Frond 17 Leaflet Nutrient Levels (expressed on a dry matter basis)											
	% Nitrogen		% Phosphorus		% Potassium		% Calcium		% Magnesium		% Chlorine	
	A.C.	UREA	A.C.	UREA	A.C.	UREA	A.C.	UREA	A.C.	UREA	A.C.	UREA
0	2.236	2.182	0.138	0.138	0.727	0.783	0.822	0.835	0.138	0.148	0.203	0.177
1	2.280	2.225	0.143	0.139	0.720	0.755	0.885	0.810	0.135	0.138	0.230	0.143
2	2.305	2.257	0.143	0.141	0.640	0.765	0.973	0.848	0.135	0.140	0.295	0.143
3	2.337	2.317	0.144	0.143	0.625	0.795	0.978	0.850	0.120	0.130	0.285	0.113
4	2.370	2.383	0.146	0.144	0.655	0.790	0.960	0.835	0.120	0.123	0.303	0.125

Increasing application levels of ammonium chloride increase the leaf area index and fractional energy interception, whilst in contrast the urea applications depress these parameters.

Both nitrogen sources increase the efficiency of energy conversion but ammonium chloride does so to a greater degree.

Ammonium chloride application increases both vegetative and bunch dry matter production with no effect on bunch index. The urea applications increase bunch dry matter production (though to a lesser degree than ammonium chloride) but don't affect vegetative dry matter production, the result being an increase in bunch index.

The results of the tissue analysis of the frond 17 leaflet samples collected in January 1990 are presented in Table 21.

Both nitrogen sources increase leaflet nitrogen levels. The urea is as efficient at increasing leaflet nitrogen levels as ammonium chloride. This is surprising as the FFB yield response to urea is inferior to that of ammonium chloride.

Both nitrogen sources increase the leaflet phosphorus levels.

The ammonium chloride applications have depressed the leaflet levels of potassium and magnesium and increased the calcium levels. The urea applications have depressed the leaflet magnesium levels but had little affect on calcium or potassium levels.

As expected ammonium chloride applications have increased the leaflet chlorine levels, whilst on the other hand urea applications have depressed leaflet chlorine. The effects of urea on cation status do not explain the poorer performance of urea compared to ammonium chloride. It appears likely that the much lower levels of chlorine are the reason for the poorer performance of urea.

TRIAL 118, SYSTEMATIC NITROGEN FERTILIZER TRIAL, KUMBANGO PLANTATION.

PURPOSE:

To provide fertilizer response information that will be useful in developing recommendations concerning fertilizer usage.

SITE DETAILS:

LOCATION; Kumbango Plantation, Field B9.

GENETIC MATERIAL; Dami commercial DxP crosses.

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

PLANTING DATE; 1977.

PLANTING DENSITY; 120 palms/ha.

DESIGN AND TREATMENTS:

DESIGN;

This experiment comprises a systematic design of 4 replicates of 7 treatments (5 treatment rates). Each replicate contains 5 treatment rates of ammonium chloride increasing systematically in one direction. This dose rate gradient in one replicate abuts a second replicate with the dose rate gradient in the opposite direction. There is a total of 28 plots, each plot consisting of the two rows of palms on either side of a harvesting path (twin-row) and containing about 33 palms. There are no guard rows between different treatment application rates.

TREATMENTS;

Fertilizer application rates are as follows;

LEVEL	0	0	0	1	2	3	4
FERTILIZER	kg fertilizer/palm/year						
Ammonium chloride	0.0	0.0	0.0	1.5	3.0	4.5	6.0

Annual fertilizer application rates are split into 2 applications per year.

Fertilizer applications commenced in April 1987.

RESULTS:

FFB yield and yield component data for January to December 1990 and January 1988 to December 1990 are presented in Tables 22 and 23 respectively. The data in these tables together with fitted quadratic regression models are illustrated in Figures 29 to 34.

Table 22: Trial 118, FFB Yield & Yield Components, Jan-Dec 1990.

A.C. Appl. Rate (kg/palm/yr)	FFB Yield (t/ha/yr)	No. Bunches (No./ha/yr)	Bunch Weight (kg/bunch)
0.0	25.45	1115	22.83
1.5	27.18	1115	24.39
3.0	28.39	1170	24.27
4.5	25.70	1034	24.85
6.0	27.03	1089	24.87

Table 23: Trial 118, FFB Yield & Yield Components, Jan88-Dec90.

A.C. Appl. Rate (kg/palm/yr)	FFB Yield (t/ha/yr)	No. Bunches (No./ha/yr)	Bunch Weight (kg/bunch)
0.0	23.73	1076	22.07
1.5	24.81	1073	23.14
3.0	25.69	1118	23.00
4.5	25.43	1087	23.41
6.0	25.18	1109	22.76

Despite the relatively high FFB yields in this trial, the ammonium chloride application is producing a significant rate response. In 1990 however the FFB yield at the higher rates has been depressed due to large drop in the number of bunches produced.

Figure 29: Trial 118, FFB Yield Response, Jan-Dec 1990.

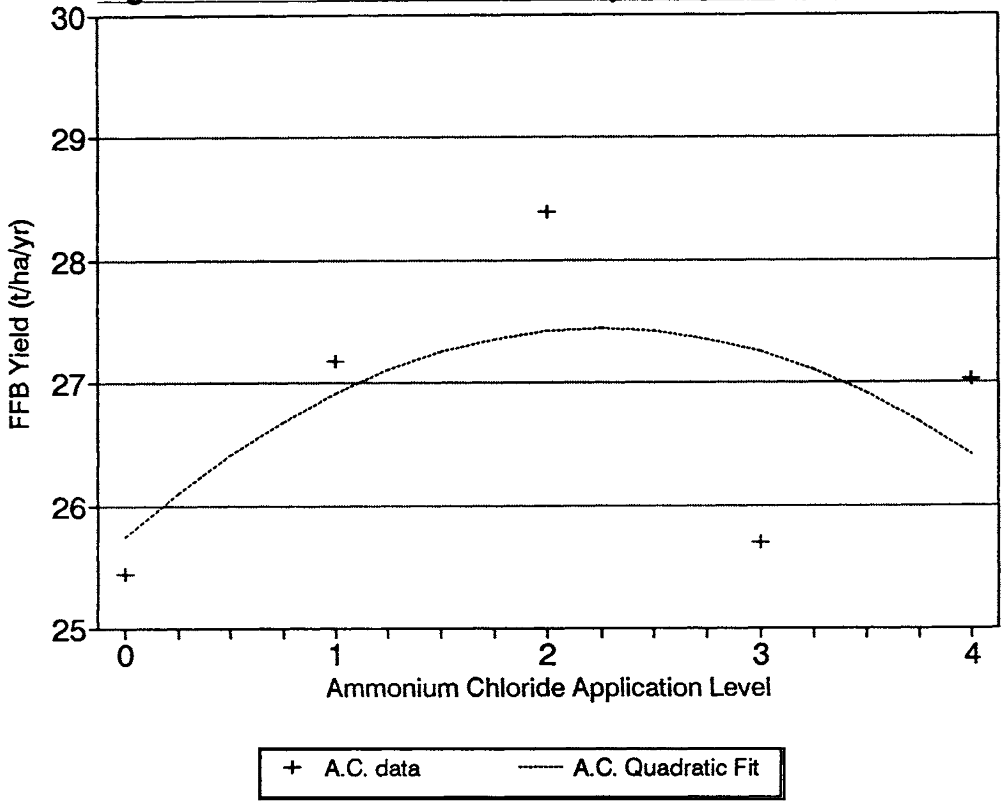


Figure 30: Trial 118, Bunch Number Response, Jan-Dec 1990.

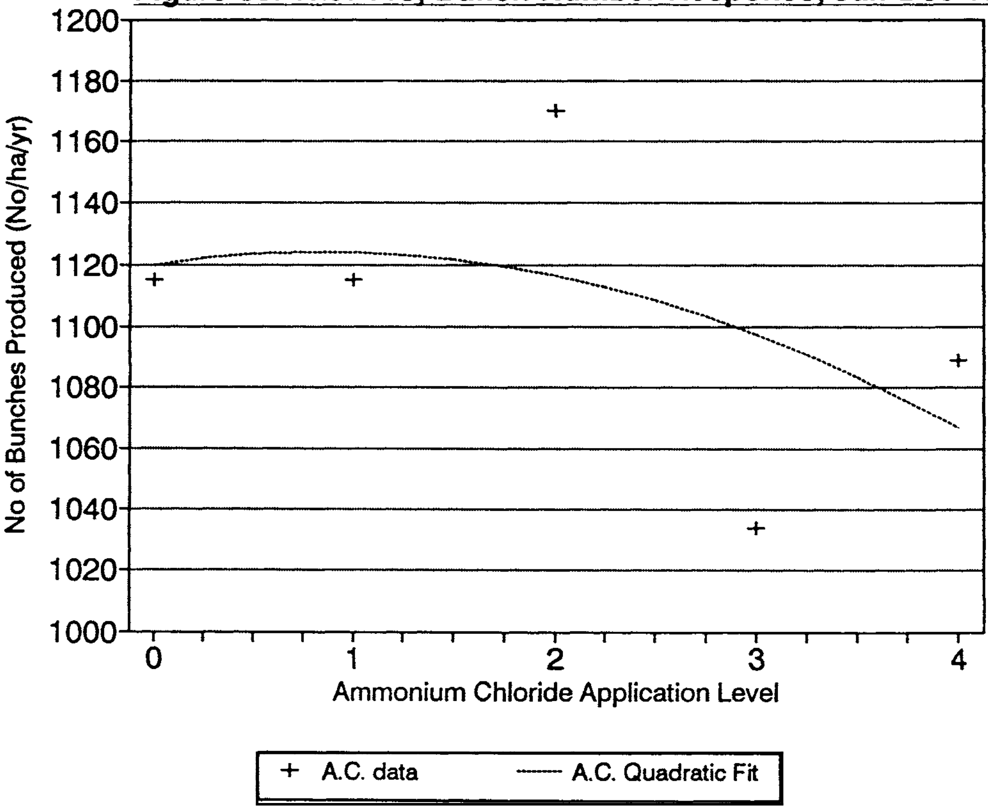


Figure 31: Trial 118, Bunch Weight Response, Jan-Dec 1990.

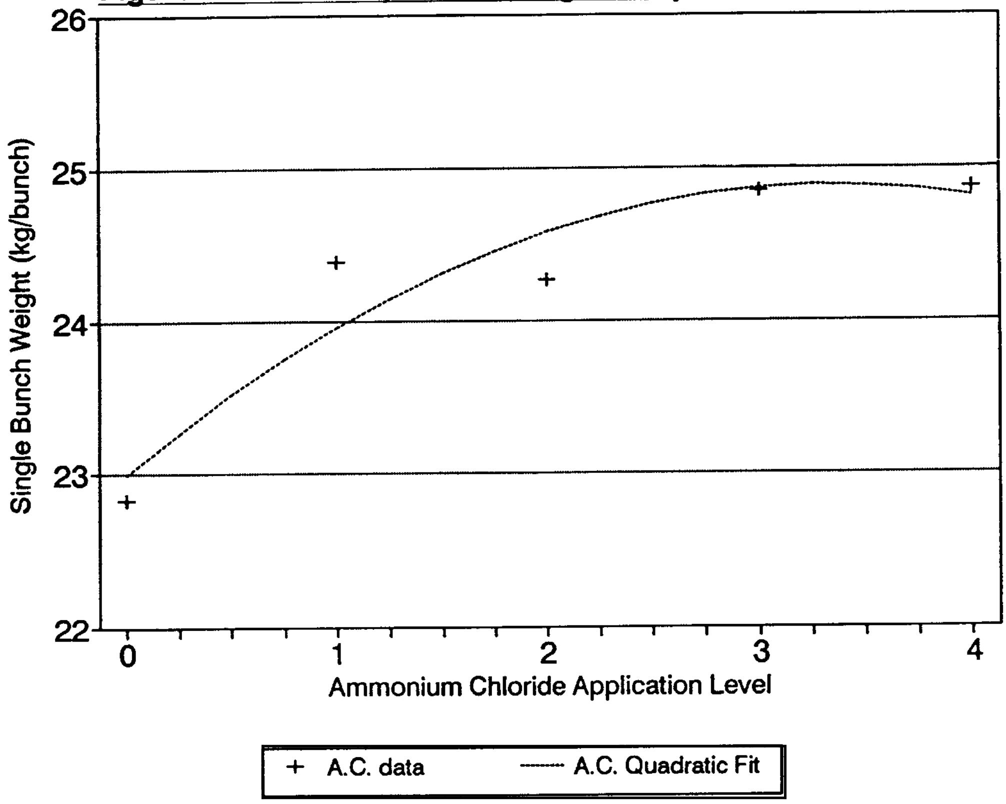


Figure 32: Trial 118, FFB Yield Response, Jan88-Dec90.

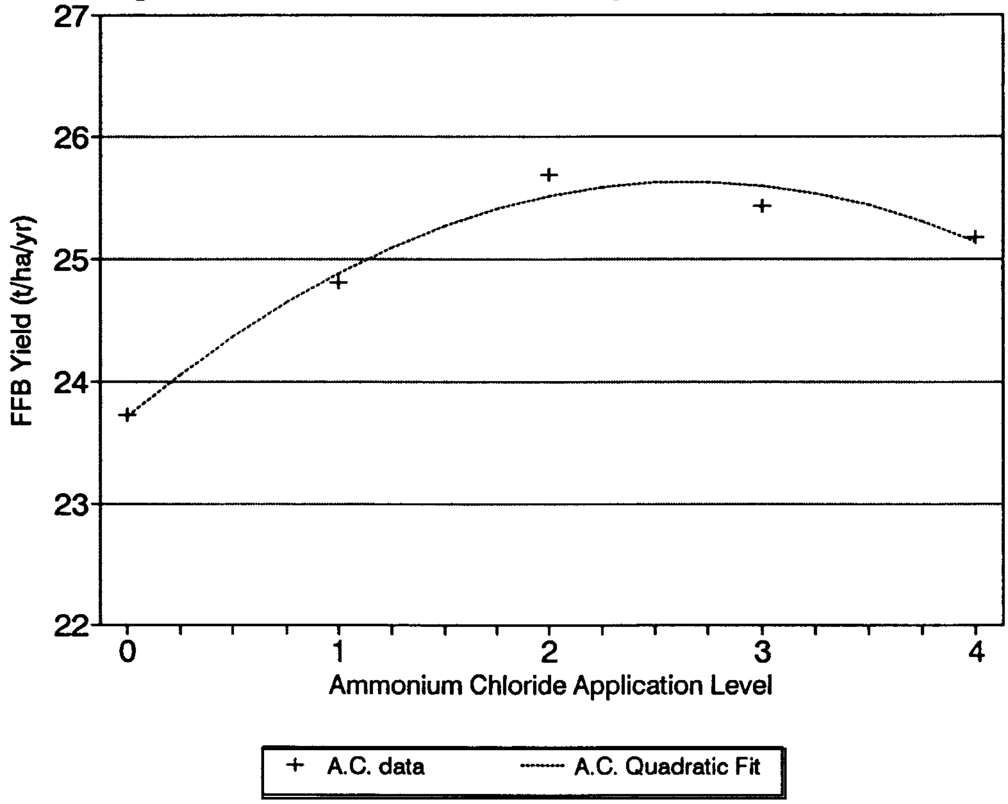


Figure 33: Trial 118, Bunch Number Response, Jan88-Dec90.

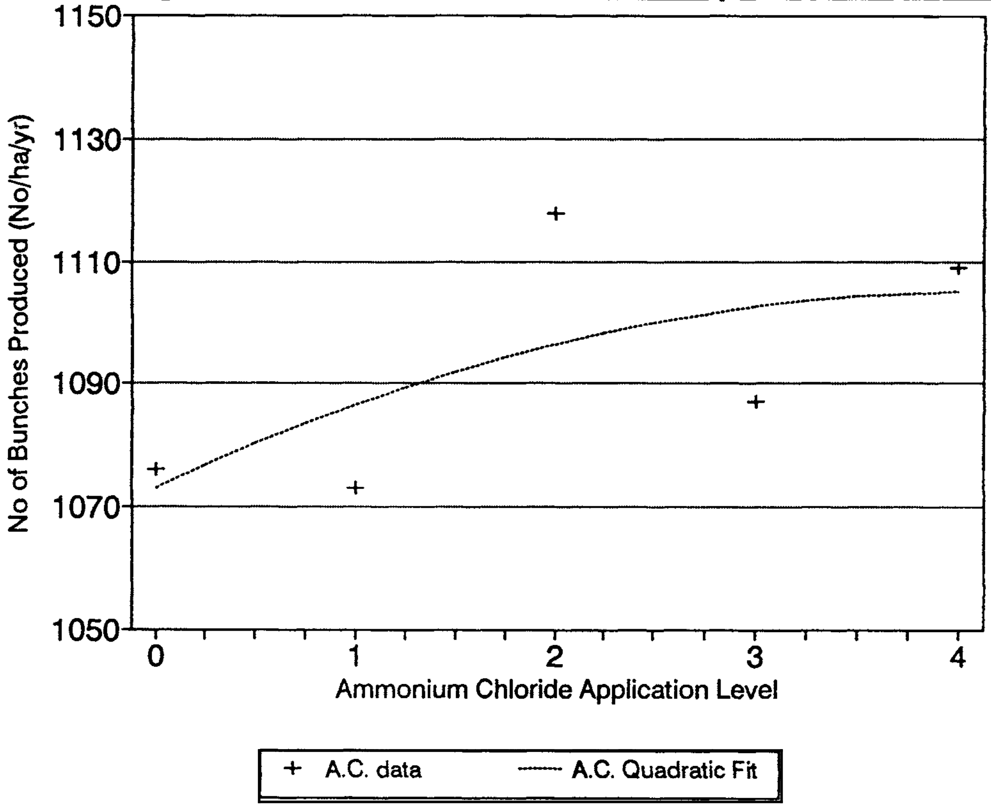
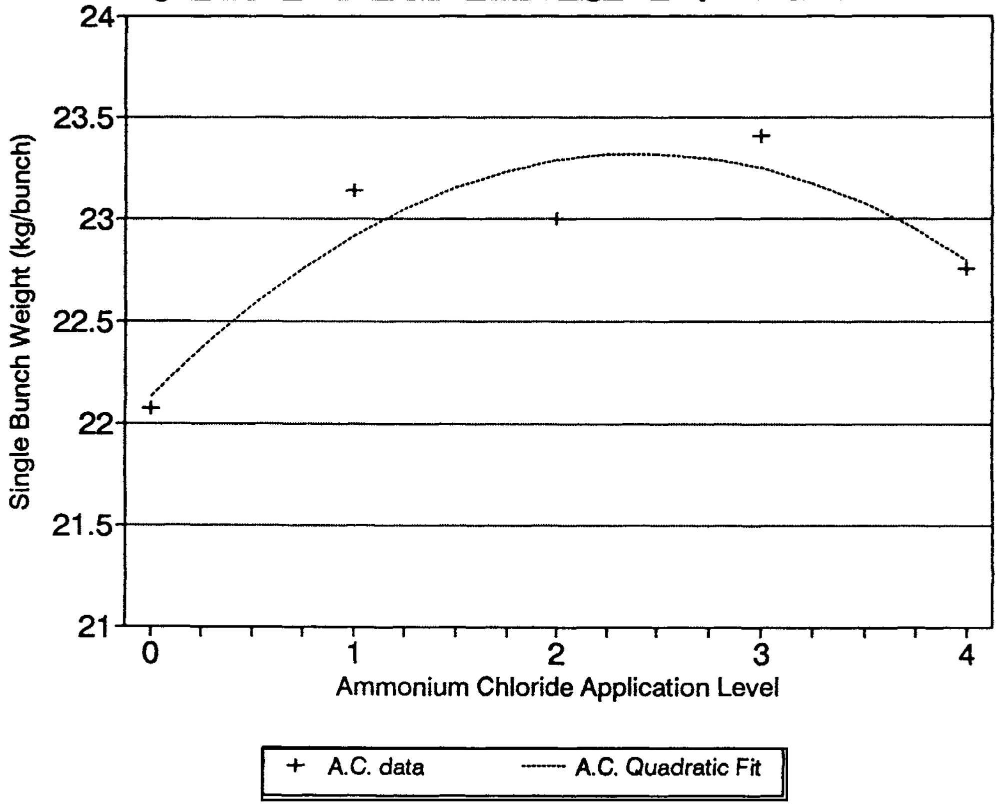


Figure 34: Trial 118, Bunch Weight Response, Jan88-Dec90.



TRIAL 119, NITROGEN/ANION FERTILIZER TRIAL, MALILIMI PLANTATION.

PURPOSE:

To investigate the response of Oil Palm to the application of various combinations of inorganic fertilizer with a view to providing information that will be useful in developing fertilizer recommendations.

SITE DETAILS:

LOCATION; Malilimi Plantation, Fields A7 and A8.

GENETIC MATERIAL; Dami commercial DxP crosses.

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

PLANTING DATE; October 1985.

PLANTING DENSITY; 135 palms/ha.

DESIGN AND TREATMENTS:

DESIGN;

This trial consists of 12 treatments replicated in 4 completely randomized blocks. There are 36 palms per plot, the central 16 being recorded.

TREATMENTS;

	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)

Treatment numbers are in brackets.

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:

FFB yield and yield component data for January to December 1990 are presented in Table 24.

Frond 17 leaflet sampling and analysis was carried out in November 1990. The results of the tissue analysis are presented in Table 25.

Table 24: Trial 119, FFB Yield & Yield Components, Jan-Dec 1990.

Treatment Number	Nutrients Applied	FFB Yield (t/ha/yr)	No. Bunches (No./ha/yr)	Bunch Wgt. (kg/bunch)
1	NIL	24.49	2682	9.14
2	N+P	23.09	2587	8.93
3	N+S	23.05	2601	8.83
4	N+Cl	24.76	2580	9.67
5	K+Cl	25.67	2689	9.56
6	N+P+K+Cl	27.60	2789	9.90
7	N+S+K+Cl	26.01	2695	9.68
8	N+Cl+K	24.41	2418	10.08
9	Mg+S	21.03	2152	9.61
10	N+P+Mg+S	26.56	2724	9.79
11	N+S+Mg	22.48	2435	9.30
12	N+Cl+Mg+S	25.58	2578	9.96
%cv		13.5	12.8	6.9
$LSD_{.05}$		4.78	476	0.95

The FFB yield data represents one years production only, therefore interpretation of the results must be made with caution. None of the fertilizer treatments significantly affected FFB yield. The presence of the individual nutrient elements, chlorine and potassium, appears to have slightly increased the FFB yield from almost 23 to 26 t/ha/yr and 24 to 26 t/ha/yr respectively. The presence of potassium, magnesium and chlorine have each increased the single bunch weights.

Table 25: Trial 119, Frond 17 Leaflet Tissue Analysis, November 1990.

Treatment Number	Nutrients Applied	Leaflet 17 Nutrient Levels (%D.M.)					
		N	P	K	Ca	Mg	Cl
1	NIL	2.68	0.166	1.10	0.858	0.193	0.148
2	N+P	2.70	0.170	1.10	0.888	0.220	0.128
3	N+S	2.68	0.163	1.09	0.885	0.208	0.140
4	N+Cl	2.68	0.164	0.94	0.920	0.195	0.413
5	K+Cl	2.74	0.164	1.01	0.978	0.215	0.403
6	N+P+K+Cl	2.71	0.167	1.00	0.950	0.180	0.410
7	N+S+K+Cl	2.71	0.162	0.97	0.933	0.210	0.393
8	N+Cl+K	2.73	0.168	0.98	0.995	0.190	0.480
9	Mg+S	2.64	0.162	1.05	0.905	0.225	0.153
10	N+P+Mg+S	2.74	0.171	1.10	0.880	0.210	0.195
11	N+S+Mg	2.72	0.162	1.06	0.913	0.195	0.235
12	N+Cl+Mg+S	2.66	0.164	0.97	0.910	0.230	0.410
%cv		2.1	1.6	6.8	6.3	10.6	21.1
$LSD_{.05}$		0.08	0.004	0.10	0.083	0.032	0.089

The chloride containing fertilizers have significantly ($p<0.001$) increased the chlorine levels in the leaflet from 0.166% to 0.418% overall. The phosphate levels in leaflet tissue have also increased significantly ($p<0.001$) from 0.164% to 0.17% with application of phosphate containing fertilizer. Potassium levels in the leaflet significantly decreased ($p=0.009$) from 1.09% to 0.94% with application of potassium containing fertilizer.

TRIAL 120, NITROGEN/ANION FERTILIZER TRIAL, DAMI PLANTATION.

PURPOSE:

To investigate the response of Oil Palm to the application of various combinations of inorganic fertilizer with a view to providing information that will be useful in developing fertilizer recommendations.

SITE DETAILS:

LOCATION; Dami Plantation, Field 9.

GENETIC MATERIAL; Dami commercial DxP crosses.

SOIL DESCRIPTION; Young very coarse textured freely draining soils formed on alluvially reworked andesitic pumiceous sands and gravel.

PLANTING DATE; 1983.

PLANTING DENSITY; 135 palms/ha.

DESIGN AND TREATMENTS:

DESIGN;

This trial consists of 12 treatments replicated in 4 completely randomized blocks. There are 25 palms per plot, the central 9 being recorded.

TREATMENTS;

	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)

Treatment numbers are in brackets.

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:

FFB yield and yield component data for January to December 1990 are presented in Table 26.

Frond 17 leaflet sampling and analysis was carried out in October/November 1990. The results of the tissue analysis are presented in Table 27.

Table 26: Trial 120, FFB Yield & Yield Components, Jan-Dec 1990.

Treatment Number	Nutrients Applied	FFB Yield (t/ha/yr)	No. Bunches (No./ha/yr)	Bunch Wgt. (kg/bunch)
1	NIL	31.11	2224	13.95
2	N+P	33.60	2370	14.27
3	N+S	31.60	2213	14.28
4	N+Cl	34.62	2381	14.58
5	K+Cl	34.27	2528	13.69
6	N+P+K+Cl	36.09	2445	14.75
7	N+S+K+Cl	35.74	2610	13.66
8	N+Cl+K	38.70	2674	14.48
9	Mg+S	38.45	2569	15.04
10	N+P+Mg+S	31.72	2374	13.40
11	N+S+Mg	37.90	2614	14.49
12	N+Cl+Mg+S	38.30	2486	15.46
%cv		9.0	7.9	8.4
$LSD_{.05}$		4.55	280	1.73

The FFB production data represents one years results only, any conclusions drawn from this data must be made with caution. The fertilizer treatments overall have significantly increased ($p=0.005$) FFB production. Comparing individual nutrient elements applied, Mg and Cl have significantly increased the yields from 34 to almost 36 t/ha/yr. There were slight increases in the FFB production observed for N, K and S additions but these are not statistically significant. Mg and K nutrient applications seem to have increased the number of bunches produced.

Table 27: Trial 120, Frond 17 Leaflet Tissue Analysis, October 1990.

Treatment Number	Nutrients Applied	Leaflet 17 Nutrient Levels (%D.M.)					
		N	P	K	Ca	Mg	Cl
1	NIL	2.47	0.153	0.860	0.805	0.153	0.263
2	N+P	2.52	0.153	0.775	0.813	0.140	0.295
3	N+S	2.46	0.146	0.870	0.785	0.130	0.325
4	N+Cl	2.49	0.152	0.830	0.845	0.140	0.383
5	K+Cl	2.47	0.152	0.820	0.868	0.148	0.405
6	N+P+K+Cl	2.48	0.150	0.800	0.815	0.140	0.395
7	N+S+K+Cl	2.48	0.148	0.830	0.753	0.120	0.388
8	N+Cl+K	2.48	0.150	0.790	0.810	0.138	0.423
9	Mg+S	2.46	0.150	0.860	0.805	0.140	0.320
10	N+P+Mg+S	2.60	0.155	0.860	0.748	0.138	0.310
11	N+S+Mg	2.49	0.145	0.850	0.698	0.118	0.315
12	N+Cl+Mg+S	2.51	0.152	0.825	0.825	0.140	0.370
%cv		2.4	2.5	7.4	8.4	13.0	13.0
$LSD_{.05}$		0.09	0.005	0.089	0.097	0.026	0.065

The application of chloride containing fertilizers has increased significantly ($p=0.001$) the chlorine levels in the leaflet tissue from 0.26% to 0.42%. The increase in the chlorine levels seems to have been accompanied by an increase in the calcium levels and depression of the K levels.

TRIAL 201, FACTORIAL FERTILIZER TRIAL, HARGY PLANTATION.

PURPOSE:

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

SITE DETAILS:

LOCATION; Hargy Plantation, Blocks 4,6 and 8.

GENETIC MATERIAL; I.R.H.O. commercial DxP crosses.

SOIL DESCRIPTION; Freely draining Andosols formed on intermediate to basic volcanic ash.

PLANTING DATE; 1973.

PLANTING DENSITY; 115 palms/ha.

DESIGN AND TREATMENTS:

DESIGN;

The trial consists of one replicate of a 3^4 factorial design. The 81 plots are divided into 3 blocks of 27 plots each. Each plot consists of 36 palms, the central 16 of which are recorded.

TREATMENTS;

Treatment application was initiated in June 1982, the rates are as follows;

LEVEL	0	1	2
FERTILIZER	kg fertilizer/palm/year		
Sulphate of Ammonia	0.0	1.0	2.0
Triple Superphosphate	0.0	0.8	1.6
Muriate of Potash	0.0	1.0	2.0
Kieserite	0.0	1.0	2.0

Fertilizers is applied twice yearly. Previous to October 1986, potassium was applied as bunch ash at rates of 0.0, 1.5 and 3.0 kg $palm^{-1}$ $year^{-1}$

In 1991 the fertilizer application rates in Trial 201 will be increased as follows;

LEVEL	0	1	2
FERTILIZER	kg fertilizer/palm/year		
Sulphate of Ammonia	0.0	3.0	6.0
Triple Superphosphate	0.0	2.0	4.0
Muriate of Potash	0.0	1.5	3.0
Kieserite	0.0	1.5	3.0

RESULTS:

FFB yield and yield component data for Jan-Dec 1990 and Jan 1988 to Dec 1990 are presented in Tables 28 and 29 respectively.

Table 28: Trial 201, FFB Yield & Yield Component Data, Jan-Dec 1990.

Main Effects	FFB Yield (t/ha/yr)	No. Bunches (No./ha/yr)	Bunch Wgt. (kg/bunch)
N_0	**18.11**	831	21.92
N_1	**19.36**	864	22.43
N_2	**20.72**	919	22.49
P_0	**17.97**	817	22.02
P_1	**19.71**	887	22.27
P_2	**20.50**	910	22.55
K_0	18.70	851	21.93
K_1	19.46	869	22.44
K_2	20.02	894	22.47
Mg_0	19.26	849	22.67
Mg_1	19.09	866	22.10
Mg_2	19.82	900	22.07
%cv	21.3	21.2	7.7
$LSD_{.05}$	2.39	107	0.99

Triple Superphosphate application has produced a significant (Jan-Dec 1990; p=0.039 [linear response component], Jan88-Dec90; p=0.005 [linear response component]) increase in FFB yield. This increase in FFB yield is due to increases in both numbers of bunches produced and single bunch weight. The increases in numbers of bunches and single bunch weight are statistically significant in the 1988 to 1990 data (NB p=0.035 [linear response component], SBW p=0.032 [linear response component]).

The ammonium sulphate application also increases FFB yield, this increase is statistically significant in the 1990 data (p=0.034 [linear response component])

Table 29: Trial 201, FFB Yield & Yield Component Data, Jan88-Dec90.

Main Effects	FFB Yield (t/ha/yr)	No. Bunches (No./ha/yr)	Bunch Wgt. (kg/bunch)
N_0	18.51	863	21.54
N_1	18.67	858	21.76
N_2	19.55	908	21.58
P_0	**17.52**	**828**	**21.23**
P_1	**19.05**	**882**	**21.62**
P_2	**20.16**	**918**	**22.04**
K_0	18.95	889	21.33
K_1	18.47	845	21.89
K_2	19.31	895	21.67
Mg_0	18.88	862	21.90
Mg_1	18.44	855	21.62
Mg_2	19.41	911	21.37
%cv	16.0	16.3	5.9
$LSD_{.05}$	1.76	82.3	0.74

The highest FFB yield is obtained with a combination if ammonium sulphate and Triple Superphosphate application as illustrated in Table 30. There appears to be little P response in the absence of N and no N response in the absence of P.

Table 30: Trial 201, N x P effect on FFB Yield, Jan-Dec 1990.

	P_0	P_1	P_2
N_0	18.03	17.42	18.87
N_1	17.48	19.70	20.91
N_2	18.39	22.02	21.74
$LSD_{.05}$		4.13	

Frond 17 leaflet tissue analysis results are presented in Table 31.

Table 31: Trial 201, Frond 17 Leaflet Nutrient Analysis, 1990.

Main Effects	Frond 17 Leaflet Nutrient Levels (as % Dry Matter)					
	N	P	K	Mg	Ca	Cl
N 0	**2.093**	**0.134**	0.798	0.123	0.816	0.268
N 1	**2.133**	**0.137**	0.803	0.122	0.808	0.277
N 2	**2.159**	**0.137**	0.789	0.117	0.813	0.269
P 0	2.122	**0.132**	**0.821**	**0.116**	0.804	0.276
P 1	2.133	**0.137**	**0.792**	**0.123**	0.806	0.269
P 2	2.130	**0.138**	**0.777**	**0.124**	0.828	0.268
K 0	2.133	0.137	0.810	**0.126**	0.806	**0.213**
K 1	2.130	0.135	0.785	**0.122**	0.803	**0.280**
K 2	2.122	0.136	0.795	**0.114**	0.828	**0.321**
Mg 0	2.122	0.136	**0.785**	**0.113**	**0.827**	0.265
Mg 1	2.144	0.136	**0.799**	**0.120**	**0.811**	0.275
Mg 2	2.119	0.136	**0.806**	**0.129**	**0.799**	0.273
cv%	4.0	2.6	4.2	10.8	6.2	8.8
$LSD_{.05}$	0.049	0.002	0.019	0.008	0.029	0.014

Ammonium sulphate application has significantly increased both the frond 17 leaflet nitrogen levels ($p=0.011$ [linear response component]) and the leaflet phosphorus levels ($p=0.022$). Ammonium sulphate also appears to depress leaflet magnesium levels as in other trials, but the effect is not statistically significant in this case.

Triple Superphosphate has significantly increased the leaflet levels of phosphorus ($p<0.001$) and magnesium ($p=0.044$ [linear regression component]) and depressed leaflet levels of potassium ($p<0.001$).

Potassium chloride applications have significantly increased leaflet chlorine levels($p<0.001$) and depressed leaflet magnesium levels ($p=0.005$ [linear regression component]).

Kieserite application has significantly increased leaflet potassium ($p=0.03$ [linear regression component]) and leaflet magnesium ($p<0.001$) levels, while depressing leaflet calcium levels ($p=0.055$ [linear regression component]).

It is difficult to determine why it is that Triple Superphosphate application produces the largest response in terms of FFB yield. It may be that Triple Superphosphate has the effect of increasing both the leaflet phosphorus and magnesium levels, both of which are low. No other combination of treatments excluding Triple Superphosphate increase both phosphorus and magnesium levels.
The observed benefit of applying Triple Superphosphate and ammonium sulphate together may be due to the effect of improving the status of N,P and Mg, all of which are probably limiting at this site.

TRIAL 401, FACTORIAL FERTILIZER TRIAL, KAUTU PLANTATION.

PURPOSE:

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

SITE DETAILS:

LOCATION; Kautu Plantation, Fields 1F and 1G.

GENETIC MATERIAL; Dami DxP commercial crosses.

SOIL DESCRIPTION; Young coarse textured freely draining soils formed on alluvially redeposited andesitic pumiceous sands and volcanic ash.

PLANTING DATE; 1986.

PLANTING DENSITY; 135 palms/ha.

DESIGN AND TREATMENTS:

DESIGN;

A 3^2x2^3 factorial design grouped in 2 block of 36 plots. One '"2' factor is 'vacant' and regarded as a replicate for the time being. The 3 factor interaction '2x2x2' is partially confounded with blocks.

TREATMENTS;

LEVEL	0	1	2
FERTILIZER	kg fertilizer/palm/year		
Ammonium chloride	0.0	3.0	6.0
Triple Superphosphate	0.0	2.0	4.0
Muriate of Potash	0.0	3.0	---
Kieserite	0.0	3.0	---

RESULTS:

FFB yield and yield component data for April to December 1990 are presented in Table 32. **As this table represents only 9 months data recording, no conclusions should be made from these results.**

The data suggests that a response to ammonium chloride is possible.

Table 32: Trial 401, FFB Yield & Yield Components, Apr-Dec 1990.

Main Effects	FFB Yield (t/ha)	No. Bunches (No./ha)	Bunch Wgt (kg/bunch)
N_0	**15.85**	1929	**8.25**
N_1	**17.29**	2081	**8.34**
N_2	**16.49**	1884	**8.81**
P_0	16.71	1960	**8.58**
P_1	16.87	1985	**8.54**
P_2	16.05	1949	**8.28**
K_0	16.11	1930	8.41
K_1	16.97	1999	8.52
Mg_0	16.55	2008	**8.28**
Mg_1	16.54	1921	**8.65**
%cv	12.0	13.1	5.9
$LSD_{.05}$ (N&P)	1.16	151	0.29
$LSD_{.05}$(K&Mg)	0.95	123	0.24

Frond 17 leaflet tissue analysis results are presented in Table 33.

Ammonium chloride application has significantly increased the leaflet levels of calcium ($p=0.002$ [linear response component]) and chlorine ($p<0.001$). Ammonium chloride application has also significantly depressed the leaflet potassium level ($p<0.001$). As yet the ammonium chloride treatment has not significantly depressed the leaflet magnesium levels.

Triple Superphosphate treatments have significantly increased the leaflet phosphorus levels. Although not statistically significant, the TSP application has tended to increase the leaflet magnesium level and depress leaflet calcium levels - effects which have been observed in other trials.

The potassium chloride treatment has significantly depressed the leaflet potassium levels ($p=0.002$) and increased leaflet calcium ($p=0.012$) and chlorine ($p<0.001$) levels. Although not statistically significant ($p=0.08$) the potassium chloride application has tended to increase the leaflet magnesium levels.

The Kieserite application has had no significant effects on leaflet nutrient levels.

There are no significant correlations between leaflet nutrient levels and FFB yield.

Table 33: Trial 401, Frond 17 Leaflet Tissue Analysis, 1990.

Main Effects	Leaflet 17 Tissue Nutrient Levels (%D.M.)					
	N	P	K	Ca	Mg	Cl
N_0	2.635	0.161	**0.888**	**0.906**	0.185	**0.288**
N_1	2.665	0.161	**0.793**	**0.940**	0.185	**0.435**
N_2	2.654	0.160	**0.782**	**0.953**	0.184	**0.482**
P_0	2.632	**0.158**	0.827	0.937	0.182	0.393
P_1	2.678	**0.161**	0.809	0.935	0.185	0.416
P_2	2.644	**0.162**	0.826	0.926	0.188	0.396
K_0	2.647	0.161	**0.849**	**0.918**	0.181	**0.353**
K_1	2.656	0.160	**0.792**	**0.948**	0.189	**0.449**
Mg_0	2.649	0.161	0.822	0.934	0.185	0.390
Mg_1	2.653	0.160	0.819	0.932	0.185	0.414
%cv	2.1	1.9	8.8	5.2	10.3	14.9
$LSD_{.05}$(N&P)	0.032	0.002	0.042	0.028	0.011	0.035
$LSD_{.05}$(K&Mg)	0.026	0.001	0.035	0.023	0.009	0.029

II. AGRONOMY AND SMALLHOLDER TRIALS

MAINLAND

(A.S. Wilkie & A.T. Oliver)

TRIAL 305, FERTILIZER FACTORIAL TRIAL, AREHE

PURPOSE:

To provide an indication of fertilizer response on Higaturu soils, for guidance on commercial fertilizer practice.

SITE DETAILS :

Location: Arehe Estate HOPPL, block 78F.
Genetic material: Dami commercial DxP crosses.
Soils: Higaturu family, which is of volcanic ash origin, consisting of deep sandy clay loam, with good drainage and physical properties.
Planting date: 1978.
Density: 130 points/ha.
Size: The trial comprises 72 plots totalling 2967 palms, including the guard rows, and is surrounded by additional areas fertilized by OPRA to ensure separation from estate fertilizing.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 305 is a randomised incomplete block factorial design, with two replicates each of 3 blocks, comprising 3x2x3x2 treatments for NxPxKxMg.
Layout: Each plot consists of a core of 16 recorded palms, surrounded by a guard row, making a total of 36 palms per plot. Additional guard palms were introduced during 1990 outside the existing plots where practicable, to provide double guard rows.
Trial commencement: September 1981.
Trial progress: Ongoing.

Treatments:

Treatments in Kg/palm/year:	0	1	2
Ammonium sulphate	0	2.0	4.0
Triple superphosphate	0	2.0	-
Muriate of potash	0	2.0	4.5
Kieserite	0	1.0	-

Modifications: Until 1984, sulphate of ammonia was applied at 1.0 and 2.0 kg, and triple superphosphate at 0.5kg per palm per year.

RESULTS :

1. Yield

Yield data for 1990, and for the 3 years 1988-1990 are summarised in Tables 34 and 35 and Figure 35.

There has been a marked response to SOA, with yields increased overall by an average of 13 tonnes in 1990, from 24 to 37.1 with 4 kg of SOA per palm. A response of up to 9 t. was obtained with only 2kg of SOA per palm.

Response to MOP averaged around 2 t/ha, but was not statistically significant for the period 1988-90. MOP increased sbw, but as the increase was accompanied by a reduction in bunch numbers the overall effect on yield was marginal.

Table II-2 indicates the interaction between MOP and SOA. In the absence of SOA there was negligible response to MOP, but with SOA MOP raised yields by up to 3 tonnes.

Maximum yields were achieved at N2K2, amounting to 38.4 t/ha in 1990 and 34 tonnes annually for the period 88-90. For comparison yields at N2K0 were 35 t and 31 t respectively.

The absence of response to TSP and Kieserite has continued.

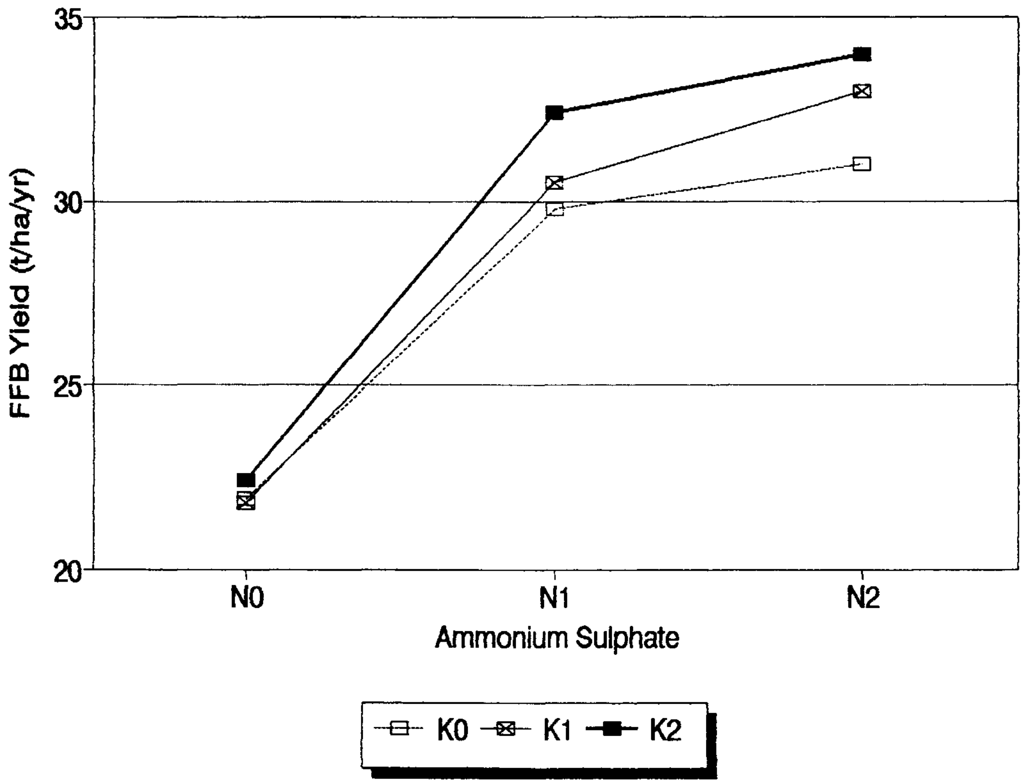
Table 34: Trial 305, Yield per hectare

	1990	1990	1990	1988/90	1988/90	1988/90	1984-88
	FFB Yield t/ha	No.of bunches /ha	Bunch Wt kg	FFB Yield t/ha	No.of Bunches /ha	Bunch Wt Kg	FFB Yield t/ha
N 0	**24.0**	**1159**	**20.2**	**22.0**	**1155**	**19.0**	**28.0**
N 1	**33.5**	**1449**	**23.2**	**30.7**	**1447**	**21.4**	**32.3**
N 2	**37.1**	**1586**	**23.4**	**32.7**	**1592**	**20.7**	**32.8**
P 0	31.4	1392	22.4	28.4	1391	20.5	31.1
P 1	31.6	1405	22.2	28.5	1405	20.2	31.0
K 0	30.6	1474	**20.6**	27.4	1475	**18.6**	**29.6**
K 1	31.8	1336	**23.4**	28.4	1327	**21.4**	**31.5**
K 2	32.2	1385	**22.9**	29.5	1392	**21.1**	**31.9**
Mg 0	32.3	1432	22.3	28.8	1435	**20.0**	31.3
Mg 1	30.7	1364	22.3	28.1	1362	**20.7**	30.8
lsd (N&K)	3.31	123	1.19	2.16	124	0.86	0.94
lsd (P&Mg)	2.7	101	0.98	1.77	101	0.7	0.77
c.v.%	18	15	9	13	15	7	5

Table 35: Trial 305 Yields in t/ha for different fertilizer combinations 1989

1990			
	K0	K1	K2
N0	24.1	24.4	23.5
N1	32.8	33.4	34.5
N2	35.0	37.8	38.4
l.s.d.		5.7	
1988-90			
	K0	K1	K2
N0	21.9	21.8	22.4
N1	29.8	30.5	32.4
N2	31.0	33.0	34.0
l.s.d.		3.7	

Figure 35: Trial 305 yields 1988-90



2. **Growth**

Full palm growth data are presented in Tables 36 and 37.

Table 36: Trial 305 Palm Vegetative Growth for 1988-90 (annual basis)

	Leaf prodn	Dry Frond wt	Frond	Bunch	Vegetative DM t/h	Total
	/year	kg	(FDM)	(BDM)	(VDM)	(TDM)
N 0	**20.3**	**3.69**	**9.5**	**18.0**	**12.6**	**30.6**
N 1	**22.5**	**4.30**	**12.3**	**25.2**	**16.5**	**41.7**
N 2	**23.0**	**4.44**	**13.0**	**26.8**	**17.4**	**44.2**
P 0	21.9	4.19	11.7	23.3	15.6	38.9
P 1	21.9	4.10	11.5	23.4	15.4	38.8
K 0	21.9	**3.89**	**10.9**	22.5	**14.6**	**37.1**
K 1	22.0	**4.25**	**11.9**	23.3	**15.9**	**39.2**
K 2	21.9	**4.29**	**12.0**	24.2	**16.0**	**40.2**
Mg 0	22.0	4.09	11.5	23.6	15.4	39.0
Mg 1	21.9	4.20	11.7	23.1	15.6	38.7
lsd (N&K)	0.58	0.17	0.72	1.77	0.89	2.36
lsd (P&Mg)	0.47	0.14	0.59	1.45	0.72	1.93
cv%	4	7	11	13	10	10
(*Dry matter calculated as carbohydrate equivalent, assuming oil energy = 2.1 x carbohydrate)						

Table 37: Trial 305, Palm vegetative growth 1988-1990 (annual basis)

	Height 1/90	Bunch Index	Leaf Area Index	Conversion Efficiency
	m	(BI)	(LAI)	(e)
N 0	5.74	0.583	5.31	1.09
N 1	6.19	0.605	5.76	1.46
N 2	6.32	0.606	5.93	1.54
P 0	6.09	0.600	5.75	1.36
P 1	6.08	0.599	5.58	1.37
K 0	5.99	0.604	5.57	1.31
K 1	6.07	0.591	5.68	1.38
K 2	6.19	0.598	5.75	1.40
Mg 0	6.05	0.603	5.58	1.38
Mg 1	6.11	0.593	5.75	1.35
lsd (N&K)	0.23	0.02	0.29	0.08
lsd (P&Mg)	0.19	0.02	0.24	0.06
cv%	6	5	9	10

SOA application increased virtually all parameters, including VI (by up to 12%), leaf production, frond DM production, BI, LAI and also substantially improved efficiency of energy conversion (+41%).

MOP increased frond weights and as a result marginally improved e but did not have a significant effect on BI.

Again there were no significant effects for TSP or kieserite, confirming the absence of response identified for yield data.

3. Nutrient analysis

The latest plant analysis results from sampling in January 1989 are presented in Tables 38 to 40 and Figure 35. Joint consideration of rachis and leaf data indicates a complex set of inter-relationships.

The latest results show three marked departures from the previous trends:

1. Kieserite has developed a significant effect in boosting leaf and rachis levels of Mg.

2. MOP has not shown any significant effect on leaf K levels on this occasion: previously it produced a marked reduction in leaf K levels. It may be that as K and Ca levels in the leaf fall this effect is lost.

3. SOA application is now producing a significant increase in rachis N levels as well as leaf levels - in fact the percentage change in the rachis of 18% is actually greater than the 15% seen in the leaf.

Generally previous trends have continued. SOA application had a major effect in reducing availability of base cations through acidification. This in turn affects levels of the other nutrients within the palm. The direct effect was seen in increased N levels, and reduced leaf Ca and leaf and rachis Mg.
A reduction in total and rachis P and an increase in leaf P levels were also brought about. Leaf K levels were unaffected (or even raised as a % of Total Bases) although the rachis levels were lowered.

TSP application effected a 49% increase in rachis P levels, and a 2% increase in leaf levels.

MOP caused major increases in cation uptake through the Cl component. Leaf levels were largely unaffected, apart from a 6% reduction in Mg, possibly as leaf Ca levels do not allow for increases in other cations. In the rachis P, K, Ca, and Mg were boosted by 29-42%. Although plant uptake of P, K and Ca was boosted by MOP application, for Mg there was little change, but the balance of nutrients within the palm was altered resulting in an increase in the rachis and a depression in the leaf. There was also the expected major effect on leaf and rachis Cl, with rachis Cl boosted by 881%, so that rachis Cl substantially exceeded leaf Cl at K1 and K2.

Table 38: Trial 305, Leaf analysis data January 1990

	N0	N1	N2	P0	P1	K0	K1	K2	Mg0	Mg1	lsd_{NK}	lsd_{PMg}	% cv
N%	**2.02**	**2.26**	**2.33**	2.19	2.22	2.21	2.21	2.2	**2.24**	**2.17**	0.10	0.08	7
%	100	112	115	100	101	100	100	100	100	97			
P%	**0.136**	**0.144**	**0.145**	**0.140**	**0.143**	0.142	0.142	0.141	0.142	0.141	0.01	0.01	7
%	100	106	107	100	102	100	100	99	100	99			
K%	0.747	0.755	0.767	0.759	0.753	0.762	0.766	0.740	0.756	0.756	0.04	0.02	7
%	100	101	103	100	99	100	101	97	100	100			
me/100g	19.1	19.31	19.62	19.41	19.26	19.49	19.59	18.93	19.34	19.34			
% TB	27	28	30	28	28	29	28	28	28	28			
Ca%	**0.736**	**0.723**	**0.682**	0.718	0.71	0.692	0.719	0.73	0.723	0.705	0.04	0.04	7
%	100	98	93	100	99	100	104	105	100	98			
me/100g	36.73	36.08	34.03	35.83	35.43	34.53	35.88	36.43	36.08	35.18			
% TB	53	52	51	52	52	51	52	53	53	51			
Mg%	**0.169**	**0.169**	**0.154**	0.166	0.162	0.17	0.163	0.159	**0.158**	**0.171**	.01	.01	12
%	100	100	91	100	98	100	96	94	100	108			
me/100g	13.91	13.91	12.67	13.66	13.33	13.99	13.42	13.09	13	14.07			
% TB	20	20	19	20	20	21	19	19	19	21			
Cl%	0.247	0.257	0.238	0.246	0.249	**0.107**	**0.296**	**0.339**	0.259	0.236	0.04	0.03	24
%	100	104	96	100	101	100	277	317	100	91			
TB me/100g	69.74	69.3	66.32	68.9	68.02	68.01	68.89	68.45	68.42	68.59			

Table 39: Trial 305, Rachis analysis January 1990

	N0	N1	N2	P0	P1	K0	K1	K2	Mg0	Mg1	lsd_{NK}	lsd_{PMg}	% cv
N%	**0.224**	**0.252**	**0.264**	0.243	0.251	0.256	0.236	0.249	0.245	0.249	0.02	0.02	12
%	100	113	118	100	103	100	92	97	100	102			
P%	**0.156**	**0.098**	**0.09**	**0.092**	**0.137**	**0.096**	**0.127**	**0.12**	0.118	0.112	0.02	0.10	26
%	100	63	58	100	149	100	132	125	100	95			
K%	**1.31**	**1.18**	**1.18**	1.23	1.22	**0.99**	**1.28**	**1.41**	1.24	1.21	0.08	0.06	11
%	100	90	90	100	99	100	129	142	100	98			
me/100g	33.5	30.18	30.18	31.46	31.2	25.32	32.74	36.06	31.71	30.95			
% TB	59	57	57	58	57	56	58	58	57	58			
Ca%	0.378	0.381	0.379	0.377	0.381	**0.328**	**0.385**	**0.424**	0.39	0.369	0.02	0.02	11
%	100	101	100	100	101	100	117	129	100	95			
me/100g	18.86	19.01	18.91	18.81	19.01	16.37	19.21	21.16	19.46	18.41			
% TB	33	36	36	35	35	36	34	34	35	34			
Mg%	**0.057**	**0.05**	**0.047**	0.05	0.053	**0.043**	**0.053**	**0.058**	0.05	0.053	.01	.01	19
%	100	88	82	100	106	100	123	135	100	106			
me/100g	4.69	4.12	3.87	4.12	4.36	3.54	4.36	4.77	4.12	4.36			
% TB	8	8	7	8	8	8	8	8	7	8			
Cl%	**0.44**	**0.399**	**0.391**	0.407	0.413	**0.077**	**0.475**	**0.678**	0.411	0.408	0.04	0.03	17
%	100	91	89	100	101	100	617	881	100	99			
TB	57.05	53.31	52.96	54.39	54.57	45.23	56.31	61.99	55.29	53.72			

Figure 36: Leaf Analysis 89 - SOA Effect

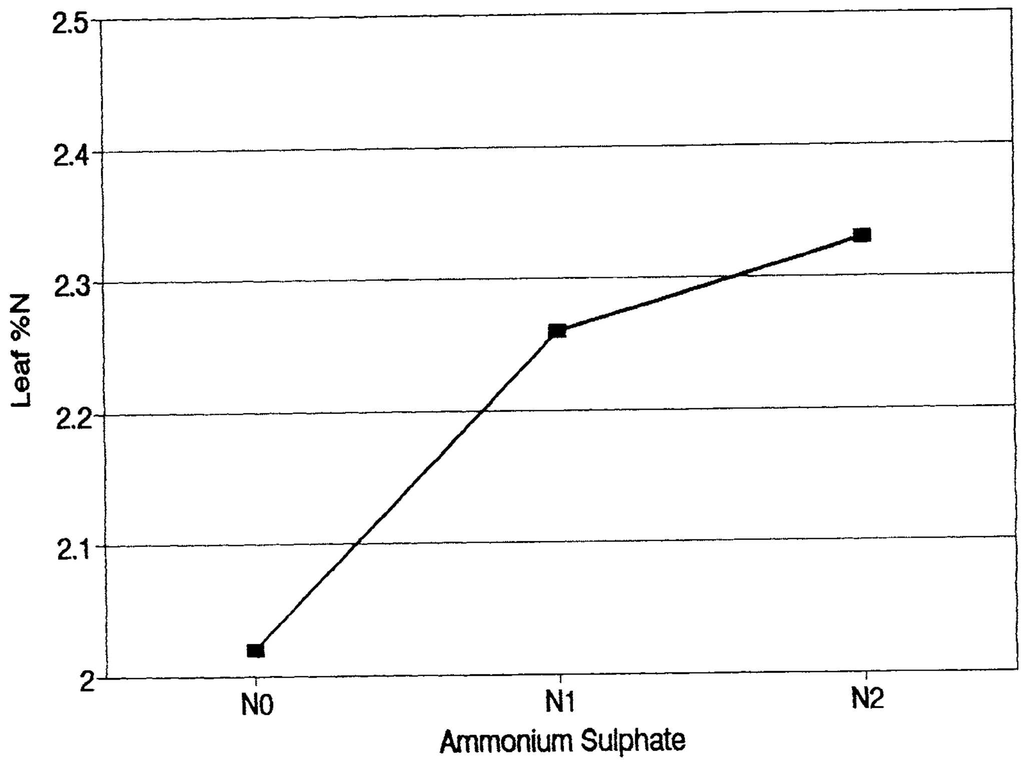


Table 40 : Rachis analysis for selected fertilizer combinations

	1990	% Ca	
	K0	K1	K2
Mg0	0.355	0.393	0.422
Mg1	0.302	0.378	0.427

4. Soil Analysis

The latest existing soil data is shown in Appendix II along with soils data from other trials for comparison.

5. Discussion

Overall the leaf levels for all nutrients are substantially lower than at the previous complete sampling in 1987. In many cases the maximum level is now below the previous minimum level. This illustrates the importance of considering relationships between nutrient levels, rather than arbitrary "critical" levels.

Interestingly the rachis nutrient levels have remained relatively constant. In general response to fertilizer differentials has been more marked in the rachis than in the leaf. The Mg levels in the rachis were particularly low, averaging .051%.

SOA application, in addition to the direct benefit of supplying the major requirement for N, also appears beneficial in increasing leaf P levels, possibly as a result of reduction in leaf Ca levels brought about by the sulphate cation.

MOP boosted uptake of phosphate and cations apart from Mg. K levels within the palm do not appear deficient, so that use of AMC might be preferable in maintaining Cl levels within the palm without the depression in leaf Mg levels unfortunately occasioned by both MOP and SOA applications.

Table g with the continuous monitoring of selected plots indicates a remarkably high yield of 33.7 t from the N1K0 plots, in spite of Cl levels of only 0.08%. Other nutrient levels also appear fairly low, with P at 0.14%, K at 0.75% and Mg at 0.17%. However K and Mg levels as percentages of total bases are reasonable.

In 1988, following an extended dry period in 1987, yields on the N1K0 plots (25.3 t) were substantially lower than those on the N1K1 plots (29.1 t). This suggests that the MOP benefit may be particularly related to periods of water stress.

SUMMARY :

The major response to SOA has continued, with a smaller response to MOP. Responses to TSP or Kieserite were absent.

General yield levels rose during 1990, and plots receiving SOA averaged 35.3 t/ha. Plots without SOA averaged 24 t/ha.

For the period 1988-90, 2 kg/palm per annum of SOA provided yields of over 29 t/ha for the minimum fertilizer input.

Maximum yields were achieved at N2K2, amounting to 38.4 t/ha in 1990 and 34 tonnes annually for the period 88-90. For comparison yields at N2K0 were 35 t and 31 t respectively.

Examination of data suggests that the MOP benefit may be particularly related to periods of water stress.

The 1990 tissue analyses show the development of a significant new response with Kieserite boosting leaf and rachis levels of Mg.

The leaf levels for all nutrients were substantially lower than at the previous complete sampling in 1987. In many cases the maximum level had fallen below the previous minimum level. This illustrates the importance of considering relationships between nutrient levels, rather than arbitrary "critical" levels.

Mg levels in the rachis were particularly low, averaging .051%.

SOA application, in addition to the direct benefit of supplying the major requirement for N, also appears beneficial in increasing leaf P levels.

K levels within the palm do not appear deficient, so that use of AMC might be preferable to MOP in maintaining Cl levels within the palm without the depression in leaf Mg levels unfortunately occasioned by both MOP and SOA applications.

Table 41: Trial 305, Progressive changes in yield and nutrient status

N0K0	82	83	84	85	86	87	88	89	90	AVG
Yield	28.3	28.3	30.4	30.2	23.3	20.0	17.6	22.8	22.9	24.9
N%	2.8		2.45	2.6	2.4	2.2	2.0	1.91	2	2.3
K%	1.2		0.97	1.02	0.95	0.91	0.98	0.63	0.73	0.92
K%TB									27	27
P%	0.18		0.17	0.17	0.16	0.15	0.14	0.131	0.13	0.15
Cl%	0.21			0.19	0.16	0.13	0.12	0.11	0.09	0.14
Cl%rch									0.06	0.06
Mg%									0.16	0.16
Mg%TB									19	19
K%rach									1.21	1.21

N1K0	82	83	84	85	86	87	88	89	90	AVG
Yield	29.0	33.2	34.0	34.7	29.7	32.2	25.3	31.2	33.7	31.4
N%	2.9		2.55	2.65	2.5	2.65		2.27	2.22	2.53
K%	1.05		0.94	0.94	0.89	0.96		0.76	0.75	0.9
K%TB									28	28
P%	0.16		0.15	0.17	0.16	0.16		0.146	0.14	0.16
Cl%	0.17			0.14	0.11	0.07		0.09	0.08	0.11
Cl%rch									0.08	0.08
Mg%									0.17	0.17
Mg%TB									20	20
K%rach									0.94	0.94

(Table 41 contd)

N0K1	82	83	84	85	86	87	88	89	90	AVG
Yield	26.9	32.2	36.9	34.7	28.4	25.8	21.85	21.3	27.1	28.4
N%	2.95		2.6	2.6	2.45	2.2		2.07	2.08	2.42
K%	1.05		0.86	0.93	0.9	0.85		0.68	0.72	0.86
K%TB									27	27
P%	0.16		0.16	0.18	0.16	0.15		0.141	0.14	0.16
Cl%	0.27			0.46	0.48	0.44		0.36	0.29	0.38
Cl%rch									0.49	0.49
Mg%									0.17	0.17
Mg%TB									20	20
K%rach									1.39	1.39

N1K1	82	83	84	85	86	87	88	89	90	AVG
Yield	28.3	31.9	36.5	38.0	33.7	32.6	29.1	32.2	34.9	33.0
N%	2.7		2.65	2.7	2.55	2.55		2.24	2.27	2.52
K%	1		0.86	0.94	0.86	0.81		0.7	0.76	0.85
K%TB									30	30
P%	0.16		0.16	0.17	0.16	0.15		0.143	0.14	0.15
Cl%	0.37			0.5	0.47	0.45		0.34	0.3	0.41
Cl%rach									0.45	0.45
Mg%									0.15	0.15
Mg%TB									19	19
K%rach									1.21	1.21

(Table 41 contd)

N2K2	82	83	84	85	86	87	88	89	90	AVG
Yield	26.9	34.6	33.8	36.0	33.9	34.1	27	34.2	35.9	32.9
N%	2.65		2.6	2.7	2.5	2.5		2.21	2.32	2.5
K%	0.95		0.85	0.94	0.89	0.84		0.72	0.73	0.85
K%TB									30	30
P%	0.16		0.16	0.16	0.16	0.15		0.14	0.14	0.15
Cl%	0.38			0.52	0.53	0.52		0.4	0.36	0.45
Cl%rch									0.67	0.67
Mg%									0.13	0.13
Mg%TB									17	17
K%rach									1.31	1.31

TRIAL 306, FERTILIZER FACTORIAL TRIAL, AMBOGO

PURPOSE:

To provide an indication of fertilizer response on Ambogo and Penderetta soils, for guidance on commercial fertilizer practice.

SITE DETAILS :

Location: Ambogo Estate HOPPL, block 79B.
Genetic material: Dami commercial DxP crosses.
Soils: Ambogo and Penderetta families - recent alluvially reworked soils of volcanic origin, having silty loam topsoil and sandy loam subsoil, with mottling due to seasonally high water tables.
Planting date: 1979.
Density: 143 points/ha.
Size: The trial comprises 81 plots totalling 3440 palms, including the guard rows, and is surrounded by additional areas fertilized by OPRA to ensure separation from estate fertilizing.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 306 is a randomised incomplete block factorial design, with one replicate of 3 blocks, comprising 3x3x3x3 treatments for NxPxKxMg.
Layout: The plots consist of a core of 16 recorded palms, surrounded by a guard row, making a total of 36 palms per plot. During 1990 additional guard palms were introduced outside the existing plots where practicable, to provide double guard rows.
Trial commencement: 1982 (first fertilizer application April 1983).
Trial progress: Ongoing.

Treatments:

Treatments in Kg/palm/year:

	Rates		
	0	1	2
Ammonium sulphate	0	3.0	6.0
Triple superphosphate	0	0.5	1.0
Muriate of potash	0	2.5	5.0
Kieserite	0	0.75	1.5

Modifications: Until 1990 SOA rates were half those indicated.

RESULTS :

1. Yield

Yield data for the period 1988-90 are summarised in Tables 42 and 43 and Figures 37 and 38.

The major response to SOA has continued in 1990, with substantially increased yields and responses. During the year the mean response to N1 was 7.6 t, and to N2 10.2 t, raising yields from 24.5 to 34.7 t/ha, for an input of 3kg of SOA per palm. The maximum yield of 35.5 t was attained with the N2K2 fertilizer combination, whilst N2K0 achieved 34 t.

There were no other significant responses apart from a minor response to MOP and interactions between SOA and kieserite and MOP.

MOP raised single bunch weights, but reduced bunch numbers, so that the yield benefit was only 1.7 t annually for the period 1988-90. Table 42 and figure 37 indicate that without SOA the application of MOP was not beneficial and may have reduced yields, whereas in the presence of SOA the MOP increased yields by up to 3 tonnes.

The interaction between kieserite and SOA appears to take the opposite form, with response to kieserite lost in the presence of SOA. This may indicate that the kieserite benefit was due to the sulphate rather than Mg, particularly as Mg plant levels in trial 306 appear to be unaffected by kieserite application.

<u>**Figure 37: Trial 306 yields 1988-90**</u>

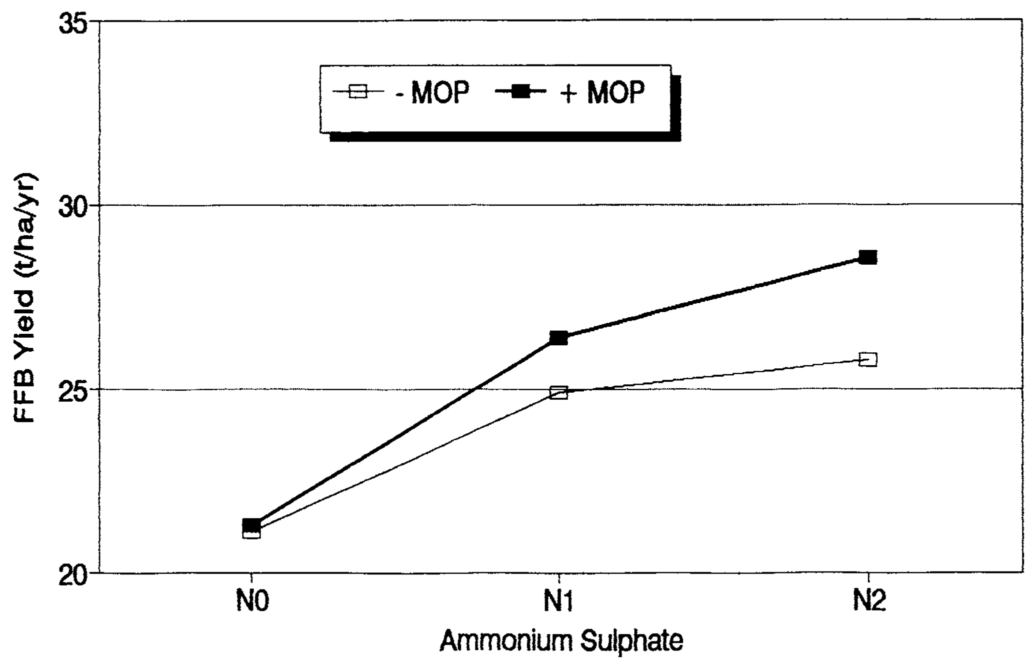


Table 42: Trial 306, Yield per hectare

	1990 Wt. of bunches t/ha	1990 No. of bunches /ha	1990 s.b.w. kg	1988/90 Wt. of bunches t/ha	1988/90 No. of bunches /ha	1988/90 s.b.w. kg
N 0	**24.5**	**1156**	**21.1**	**21.2**	**1101**	**19.3**
N 1	**32.1**	**1357**	**23.6**	**26.0**	**1221**	**21.3**
N 2	**34.7**	**1473**	**23.6**	**27.6**	**1308**	**21.2**
P 0	29.9	1325	22.4	25.0	1226	20.3
P 1	30.0	1310	22.8	24.6	1193	20.6
P 2	31.3	1352	23.1	25.2	1211	20.9
K 0	30.0	**1397**	**21.4**	**23.9**	1247	**19.2**
K 1	31.1	**1303**	**23.8**	**25.6**	1193	**21.4**
K 2	30.1	**1286**	**23.2**	**25.3**	1190	**21.2**
Mg 0	29.8	1329	22.3	24.4	1198	20.3
Mg 1	30.1	1310	22.9	25.3	1235	20.5
Mg 2	31.4	1348	23.2	25.1	1196	21.0
lsd	2.2	72	1.34	1.34	56	0.83
c.v.	13	10	10	10	8	7

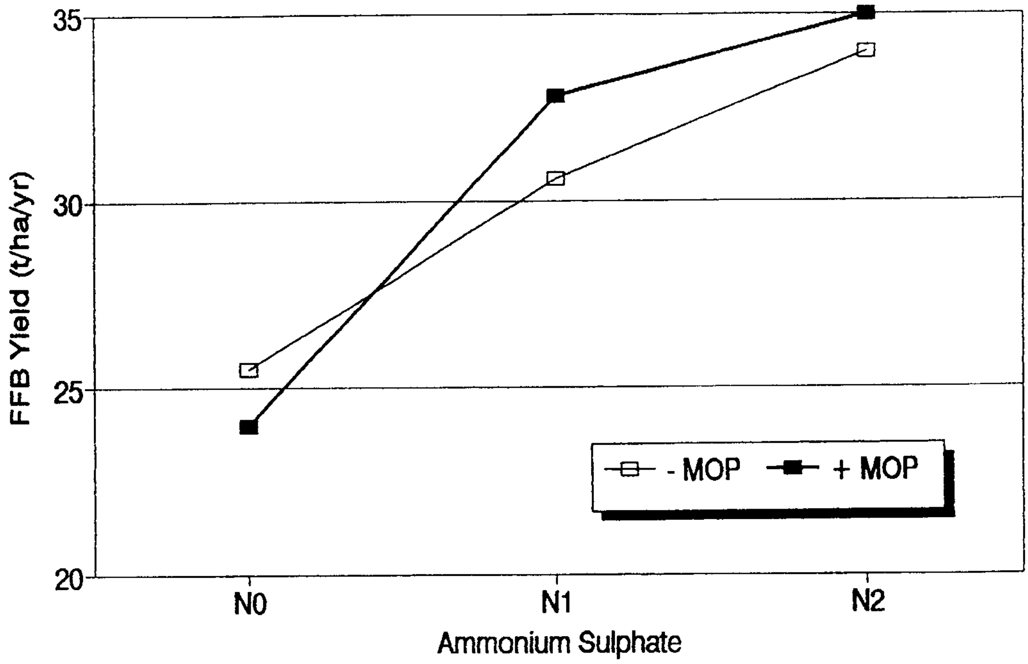
Note: NxMg interaction for 1990 bunches/ha significant at 5%
NxMg and NxK interactions for 88-90 bunches/ha significant at 5%

Table 43: Fertilizer interaction tables: annual means

NxK Yield t/ha 1990				NxK Yield t/ha 88/90			
	K0	K1	K2		K0	K1	K2
N0	25.5	25.4	22.6	N0	21.1	21.9	20.7
N1	30.6	33.3	32.3	N1	24.9	26.4	26.4
N2	34.0	34.5	35.5	N2	25.8	28.3	28.8
	l.s.d.	= 3.8			l.s.d.	= 2.3	
NxMg Yield t/ha 1990				**NxMg Yield t/ha 88/90**			
	Mg0	Mg1	Mg2		Mg0	Mg1	Mg2
N0	22.2	25.0	26.3	N0	19.3	22.7	21.7
N1	32.8	32.1	31.2	N1	26.6	26.2	25.2
N2	34.4	33.0	36.6	N2	27.2	27.1	28.6
	l.s.d	= 3.8			l.s.d.	= 2.3	

Note: N,P & K are coded for the fertilizer rates given at the start of this section.

Figure 38: Trial 306 yields 1990



2. Growth

Table 44 indicates the components of production for 306 for the period 1988 to 1990.

SOA has significantly increased every growth parameter, including the important bunch index (BI) and the efficiency of conversion (e) parameters. This emphasises the vital importance of N at Higaturu.

As with yield, there were a number of significant interactions between SOA and MOP and kieserite.

No response to TSP was identified, and no overall response to kieserite.

MOP had a relatively minor effect increasing DM production by means of increases in frond weight and BDM. It had no significant effect on the major parameters of BI, LAI and e.

Bunch index values have remained below 305 values, reflecting the relatively poorer yields from trial 306 for the period 88-90.

Table 44 : Trial 306, Growth data for 1988 to 1990

	Leaf prdn. (n)	Frond Wt. (kg)	Frond DM t/ha (FDM)	Bunch DM t/ha (BDM)	Veg. DM t/ha (VDM)	Total DM t/ha (TDM)
N 0	**22.5**	**3.01**	**12.3**	**17.4**	**15.6**	**33.0**
N 1	**24.1**	**4.15**	**14.3**	**21.3**	**18.2**	**39.5**
N 2	**24.3**	**4.28**	**14.9**	**22.7**	**19.0**	**41.7**
P 0	23.7	4.08	13.8	20.5	17.6	38.1
P 1	23.7	4.07	13.8	20.1	17.6	37.7
P 2	23.5	4.09	13.8	20.7	17.6	38.3
K 0	23.8	**3.95**	**13.4**	**19.6**	**17.1**	**36.7**
K 1	23.6	**4.09**	**13.8**	**21.0**	**17.7**	**38.6**
K 2	23.6	**4.20**	**14.2**	**20.7**	**18.1**	**38.8**
Mg 0	23.5	3.98	13.4	20.0	17.1	37.1
Mg 1	23.7	4.11	14.0	20.7	17.8	38.5
Mg 2	23.8	4.14	14.1	20.6	17.9	38.5
lsd	0.36	0.17	0.59	1.1	0.73	1.67
c.v.	3	7	8	10	7	8

Significant interactions:
FDM: NxK , NxMg . FW: NxK , NxMg . VDM:NxK,NxMg .
BI: NxK , NxMg , PxK

Table 45: Trial 306, Growth data for 1988 to 1990

	Bunch Index (BI)	Leaf Index (LAI)	Fract. inter. (f)	Conversion efficiency (e)
N 0	**0.526**	**6.3**	**0.931**	**1.13**
N 1	**0.538**	**6.8**	**0.940**	**1.35**
N 2	**0.543**	**6.8**	**0.946**	**1.41**
P 0	0.536	6.6	0.938	1.30
P 1	0.532	6.7	0.943	1.28
P 2	0.54	6.5	0.936	1.30
K 0	0.534	6.4	0.934	1.26
K 1	0.542	6.8	0.944	1.31
K 2	0.531	6.6	0.939	1.32
Mg 0	0.537	6.4	0.932	1.28
Mg 1	0.537	6.8	0.944	1.30
Mg 2	0.533	6.6	0.941	1.31
lsd	0.01	0.38	0.01	0.06
c.v.	3	10	2	8

3. **Nutrient analysis**

The most recent plant analyses are given in Tables 46 and 47 and Figure 39.

These are in line with the responses found in all the other Higaturu trials. Nutrient levels are generally very close to those on trial 305, apart from a higher leaf Mg at 25% of TB rather than 20% and rachis Mg levels double those for 305, reflecting soil levels several times higher in trial 306, which was the principal difference between the soil analyses at the 2 sites.

SOA had the usual effect of direct increases in leaf and rachis N levels, as well as bringing about reductions in leaf Ca and Mg, increases in leaf K, and re-distribution of P from the rachis to the leaf.

TSP application did not have any significant effect on plant nutrient levels.

The only significant effect of kieserite was an increase in rachis Mg levels of 15%.

MOP application raised Cl levels in the leaf and rachis by 270% and 1285% respectively. Levels of all bases were increased in the rachis, particularly K which rose by 53% to a maximum of 1.78%. In the leaf there was an 8% increase in Ca, which was associated with a reduction in leaf K by 10% and Mg by 9%.

__Figure 39: Trial 306, Tissue N analysis 1989 - SOA effect__

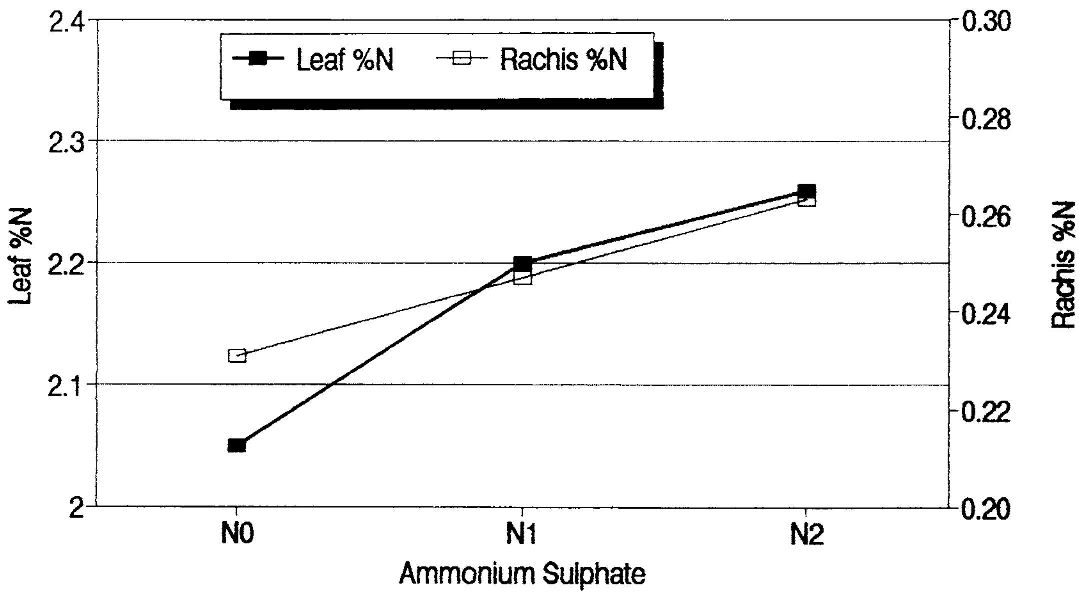


Table 46: Trial 306 leaf analysis data

	N0	N1	N2	P0	P1	P2	K0	K1	K2	Mg0	Mg1	Mg0	lsd	cv
N%	**2.05**	**2.2**	**2.26**	2.17	2.14	2.2	2.17	2.17	2.17	2.16	2.18	2.17	0.06	5
%	100	107	110	100	99	101	100	100	100	100	101	100		
P%	**0.142**	**0.148**	**0.149**	0.146	0.146	0.147	0.147	0.146	0.145	0.146	0.147	0.146	0.003	3
%	100	104	105	100	100	101	100	99	99	100	101	100		
K%	**0.767**	**0.804**	**0.784**	0.789	0.781	0.784	**0.825**	**0.767**	**0.762**	0.784	0.794	0.776	0.025	6
%	100	105	102	100	99	99	100	93	92	100	101	99		
me/100g	19.6	20.6	20.1	20.2	20	20.1	21.1	19.6	19.5	20.1	20.3	19.8		
% TB	27	29	29	28	28	28	29	28	27	28	28	28		
Ca%	**0.69**	**0.661**	**0.654**	0.667	0.675	0.663	**0.64**	**0.674**	**0.69**	0.669	0.668	0.667	0.023	6
%	100	96	95	100	101	99	100	105	108	100	100	100		
me/100g	34.4	33	32.6	33.3	33.7	33.1	31.9	33.6	34.4	33.4	33.3	33.3		
% TB	47	46	46	47	47	47	44	47	48	47	47	46		
Mg%	**0.228**	**0.219**	**0.214**	0.219	0.224	0.217	**0.229**	**0.215**	**0.217**	0.22	**0.215**	0.226	0.011	9
%	100	96	94	100	102	99	100	94	95	100	98	103		
me/100g	18.77	18.02	17.61	18.02	18.44	17.86	18.85	17.7	17.86	18.11	17.7	18.6		
% TB	26	25	25	25	26	25	26	25	25	25	25	26		
Cl%	0.316	0.304	0.325	0.296	0.309	0.341	**0.15**	**0.391**	**0.405**	0.301	0.317	0.328	0.045	26
%	100	96	103	100	104	115	100	261	270	100	105	109		
mmol/100g	8.91	8.58	9.17	8.35	8.72	9.62	4.23	11.03	11.42	8.49	8.94	9.25		
% TB	12	12	13	12	12	14	6	16	16	12	13	13		
TB	72.77	71.62	70.31	71.52	72.14	71.06	71.85	70.9	71.76	71.61	71.3	71.7		

Table 47: Trial 306, Rachis Analysis Data 1989

	N0	N1	N2	P0	P1	P2	K0	K1	K2	Mg0	Mg1	Mg0	lsd	cv
N%	**0.231**	**0.249**	**0.263**	0.243	0.251	0.263	0.245	0.248	0.25	0.246	0.246	0.25	0.014	10
%	100	108	114	100	103	108	100	101	102	100	100	102		
P%	**0.184**	**0.133**	**0.094**	0.132	0.135	0.144	**0.103**	**0.151**	**0.157**	0.131	0.139	0.14	0.018	24
%	100	72	51	100	102	109	100	147	152	100	106	107		
K%	1.54	1.54	1.51	1.57	1.53	1.51	**1.16**	**1.67**	**1.78**	1.48	1.57	1.57	0.134	16
%	100	100	98	100	97	96	100	144	153	100	106	106		
me/100g	39.39	39.39	38.62	40.15	39.13	38.62	29.67	42.71	45.52	37.85	40.15	40.15		
% TB	58	58	58	59	58	59	55	59	60	59	59	58		
Ca%	0.39	0.396	0.391	0.389	0.407	0.38	**0.335**	**0.418**	**0.424**	0.379	0.4	0.398	0.036	17
%	100	102	100	100	105	98	100	125	127	100	106	105		
me/100g	19.46	19.76	19.51	19.41	20.31	18.96	16.72	20.86	21.16	18.91	19.96	19.86		
% TB	29	29	30	29	30	29	31	29	28	29	29	29		
Mg%	0.107	0.1	0.097	0.1	0.103	0.101	**0.09**	**0.107**	**0.106**	0.096	0.099	0.11	<.01	19
%	100	93	91	100	103	101	100	119	118	100	103	115		
me/100g	8.81	8.23	7.98	8.23	8.48	8.31	7.41	8.81	8.72	7.9	8.15	9.05		
% TB	13	12	12	12	12	13	14	12	12	12	12	13		
Cl%	0.615	0.595	0.626	0.612	0.615	0.608	**0.082**	**0.699**	**11.054**	0.556	0.675	0.604	0.145	43
%	100	97	102	100	100	99	100	852	1285	100	121	109		
mmol/100g	17.35	16.78	17.66	17.26	17.35	17.15	2.31	19.72	29.73	15.68	19.04	17.04		
% TB	26	25	27	25	26	26	4	27	39	24	28	25		
TB	67.66	67.38	66.11	67.79	67.92	65.89	53.8	72.38	75.4	64.66	68.26	69.06		

4. Soil

The most recent soil data is shown in Appendix II along with soil data from other trials for comparison.

5. Discussion

Table 48 indicates results from the continuous monitoring plots. The MOP response is particularly variable between years. This could be explained by the involvement of Cl with plant water regulation, which would allow better performance under dry conditions with higher Cl levels. Under non-limiting conditions this benefit might disappear.

Examination of leaf and rachis data for trial 306 does not indicate a K deficiency, confirming the suggestion of a Cl response.

SUMMARY :

The major response to SOA has continued in 1990, with substantially increased yields and responses.

During the year the mean response to N1 was 7.6 t, and to N2 10.2 t, raising yields from 24.5 to 34.7 t/ha, for an input of 3kg of SOA per palm.

The maximum yield of 35.5 t was attained with the N2K2 fertilizer combination, whilst N2K0 achieved 34 t.

SOA also significantly increased every growth measurement, including the important bunch index (BI) and the efficiency of conversion (e) parameters, which were unaffected by any other nutrients.

No overall significant yield responses were found for TSP or kieserite.

In the absence of SOA the MOP treatment tended to reduce yields, whereas in the presence of SOA the MOP increased yields up to 3 tonnes.

Bunch index values have remained below 305 values, reflecting the relatively poorer yields from trial 306 for the period 88-90.

Examination of leaf and rachis data for trial 306 does not indicate a K deficiency, confirming the suggestion that the MOP benefit is due to a Cl response.

The Cl benefit would be expected to be mainly expressed under conditions of moisture stress, which would account for the variability of response to MOP in different years.

Table 48: Progressive changes in yield and nutrient status

N0K0	83	84	85	86	87	88	89	90	AVG
Yield		26.1	30.3	23.2	14.4	15.7	18.7	21.1	21.36
N%	2.8	2.8	2.6	2.4	2.3		2.01	2.07	2.43
K%	1.2	1.22	1.13	1.01	0.77		0.77	0.84	0.99
K%TB								29	29
P%	0.18	0.18	0.17	0.15	0.14		0.14	0.14	0.16
Cl%	0.23	0.1	0.09	0.05	0.04		0.05	0.07	0.09
Cl% rc								0.07	0.07
Mg%								0.25	0.25
Mg%TB								27	27
K% rc							1.03	1.3	1.17

N1K0	83	84	85	86	87	88	89	90	AVG
Yield		23.7	38.0	32.9	27.7	19.4	24.9	26.5	27.59
N%	2.6	2.7	2.9	2.5	1.9		2.33	2.33	2.47
K%	1.2	1.07	1.02	1.06	0.81		0.8	0.86	0.97
K%TB								30	30
P%	0.16	0.18	0.18	0.16	0.16		0.15	0.15	0.16
Cl%	0.21	0.09	0.1	0.09	0.04		0.06	0.08	0.1
Cl% rc								0.07	0.07
Mg%								0.21	0.21
Mg%TB								24	24
K% rc							1	1.02	1.01

(Table 48 contd)

N0K1	83	84	85	86	87	88	89	90	AVG
Yield		21.4	33.7	31.4	22.5	16.7	21.5	25.8	24.71
N%	2.7	2.8	2.7	2.6	2.2		2.04	1.96	2.43
K%	1.2	1.13	0.98	0.87	0.79		0.79	0.82	0.94
K%TB								26	26
P%	0.16	0.17	0.17	0.14	0.14		.145	.139	0.15
Cl%	0.31	0.36	0.56	0.46	0.48		0.38	0.36	0.42
Cl% rc								0.56	0.56
Mg%								0.22	0.22
Mg%TB								23	23
K% rc							1.2	1.4	1.3
N1K1	83	84	85	86	87	88	89	90	AVG
Yield		29.9	33.1	33.6	31.3	22.6	28.5	32.4	30.2
N%	2.7	2.8	2.6	2.7	2.5		2.18	2.23	2.53
K%	1.1	1.05	0.97	0.89	0.78		0.85	0.79	0.92
K%TB							1.1	27	14
P%	0.16	0.17	0.17	0.15	0.15		.146	.151	0.16
Cl%	0.32	0.47	0.47	0.47	0.44		0.36	0.33	0.41
Cl% rc								0.47	0.47
Mg%								0.2	0.2
Mg%TB								22	22
K% rc							1.1	1.4	1.25

Table 48 contd.)

	83	84	85	86	87	88	89	90	AVG
Yield								33.9	33.9
N%								2.4	2.4
K%								0.83	0.83
K%TB								30	30
P%								.151	0.15
Cl%								0.34	0.34
Cl% rc								0.57	0.57
Mg%								0.2	0.2
Mg%TB								24	24
K% rc								1.45	1.45
ASL analyses to 1988, then AAR									

TRIAL 309-B, SOURCES OF POTASSIUM TRIAL, AMBOGO

PURPOSE :

To provide a comparison between bunch ash and MOP, with and without SOA, both as a basis for practical fertilizer recommendations, and to extend the understanding of anion effects and K uptake within the oil palm.

SITE DETAILS :

Location: Ambogo Estate HOPPL, block 80H.
Genetic material: Dami commercial DxP crosses.
Soils: Penderetta family - of recent alluvially reworked volcanic origin, having a thin dark sandy clay loam topsoil, overlying a sandy loam subsoil, with mottling due to seasonally high water tables.
Planting date: 1980.
Density: 143 points/ha.
Size: The trial comprises 25 plots totalling 1162 palms including the guard rows, and is surrounded by additional areas fertilized by OPRA to ensure separation from estate fertilizing.

DESIGN AND TREATMENT DETAILS :

Background: Trial 309-B has been superimposed on an EFB trial
commenced in 1984. Final details of trial 309 are available in the 1987 and 1988 Annual Reports.
Statistical background: Trial 309 is a latin square design, with 5 treatments, each occurring once on each previous treatment, and once on each previous block.
Layout: The plots consist of a core of 16 recorded palms, surrounded by a guard row, making a total of 36 palms per plot. Additional guard palms were introduced during 1990 outside the existing plots where practicable, to provide double guard rows.
Trial commencement: 1984.
Trial progress: Converted to Trial 309-B in January 1988.
Treatment application: January 1988 and then every 6 months.

Treatments:

Treatment codes:	1	2	3	4	5
MOP palm/yr	0	2	0	2	0
Bunch Ash palm/yr	0	0	4	0	4
SOA palm/yr	0	0	0	2	2

Notes:

1. The exact rate of Bunch Ash may be adjusted to achieve equivalent K content to the MOP applications.

2. The Bunch Ash is normally applied 1 month after the other fertilizers, to avoid volatalisation of ammonium salts.

1. **Trial Modification: 1990**

The zero N plots did not show any response to K treatments, so the treatment structure was modified replacing these 2 treatments with a direct comparison of N sources without K application, whilst retaining both the existing N plus K treatments and the control.
The opportunity was also taken to adjust the N treatment rates to bring them into line with the revised rates in use in the 310 anion trial. The K application rate was also increased to achieve a balance in Cl levels between the AMC and SOA + MOP treatments.

Each N source supplies the same rates of N in different anionic combinations. Comparison between the revised treatments will allow identification of response due to different combinations of N, K and anions.

The revised treatments are as follows:

Treatment codes:	1	2	3	4	5
MOP palm/yr	0	0	0	4.4	0
Bunch Ash palm/yr *	0	0	0	0	8.8
SOA palm/yr	0	0	4	4	4
AMC palm/yr	0	3.2	0	0	0

Notes:

1. The exact rate of Bunch Ash may be adjusted to achieve equivalent K content to the MOP applications.

2. The Bunch Ash is normally applied 1 month after the other fertilizers, to avoid volatalisation of ammonium salts.

The new treatments were first applied on 4th June 1990, and thus are not expected to be reflected in 1990 yield recording, for which the earlier 309 (b) analysis has been used.

2. **Materials**

Table 49 indicates the analysis of the bunch ash used during the latest application round. This analysis is similar to the previous years analyses.

Table 49: Trial 309-B Bunch Ash Analysis

		December 1990 Sample No 1	2	3	ASL Mean	DM basis
ASL						
Dry Matter	%	91.6	90.6	90.6	90.9	87.3
Water sol K	%	27	25	25	26	25
Acid digst K	%	24	21	19	21	20.2
P	%	1.5	1.5	1.5	1.5	1.441
S	%	0.77	0.71	0.75	0.743	0.714
Na	%	0.13	0.12	0.12	0.123	0.118
Ca	%	4.7	4.7	4.8	4.73	4.54
Mg	%	2	2.1	2	2.03	1.95
Fe	ppm	2430	2930	2090	2483	2385
Mn	ppm	280	295	295	290	279
Zn	ppm	310	320	310	313	301
Cu	ppm	150	160	150	153	147
B	ppm	71	102	78	84	81

N.B.
1. ASL data reported on an "as received " basis
2. Adjusted to a "as used" basis using the DM figures measured at OPRA prior to despatch.

3. **Yield**

There has been a remarkable response to the application of SOA at the low rate of 2kg per palm, which commenced in 1988. The mean response in 1990 was 14.4 t (average response for 89/90 was 12 t).

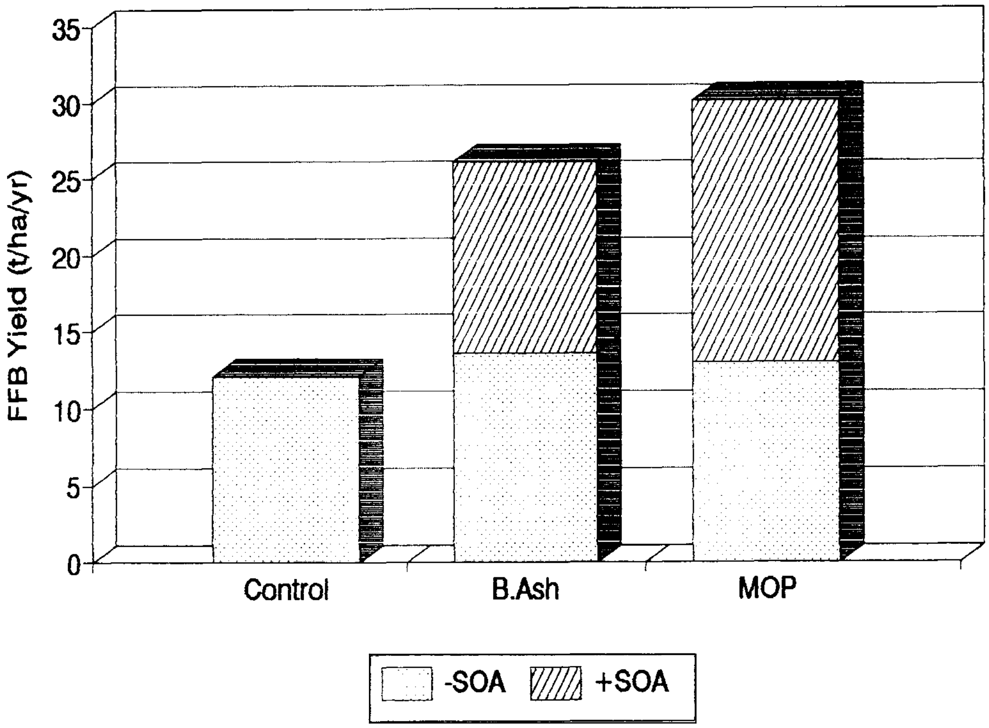
The control plots averaged 12.1 t. The SOA response arose as a combination of improved bunch numbers and improved bunch weights.

Table 50: Trial 309-B yield data

	FFB Yield t/ha	Bunch Number /ha	Bunch Wt. (kg)	FFB Yield t/ha	Bunch Number /ha	Bunch Wt. (kg)
Treatments	1990	1990	1990	89-90	89-90	89-90
Individual						
Control	**12.1**	**858**	**14.0**	**10.6**	**769**	**13.4**
MOP	**13.0**	**838**	**15.3**	**10.9**	**752**	**14.1**
BA	**13.6**	**894**	**15.0**	**11.5**	**811**	**13.8**
MOP+N	**30.1**	**1416**	**21.3**	**24**	**1248**	**19.0**
BA+N	**26.1**	**1367**	**19.1**	**22.4**	**1267**	**17.6**
lsd	5.7	251	3.1	4.2	218	2.8
sed	2.6	114	1.41	1.9	99	1.27
Grouped						
+SOA	**28.1**	**1392**	**20.2**	**23.2**	**1257**	**18.3**
-SOA	**13.3**	**866**	**15.1**	**11.2**	**781**	**14.0**
MOP	**21.5**	**1127**	**18.3**	**17.4**	**1000**	**16.6**
BA	**19.8**	**1131**	**17.0**	**16.9**	**1039**	**15.7**
gm	19	1075	17	15.9	969	15.6
lsd	4	178	2.2	3	154	2
cv	22	17	13	19	16	13

MOP and BA in the absence of N did not differ significantly from the control. In the presence of N a MOP response appeared to be developing, with sbw about 2 kg higher and yield up to 4 t higher, although at this stage the effect is not statistically significant at the 5% level. An increase in sbw is characteristic of the MOP effect seen in the other trials. Interestingly this effect is not seen with BA, which is also proving effective in supplying K to the plant, suggesting that the benefit is due to Cl rather than K.

Figure 40: Trial 309-B Yields 1990



4. Growth

As in the other Higaturu trials N has again had a highly significant effect on every aspect of palm growth, including the vital parameters of BI (+19%), LAI (+17%), and e (+68%).

Examination of individual treatments indicated a consistent advantage to the N+MOP treatment in comparison to the N+BA treatment. This contrast was not visible in comparison of MOP and BA in the absence of SOA (both of which were virtually identical to the control). This would confirm the general trend for MOP response only to be identified in the presence of the major limiting factor: N.

With the new N treatments introduced in June 1990 there was a very dramatic improvement seen in palm colour and leaf development over the subsequent few months, and the initial effects are expected to be reflected in the 1991 recordings.

<u>**Table 51: Expt. 309, Palm Growth parameters 1989-90**</u>

	6/90 Vt.Ht. (m)	89-90 Frd.pr /yr	89-90 Frd.wt kg	89-90 FDM t/ha/y	89-90 BDM t/ha/y	89-90 VDM t/ha/y	89-90 TDM t/ha/y	89-90 BI	1990 LAI	1990 f	1990 e gMJ^{-1}
Control	3.03	**19.7**	**2.2**	**6.2**	**8.7**	**7.9**	**16.6**	**0.51**	**4.5**	**0.850**	**0.62**
MOP	3.22	**20.2**	**2.4**	**6.9**	**8.9**	**8.7**	**17.6**	**0.49**	**4.6**	**0.863**	**0.65**
BA	3.1	**20.6**	**2.2**	**6.6**	**9.4**	**8.4**	**17.8**	**0.52**	**4.5**	**0.856**	**0.66**
MOP+ N	3.3	**22.8**	**2.9**	**9.5**	**19.7**	**12.8**	**32.5**	**0.60**	**5.6**	**0.910**	**1.14**
BA+N	3.15	**23.1**	**2.6**	**8.6**	**18.4**	**11.6**	**30.0**	**0.61**	**5.2**	**0.893**	**1.07**
lsd	0.35	0.8	0.33	1.1	3.4	1.6	4.9	0.04	0.59	0.034	0.16
Grouped											
+SOA	3.22	**23**	**2.8**	**9.1**	**19**	**12.2**	**31.2**	**0.60**	**5.4**	**0.901**	**1.11**
-SOA	3.16	**20.4**	**2.3**	**6.8**	**9.2**	**8.5**	**17.7**	**0.51**	**4.6**	**0.859**	**0.66**
MOP	3.26	21.5	**2.7**	8.2	14.3	10.7	25.0	0.55	5.1	0.886	0.89
BA	3.12	21.9	**2.4**	7.6	13.9	10	23.9	0.56	4.9	0.874	0.87
lsd	0.25	0.56	0.24	0.8	2.4	1.1	3.5	0.03	0.42	0.024	0.12
cv	8	8	10	11	19	12	16	6	9	3	14

5. **Nutrient Analysis**

Details of the latest analyses are given in Tables 52, 53 and Figures 41 and 42

The major response, corresponding to yield differentials was an increase in N levels within plants receiving SOA. SOA also brought about reductions in leaf Ca and plant Mg, increases in leaf K, and redistribution of P from the rachis to the leaf. Uptake of Cl was enhanced in the presence of SOA, with leaf levels increased by 20%.

The overall effect of SOA was to depress the level of total bases, whereas the overall effect of MOP was to raise the level of total bases. SOA had an acidifying effect reducing soil base levels, while the Cl uptake from MOP was accompanied by an increased base uptake.

In comparing MOP and BA the main difference was the direct Cl effect of MOP, and the associated rise in base levels. In the leaf this resulted in an increased Ca level and a reduced K level. BA application actually appeared to reduce plant Ca levels. Both sources substantially raised plant K levels. In the absence of SOA BA was as effective as MOP, but in the presence of SOA, MOP had an enhanced effect and BA a reduced effect. Neither source demonstrated a significant effect upon Mg nutrition.

Fig. 41: Trial 309, Leaf % N

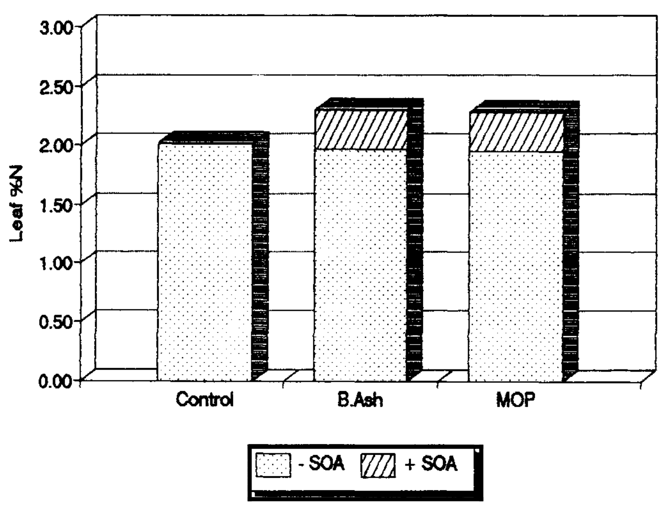


Fig. 42: Trial 309, Leaf % Cl

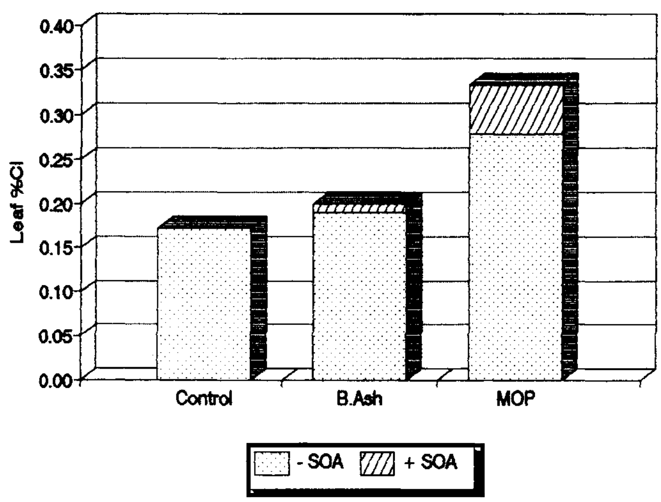


Table 52: Trial 309-B, Leaf Analysis Related to Fertilizer Treatment

	0	KCL	BA	KCl+N	BA+N	+N	-N	KCL	BA	lsd1	lsd2	cv
N%	2.02	1.95	1.97	2.28	2.3	2.29	1.96	2.11	2.13	0.2	0.14	7
%	100	97	98	113	114	100	86	92	93			
P%	0.14	0.141	0.141	0.147	0.15	0.149	0.141	0.144	0.146	0.006	0.004	3
%	100	101	101	105	107	100	95	97	98			
K%	0.742	0.732	0.782	0.846	0.884	0.865	0.757	0.789	0.833	0.084	0.059	8
%	100	99	105	114	119	100	88	91	96			
me/100g	19	18.7	20	21.6	22.6	22.1	19.4	20.2	21.3			
% TB	25	23	26	29	30	30	25	26	28			
Mg%	0.24	0.26	0.26	0.21	0.21	0.212	0.266	0.239	0.239	0.035	0.025	11
%	100	112	110	88	89	100	125	113	113			
me/100g	19.8	22.1	21.7	17.3	17.6	17.4	21.9	19.7	19.7			
% TB	26	28	28	23	24	23	28	26	26			
Ca%	0.762	0.79	0.73	0.72	0.7	0.712	0.765	0.76	0.717	0.057	0.041	6
%	100	104	96	95	92	100	107	107	101			
me/100g	37.4	39	36	35.5	34.3	34.9	37.5	37.3	35.1			
% TB	49	49	46	48	46	47	48	48	46			
Cl%	0.172	0.28	0.19	0.33	0.2	0.267	0.234	0.306	0.195	0.033	0.023	10
%	100	162	110	194	116	100	88	115	73			
me/100g	4.9	7.8	5.4	9.4	5.6	7.5	6.6	8.6	5.5			
% TB	6	10	7	13	8	10	8	11	7			
TB	76.2	79.8	77.7	74.4	74.5	74.4	78.8	77.2	76.1			

[lsd1 and lsd2 are for individual (columns 2-6) and grouped (columns 7-10) treatments respectively]

Table 53: Trial 309-B Rachis analysis related to fertilizer treatment

		KCl	B.A.	KCL+N	B.A.+N	+N	-N	KCl	B.A.	lsd1	lsd2	cv
N%	0.21	0.212	0.204	0.22	0.216	0.218	0.208	0.216	0.21	0.026	0.019	9
%	100	101	97	105	103	100	95	99	96			
P%	0.137	0.15	0.177	0.132	0.095	0.114	0.163	0.141	0.136	0.048	0.034	25
%	100	109	129	96	69	100	143	124	119			
K%	0.92	1.18	1.16	1.25	1.04	1.15	1.17	1.21	1.1	0.167	0.118	11
%	100	128	126	136	113	100	102	105	96			
me/100g	23.5	30.2	29.7	32	26.6	29.4	29.9	30.9	28.1			
% TB	55	57	61	61	63	62	59	59	62			
Mg%	0.072	0.096	0.078	0.06	0.044	0.052	0.087	0.078	0.061	0.032	0.023	21
%	100	133	108	83	61	100	167	150	117			
me/100g	5.9	7.9	6.4	4.9	3.6	4.3	7.2	6.4	5			
% TB	14	15	13	9	8	9	14	12	11			
Ca%	0.278	0.308	0.262	0.318	0.25	0.284	0.285	0.313	0.256	0.038	0.027	10
%	100	111	94	114	90	100	100	110	90			
me/100g	13.6	15.1	12.8	15.6	12.3	13.9	14	15.3	12.5			
% TB	32	28	26	30	29	29	27	29	27			
Cl%	0.074	0.348	0.108	0.38	0.082	0.231	0.228	0.364	0.095	0.057	0.041	21
%	100	470	146	514	111	100	99	158	41			
me/100g	2.1	9.8	3	10.7	2.3	6.5	6.4	10.3	2.7			
% TB	5	18	6	20	5	14	13	20	6			
TB	43	53.2	48.9	52.5	42.5	47.6	51.1	52.6	45.6			

[lsd1 and lsd2 are for individual (columns 2-6) and grouped (columns 7-10) treatments respectively]

6. Discussion

The tissue data indicate that principle nutritional difference between BA and MOP was the Cl component of the MOP, and associated changes plant base levels. Both sources had broadly similar effects upon K nutrition, although in the presence of SOA, MOP effected a substantially greater increase in plant K uptake. However, the associated base uptake resulted in a lower leaf K response to MOP than to BA even in the presence of SOA.

In comparing production responses between MOP and BA it would therefore be reasonable to attribute any differences to Cl nutrition rather than K nutrition. As the nature of the response developing to MOP in this trial is identical to that in the other trials, with increases in sbw and frond weight, this would confirm that responses to MOP at Higaturu could generally be attributed to Cl rather than to K.

This trial has major implications for smallholder production, indicating the scope for yield increases from the smallholder average of 12 t (which almost exactly corresponds with the trial control) to as much as 30 t with very modest inputs of N fertilizer.
Use of AMC to supply Cl, rather than straight SOA appears to offers the potential for several tonnes of additional yield for no additional cost.

The trial is also particularly valuable as a demonstration for visitors of the dangers of failing to fertilize correctly.

SUMMARY:

There has been a remarkable response to the application of SOA at the low rate of 2kg per palm, which commenced in 1988. A maximum response of 18 t was recorded in 1990 (in the presence of MOP). The control plots averaged 12.1 t.

With the introduction of new N fertilizer treatments, rapid visual improvement has been noted on palms receiving N for the first time.

The trial has major implications for smallholder production, indicating the scope for yield increases from the smallholder average of 12 t (which almost exactly corresponds with the trial control) to as much as 30 t with very modest inputs of N fertilizer.

Use of AMC to supply Cl, rather than straight SOA appears to offer the potential for several tonnes of additional yield at no additional cost.

No response to K was identified.

No response to MOP or BA was identified in the absence of SOA.

In the presence of SOA a response to Cl appears to be developing, with increases in sbw and frond weight particularly apparent.

The trial confirms that the responses to MOP at Higaturu are more likely to be due to Cl than to K.

Both MOP and BA appear efficient sources of K. Application of MOP also increased plant Ca content in comparison with BA.

In terms of effects upon tissue nutrients, the overall effect of SOA was to depress the level of total bases, whereas the overall effect of MOP was to raise the level of total bases. This can be accounted for by a the acidifying effect of SOA reducing soil base levels, and the Cl uptake from MOP being accompanied by an increased base uptake.

The trial is also particularly valuable as a demonstration for visitors of the dangers of failing to fertilize correctly.

The plots which received EFB in 1984 have continued to yield 20% above the no EFB controls in 1990.

Table 54: Trial 309-B Progressive changes in yield and nutrient status

		ASL	AAL	DAL	
Control		88	89	90	Avg
17	Yield	7.70	9.70	10.6	9.33
	N%	1.90	2.02	2.05	1.99
	K%	0.69	0.77	0.79	0.75
	K% TB			23	
	P%	0.14	0.14	0.14	0.14
	Cl%	0.20	0.17		0.19
	Mg%	0.27	0.24	0.35	0.29
	Mg% TB			32	32.00
	K% rc	0.66	1.00		0.83

(Table 54 contd.)

MOP		88	89	90	Avg
12	Yield	12.70	13.30	13.8	13.27
	N%	2.00	1.87	1.9	1.92
	K%	0.63	0.62	0.77	0.67
	K% TB			22	
	P%	0.14	0.13	0.14	0.14
	Cl%	0.22	0.23		0.23
	Mg%	0.36	0.26	0.36	0.33
	Mg% TB			33	33.00
	K% rc	0.87	1.06		0.97

BA		88	89	90	Avg
1	Yield	14.9	15.1	19.9	16.63
	N%	2	1.97	2.09	2.02
	K%	0.71	0.77	0.86	0.78
	K% TB			27	
	P%	0.14	0.146	0.15	0.15
	Cl%	0.26	0.2		0.23
	Mg%	0.24	0.2	0.74	0.39
	Mg% TB			30	30.00
	Rach K%	0.8	1.03		0.92

(Table 54 contd.)

MOP+N		88	89	90	Avg
23	Yield	10.6	18	29.5	19.37
	N%	2	2.24	2.22	2.15
	K%	0.71	0.8	0.82	0.78
	K% TB			26	
	P%	0.14	0.144	0.14	0.14
	Cl%	0.2	0.25		0.23
	Mg%	0.26	0.18	0.22	0.22
	Mg% TB			23	23.00
	Rach K%	0.93	1.18		1.05
BA+N		**88**	**89**	**90**	**Avg**
9	Yield	8.2	20.9	27.1	18.73
	N%	2	2.46	2.45	2.30
	K%	0.64	0.92	0.92	0.83
	K% TB			28	
	P%	0.14	0.151	0.16	0.15
	Cl%	0.23	0.18		0.21
	Mg%	0.32	0.21	0.25	0.26
	Mg% TB			25	25.00
	K% rc	0.73	1.05		0.89

(For 1990 tissue data from plots 18 & 22 was substituted for plots 1 & 12)

TRIAL 310, ANION AND FERTILIZER FREQUENCY TRIAL, AMBOGO

PURPOSE:

1. To compare response to the K cation, and S and Cl anions in different combinations.

2. To compare urea, SOA and AMC as N fertilizer sources.

3. To compare responses to bunch ash and MOP.

4. To compare different practical regimes of fertilizers supplying N, K and anions.

SITE DETAILS :

Location: Ambogo Estate HOPPL, block 80 D.5.
Genetic material: Dami commercial DxP crosses.
Soils: Ambogo and Penderetta families, which are of recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam subsoil, with seasonally high water tables.
Planting date: 1980
Density: 143 points/ha.
Size: The trial comprises 35 plots totalling 1528 palms including the guard rows, and is surrounded by additional areas fertilized by OPRA to ensure separation from estate fertilizing.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 310 is a randomised complete block trial, of 5 replicates, each comprising 7 different treatments.
Layout: The plots consist of a core of 16 recorded palms, surrounded by a guard row, making a total of 36 palms per plot. Additional guard palms were introduced during 1990 outside the existing plots where practicable, to provide double guard rows.
Trial commencement: November 1986.
Trial progress: Ongoing.

Treatments from November 1990:

Revised Treatments				Previous	
Code	N	K	Notes	Treatments:	Notes
1.	Urea	-	N	Urea	N
2.	SOA	-	NS	Sulphate	N + S
3.	AMC	-	NCl	Chloride	N + Cl
4.	SOA	BA	NS + K	SOP: 6 monthly	N + KS
5.	AMC	BA	NCl+ K	MOP: 6 monthly	N + KCl
6.	SOA	MOP	NS + KCl	SOP: annually	N + KS
7.	SOA/AMC	-	NS + NCl	MOP: annually	N + KCl

The revised system maintains the balance of anions except for treatments 6 and 7 where this is impossible due to application of both types of anion. However, treatments 6 & 7 both have the same input of the important Cl anion, and make the practical comparison between AMC and SOA, and SOA and MOP at the same overall N input.

As in trial 309 bunch ash is applied to provide equivalent K levels to the mineral K fertilizers.

Fertilizer application rates in kg/palm/year:

Treatment :	1	2	3	4	5	6	7
Urea	1.8	0	0	0	0	0	0
SOA	0	4	0	4	0	4	2
AMC	0	0	3.2	0	3.2	0	1.6
BA	0	0	0	4.4	4.4	0	0
MOP	0	0	0	0	0	2	0

Modifications:

1. Originally Magnesium based salts were used as the non-potassium source for sulphate and chloride. These presented serious problems in supply, storage and application. From November 1988 until May 1990, sodium chloride and sodium sulphate were substituted, to overcome these problems and also provide a comparable mono-valent anion source.

2. Application of nitrogen to the trial area was commenced with an overall application of urea at 600 gm/palm on 22/12/88 and was continued twice a year. From November 1990 urea was restricted to the control plots, and the rate was increased to 900 gm/palm.

3. Treatments were completely revised in November 1990, with the introduction of Nitrogen salts as anion sources, and BA as a non-ionic K source. A 50% increase in N rates was also effected. The comparison between different frequencies of K fertilizer application was replaced with new dual anion treatments.

RESULTS :

1. Yield:

Yields in trial 310 have generally been low, and this can be attributed to the late commencement of N fertilizing (December 1988) and the subsequent relatively low rate in use until November 1990.

It is probable that shortage of N restricted responses in the trial.

Yield response for the period 1989-90 has finally provided a clear differentiation between response to K and response to Cl.
Examination of the data indicates that there was a clear response to Cl but no response to K.

The response was mainly as an increase in sbw (up to 2.3 kg). The response has been largely balanced by reductions in bunch numbers, but in 1990 the overall yield was increased by 2.6 t by chloride, and 2.1 t by sulphate. The equivalent K anion sources both gave lower responses, indicating the possibility of a reduction in yield through application of K fertilizer in comparison to other anion sources.

In comparing 6 monthly application of MOP against a single annual application of the same amount, no difference has been detected for the entire trial period. This indicates that if the primary requirement is for Cl, an application frequency of once a year is quite adequate.

Table 55: Trial 310 Yield data

	1990			89-90		
	Wt. of bunches	No. of bunches per ha	Single Bch.Wt kg	Wt. of bunches t/ha	No. of bunches per ha	Single Bch.Wt kg
Control	26.8	1444	**18.5**	24.5	1301	18.7
S	28.9	1489	**19.5**	26.9	1412	19.1
Cl	29.4	1446	**20.4**	25.7	1253	20.6
KS	26.1	1353	**19.3**	24.4	1284	19.1
KCl	28.5	1373	**20.8**	25.3	1244	20.3
-K	29.2	1468	19.9	26.3	1333	19.8
+K	27.3	1363	20.1	24.9	1264	19.7
Cl	29.0	1410	**20.6**	25.5	**1248**	**20.4**
S	27.5	1421	**19.4**	25.7	**1348**	**19.1**
1x	27.0	1329	20.4	24.5	1234	19.9
2x	27.6	1397	19.7	25.2	1294	19.4
lsd K	2.6	135	1.1	2.1	110	0.93
lsdCl,S	2.4	127	1	2	103	0.88
lsd 1,2	3	155	1.3	2.4	127	1.08
c.v.	12	12	7	10	11	6

Figure 43: Trial 310 Yields 1990

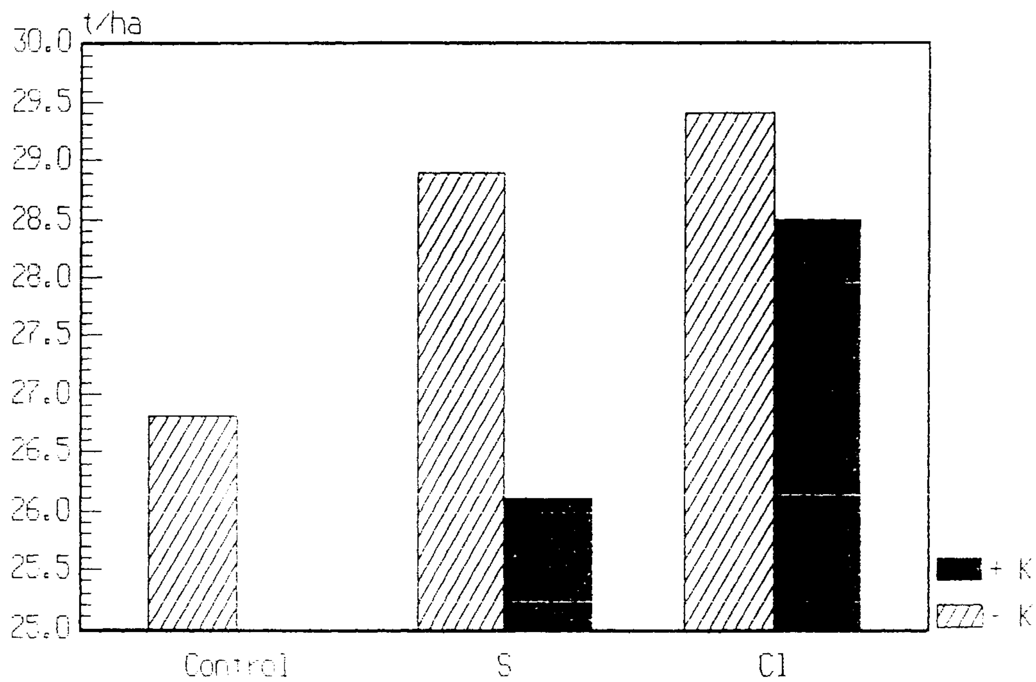
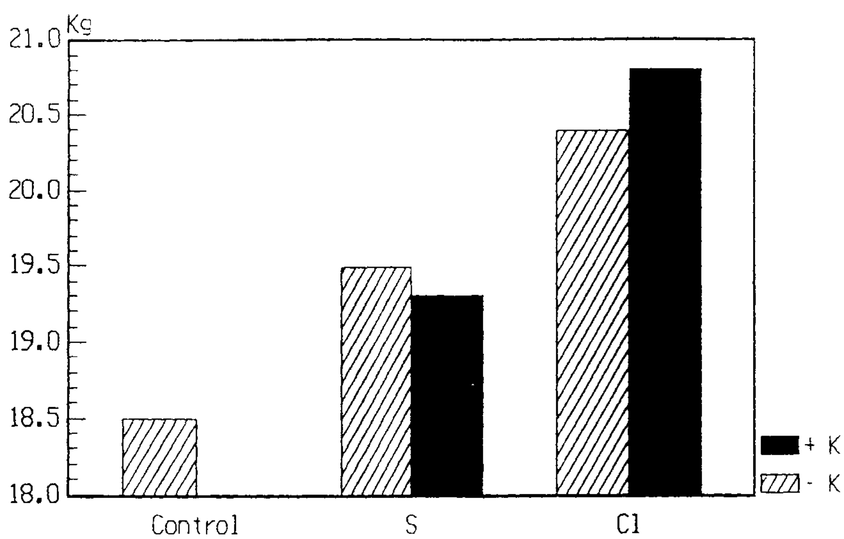


Figure 44: Trial 310 Single Bunch 89/90



2. **Growth**

The latest data provide a much clearer picture of responses developing within the trial, possibly as a result of improvements in N nutrition arising subsequent to the December 1988 introduction of N fertilizing for the trial.

Clear responses to Cl have been identified in terms of increases in FW, FDM and VDM. The S treatments were also consistently above the control, with the vegetative responses about 50% of those to Cl.
There was no response to K and no response to MOP application frequency.

Since FW, FDM and VDM are characteristically increased by MOP application in the other trials, these results confirm that responses to MOP at Higaturu have been due to Cl rather than K.

3. **Plant Analysis.**

Trial 310 provides an interesting opportunity to unravel the relative effects of K and Cl, which is mot possible in the major factorials where these 2 nutrients are applied in combination as MOP.

Application of K (as SOP or MOP) in comparison to the other treatments resulted in:

1. An increase in rachis K levels and decrease in leaf K levels.
2. A depression of the already low N levels.

3. Increased Ca levels in the plant.

4. A 56% increase in the Cl content of the rachis (but no effect on the leaf) in comparison to Magnesium chloride.

Effects of the different fertilizers upon Mg levels were particularly interesting:

1. Kieserite application was quite ineffective, actually reducing Mg levels.

2. Both MOP and SOP application surprisingly raised Mg levels.

3. The most effective fertilizer in increasing Mg (6% in the leaf and 38% in the rachis) was magnesium chloride.

Table 56: Trial 310 Palm Growth and Conversion data

	9/90 Height m (VH)	89-90 Leaf prdn (n)	89-90 Dry Frond weight kg (FW)	89-90 Frond DM tha (FDM)	89-90 Bunch DM tha (BDM)	89-90 Veg. DM tha (VDM)	89-90 Total DM tha (TDM)	89-90 Bunch Index (BI)	1989 Leaf Area Index (LAI)	1989 Extinct. coeff (f)	1989 Effic. energy (e)
Control	4.81	22	**3.47**	**9.7**	20.1	**13**	33.1	0.605	5.8	0.916	1.15
S	4.85	22.4	**3.55**	**10.1**	22.1	**13.6**	35.7	0.617	5.9	0.919	1.24
Cl	4.79	22.4	**3.71**	**10.6**	21.1	**14.1**	35.2	0.599	6.2	0.927	1.21
KS	4.85	21.9	**3.64**	**10.1**	20.0	**13.5**	33.5	0.596	6.1	0.924	1.16
KCl	4.74	22.2	**3.81**	**10.7**	20.7	**14.2**	34.9	0.592	5.9	0.919	1.21
-K	4.82	22.4	3.63	10.3	21.6	13.9	35.5	0.608	6.0	0.923	1.23
+K	4.8	22	3.72	10.4	20.4	13.9	34.2	0.594	6.0	0.922	1.19
Cl	4.77	22.3	**3.76**	**10.7**	20.9	**14.2**	35.1	0.596	6.0	0.923	1.21
S	4.85	22.1	**3.6**	**10.1**	21.0	**13.6**	34.6	0.607	6.0	0.922	1.20
1x	4.8	22.2	3.74	10.5	20.1	13.9	34.0	0.591	5.9	0.919	1.18
2x	4.8	21.9	3.71	10.3	20.6	13.8	34.4	0.598	6.1	0.924	1.19
lsd K	0.23	0.4	0.15	0.51	1.71	0.67	2.2	0.015	0.26	0.008	0.072
lsd Cl,S	0.21	0.4	0.14	0.48	1.61	0.63	2.08	0.014	0.24	0.008	0.068
lsd 1,2	0.26	0.5	0.18	0.59	1.97	0.77	2.55	0.018	0.3	0.01	0.083
c.v.	6	3	5	6	10	6	8	3	5	1	8

Table 57: Trial 310, Leaf analyses, October 1988

	0	S	Cl	KS	KCl	-K	+K	Cl	S	lsd1	lsd2	cv
N%	2.23	2.2	2.24	2.03	2.04	2.22	2.04	2.11	2.11	0.085	0.074	4
%	100	99	100	91	91	100	91	95	95			
P%	0.146	0.144	0.149	0.15	0.149	0.146	0.149	0.149	0.147	0.005	0.004	3
%	100	99	102	103	102	100	102	102	101			
K%	1.09	1.1	1.06	1.01	0.97	1.08	0.99	1.01	1.06	0.054	0.047	5
%	100	101	97	93	89	99	91	93	97			
me/100g	27.9	28.1	27.1	25.8	24.8	27.6	25.3	25.8	27.1			
% TB	31	33	30	29	29	32	29	29	31			
Mg%	0.262	0.239	0.278	0.264	0.254	0.258	0.259	0.266	0.252	0.016	0.013	7
%	100	91	106	101	97	98	99	101	96			
me/100g	21.6	19.7	22.8	21.7	20.9	21.2	21.3	21.9	20.7			
% TB	24	23	26	24	24	24	24	25	24			
Ca%	0.802	0.766	0.802	0.843	0.84	0.784	0.841	0.82	0.805	0.036	0.03	5
%	100	96	100	105	105	98	105	102	100			
me/100g	39.3	37.5	39.3	41.3	41.2	38.4	41.2	40.2	39.5			
% TB	44	44	44	47	47	44	47	46	45			
Cl%	0.149	0.198	0.372	0.1707	0.399	0.285	0.285	0.385	0.185	0.019	0.017	8
%	100	133	249	115	268	191	191	258	124			
mmol/100g	4.2	5.6	10.5	4.8	11.3	8	8	10.9	5.2			
S%	0.138	0.128	0.119	0.128	0.125	0.123	0.126	0.122	0.128	0.009	0.008	8
%	100	92	86	93	91	89	103	99	104			
mmol/100g	4.3	4	3.7	4	3.9	3.8	3.9	3.8	4			
TB	88.8	85.3	89.2	88.8	86.9	87.2	87.8	87.9	87.3			

[lsd1 and lsd2 are for individual columns (columns 2-6) and grouped treatments (columns 7-10) respectively]

Table 58: Trial 310. Rachis analyses, October 1988

	0	S	Cl	KS	KCl	-K	+K	Cl	S	lsd1	lsd2	cv
N%	0.234	0.229	0.257	0.237	0.233	0.243	0.235	0.231	0.247			
%	100	98	110	101	100	104	100	99	106			
P%	0.154	0.142	0.243	0.178	0.196	0.192	0.186	0.219	0.16	0.037	0.031	21
%	100	92	158	116	127	125	121	142	104			
K%	0.94	0.97	1.07	1.11	1.13	1.02	1.12	1.1	1.04	0.094	0.082	9
%	100	103	114	118	120	109	119	117	111			
me/100g	24	24.8	27.4	28.4	28.9	26.1	28.6	28.1	26.6			
% TB	39	39	34	37	36	36	36	35	38			
Mg%	0.062	0.059	0.086	0.077	0.083	0.072	0.08	0.084	0.068	0.006	0.005	8
%	100	95	138	124	134	117	128	135	109			
me/100g	5.1	4.9	7.1	6.3	6.8	6	6.6	6.9	5.6			
% TB	8	8	9	8	8	8	8	9	8			
Ca%	0.663	0.709	0.924	0.844	0.918	0.818	0.881	0.922	0.776	0.13	0.113	17
%	100	107	139	127	138	123	133	139	117			
me/100g	32.5	34.7	45.3	41.4	45	40.1	43.2	45.2	38			
% TB	53	54	57	54	56	56	55	56	54			
Cl%	0.058	0.087	0.228	0.081	0.356	0.158	0.218	0.292	0.084	0.027	0.023	17
%	100	148	391	139	609	270	373	500	144			
mmol/100g	1.6	2.4	6.4	2.3	10	4.4	6.1	8.2	2.4			
S%	0.032	0.032	0.032	0.027	0.028	0.032	0.027	0.03	0.029	0.009	0.008	30
%	100	100	100	84	87	100	83	93	90			
mmol/100g	1	1	1	0.8	0.9	1	0.8	0.9	0.9			
TB	61.6	64.4	79.8	76.1	80.7	72.2	78.4	80.2	70.2			

[lsd1 and lsd2 are for individual columns (columns 2-6) and grouped treatments (columns 7-10) respectively]

The overall effects of Cl application were:

1. Increases of several hundred percent in the plant Cl level.

2. A minor depression of leaf K, and an increase in rachis K.

3. An increase of 43% over the control in rachis P levels.

4. An increase in Ca level, particularly in the rachis.

Being taken in 1988, these results were will require confirmation by subsequent analyses. The situation is further complicated by modification of the treatments, and it is suggested that a full sampling be conducted in 1992, when the revised treatments have had time to be effective.

4. **Soil Data**

The latest soil analyses from this trial are shown in Appendix II along with similar data from other trials.

5. **Discussion**

5.1 Yield and Growth

Increases in sbw, FW, FDM and VDM are typical of responses seen in the Popondetta trials to MOP, and would confirm that the MOP benefit at Higaturu is presently due to the Cl component rather than to K. The increase in sbw could be seen as beneficial in terms of reduced costs, even if there were no associated increase in yield.

The response to non K sulphate agrees with the kieserite results in other trials where a response was found mainly in the absence of SOA. This would indicate a response to sulphate, rather than to Mg, particularly as kieserite applications have actually reduced the plant Mg levels.

With the sizeable response to non K chloride it is not possible to rule some Mg response, particularly as these fertilizers effected an increase in plant Mg levels, which had not been possible with the more usual kieserite source in use in the other trials. On the other hand Cl applications have also been beneficial even in combination with K and Na, so that there is definitely a Cl response, whether or not an Mg response may also exist.

One disadvantage of the revised treatments is that the measurement of anion response by comparison to the control will be difficult, since it will be confounded with a difference in N sources. If N utilisation from urea is poorer than from SOA and AMC, it may not be possible to distinguish between the benefits due to improved N nutrition, and those attributable to the anion effects.

5.2 Plant Analysis

Tissue analysis is providing very useful comparisons of the nutritional effects of the different anions, which will be a valuable baseline for assessing and understanding responses in all trials.

The response to magnesium chloride application was very interesting.

Although plant Mg levels are low, kieserite applications have not had any effect on Mg nutrition. The possibility that Mg nutrition might be improved by applying magnesium chloride as an alternative could have far reaching consequences for the improvement of yield on the PNG soils, and certainly deserves further investigation.

K application was observed to increase Ca levels. With high base saturation levels at Higaturu, plant Ca levels are such that Mg and K plant levels can be depressed, and raised Ca uptake would not be seen as beneficial.

The stimulation of Ca uptake by MOP application has usually been attributed entirely to the Cl effect, but this data indicates the possibility of an additional K effect. How application of one base would also stimulate uptake of another is not clear.

Application of K in other forms such as BA or EFB has not been found to promote Ca uptake, so that for practical purposes the increased Ca uptake can be attributed to the application of K as fertilizer salts: particularly MOP. The exact contribution of the K and the anion to the increased Ca uptake then become irrelevant to estate practice, since the 2 have to be applied in combination.

Assessment of rachis and soil data indicate that K availability in trial 310 is relatively poor in comparison to general Higaturu levels. Thus the absence of a K response in trial 310 is a conclusive indication that K responses can not generally be expected at other Higaturu locations.

SUMMARY

The latest data provide a much clearer picture of responses developing within the trial, possibly as a result of improvements in N nutrition arising subsequent to the December 1988 introduction of N fertilizing for the trial.

There was a clear yield response to Cl but no positive response to K.

There is evidence of response to sulphate as well as Cl, with Cl having a greater effect than sulphate.

Cl provided an increase in sbw of up to up to 2.3 kg, and a yield response of up to 2.6 t/ha, in addition to increases in FW, FDM and VDM.

Sulphate application provided an increase in sbw of up to up to 1 kg, and a yield response of up to 2.1 t/ha, as well as minor increases in FW, FDM and VDM.

The form of the response to Cl is identical to that seen to MOP in the other trials: with relatively poor K nutrition in trial 310 this is a conclusive indication that the responses to MOP at Higaturu can be attributed to Cl rather than to K.

The non-K fertilizers provided higher yields than the K fertilizers, indicating the possibility of a reduction in yield through application of K fertilizer in comparison to other salts.

In comparing 6 monthly application of MOP against a single annual application of the same amount, no difference has been detected for the entire trial period. Thus if the requirement is for Cl, an application frequency of once a year is quite adequate.

Effects of the different fertilizers upon Mg levels were interesting:

1. Kieserite application was quite ineffective, actually reducing Mg levels.

2. Both MOP and SOP application surprisingly raised Mg levels.

3. The most effective fertilizer in increasing Mg (6% in the leaf and 38% in the rachis) was magnesium chloride.

The response to magnesium chloride application could have far reaching consequences for the improvement of yield on low Mg status sites in PNG.

The response to kieserite (and sodium sulphate) agrees with the results from other trials where responses were found mainly in the absence of SOA, indicating a response to sulphate, particularly as kieserite applications have actually reduced the plant Mg levels.

Practical implications are that the primary anionic requirement is for Cl, with the likelihood of a supplementary benefit from sulphate application. Application of MOP or SOP is not required at present if other sources of the required anions can be obtained more cheaply.

Table 59: Trial 310 Progressive changes in yield and nutrients

			ASL		DAL	AVG
Control		87	88	89	90	
Plot 6	Yield	32.1	25.2	22.9	24	26.05
	N%	2.4	2.4		2.36	2.39
	K%	0.95	0.82		0.89	0.89
	K% TB		26		27	26.5
	P%	0.16	0.15		0.17	0.16
	Cl%	0.17	0.16			0.17
	Mg%	0.19	0.23		0.2	0.21
	Mg%TB		23		19	21
	K% rc		0.69			0.69

Cl		87	88	89	90	AVG
Plot 1	Yield	31.1	21.6	24.6	27.7	26.25
	N%	2.4	2.2		1.97	2.19
	K%	1	0.83		0.93	0.92
	K% TB		27		31	29
	P%	0.17	0.16		0.16	0.16
	Cl%	0.2	0.31			0.26
	Mg%	0.24	0.25		0.24	0.24
	Mg% TB		26		26	26

(Table 59 contd.)

KCl		87	88	89	90	AVG
Plot 7	Yield	32.4	26.7	22.9	27.4	27.35
	N%	2.6	2.4		2.08	2.36
	K%	0.96	0.74		0.85	0.85
	K% TB		23		27	25
	P%	0.16	0.15		0.18	0.16
	Cl%	0.2	0.37			0.29
	Mg%	0.23	0.25		0.21	0.23
	Mg% TB		24		22	23

SO4		87	88	89	90	AVG
Plot 5	Yield	34.7	27.4	24.8	27.8	28.68
	N%	2.4	2.4		2.28	2.36
	K%	0.93	0.76		0.98	0.89
	K% TB		25		30	27.5
	P%	0.17	0.15		0.18	0.17
	Cl%	0.17	0.16			0.17
	Mg%		0.2		0.21	0.21
	Mg% TB		21		21	21

(Table 59 contd.)

K2SO4		87	88	89	90	AVG
Plot 2	Yield	34.4	28.4	22.1	27.4	28.08
	N%	2.3	2.2		2.18	2.23
	K%	0.91	0.79		0.96	0.89
	K% TB		25		31	28
	P%	0.17	0.16		0.16	0.16
	Cl%	0.16	0.17			0.17
	Mg%		0.25		0.23	0.24
	Mg% TB		26		24	25

TRIAL 311, N, K, EFB FERTILIZER FACTORIAL, ISAVENE

PURPOSE:

To investigate in depth the responses to N and K fertilizers, and their interaction with EFB, in order to provide guidance on fertilizer policy.

SITE DETAILS :

Location: Isavene Estate HOPPL, block 78A.
Genetic material: Dami commercial DxP crosses.
Soils: Higaturu family, which is of volcanic ash origin, consisting of deep sandy clay loam, with good drainage and physical properties.
Planting date: 1978.
Density: 130 points/ha.
Size: The trial comprises 32 plots totalling 1674 palms, including the guard rows, and is surrounded by additional areas fertilized by OPRA to ensure separation from estate fertilizing.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 311 is a randomized incomplete block factorial design, with one replicate and 2 blocks, comprising 4x4x2 treatments for NxKxEFB.
Layout: The plots consist of a core of 16 recorded palms, surrounded by a guard row, making a total of 36 palms per plot. Additional guard palms were introduced during 1990 outside the existing plots where practicable, to provide double guard rows.
Trial commencement: April 1988.
Trial progress: Ongoing.
Treatments in kg/palm/year:

		Level			
Fertilizer		0	1	2	3
N	SOA	0	2	4	6
K	MOP	0	2	4	6

EFB: EFB 0 receives no EFB. EFB 1 receives EFB. The EFB was first applied by hand between 5th and 24th November 1988 at a rate of 333 kg (fresh ex-mill weight) per treated palm, as a mulch between palm circles.
At 130 palms/ha, this equates to 32.5 t/ha/yr. During 1990 the second application was due in March, but was mainly undertaken in August and September. The application rate was 500kg per treated palm, at which rate application is intended to be repeated every 2 years.

RESULTS :

1. Yield

Table 60 indicates the summarised yields for 1989 and 1990, and Table 61 the production for particular fertilizer combinations.
Figures 45 and 46 illustrate the responses.

Table 60: Trial 311 Yield data

	1990 Wt of bunches t/ha	1990 No of bunches /ha	1990 s.b.w. kg	89-90 Wt of bunches t/ha
N 0	**30.2**	**1291**	**23.4**	**29.0**
N 1	**32.0**	**1347**	**23.7**	**31.3**
N 2	**32.8**	**1304**	**25.2**	**32.9**
N 3	**34.9**	**1431**	**24.5**	**34.0**
K 0	**31.4**	**1369**	**23.0**	**31.0**
K 1	**30.6**	**1256**	**24.3**	**30.7**
K 2	**33.2**	**1333**	**25.0**	**31.6**
K 3	**34.6**	**1415**	**24.5**	**33.9**
EFB 0	31.9	1330	23.9	**30.8**
EFB 1	33.1	1356	24.4	**32.8**
lsd (EFB)	1.8	81	0.9	1.2
lsd (NK)	2.5	114	1.3	1.6
c.v.	7	7	5	5

The combined yield data for 1989 and 1990 indicate significant responses for all treatments. On an annual basis SOA boosted yields by 5 tonnes at the N3 rate; MOP increased yields by 2.9 tonnes at the K3 rate, and EFB boosted yields by 2 tonnes/ha.

The form of the response to SOA and MOP was mainly linear, and maximum yields were generally obtained with high combined inputs of SOA and MOP. The response to SOA appeared to be nearly double that obtained to MOP or EFB. For both N3 and K3 rates maximum yields attained the exceptional level of 34 t/ha, and the combined N3K3 treatment yielded 35 t/ha.

In the presence of EFB the response to the N1 SOA rate was marked, but response to the higher rates was slight. Without EFB the response to SOA was virtually linear from 0 to 6 kg.

The observed response to MOP was variable. At the maximum rate of 6 kg the response was invariably positive. At the lower K1 rate of 2 kg, response varied. In combination with EFB or high N, there was a positive response, with yields exceeding the K0 and K2 rates. In the absence of EFB and at low N rates the K1 application depressed yield.

Table 61: Trial 311 Production figures for specific fertilizer combinations

Yield in t/ha 89,90		K0	K1	K2	K3
	N0	28.40	25.00	30.00	32.50
	N1	30.60	29.10	31.90	33.70
	N2	32.80	32.30	32.10	34.40
lsd 3.3	N3	32.20	36.40	32.50	35.00
Yield in t/ha 89,90		**K0**	**K1**	**K2**	**K3**
	EFB0	29.9	27.9	31.8	33.7
lsd 2.3	EFB1	32.1	33.5	31.5	34.1
Yield in t/ha 89,90		**N0**	**N1**	**N2**	**N3**
	EFB0	27.9	29.1	32.2	34.2
lsd 2.3	EFB1	30.1	33.5	33.6	34.1

(Table 61 contd)

FDM prodn t/ha 1990		K0	K1	K2	K3
	EFB0	10.1	10.6	11.2	11.5
lsd 1.9	EFB1	10.7	11.4	11.4	11.2
FDM prodn t/ha 1990		**N0**	**N1**	**N2**	**N3**
	EFB0	9.3	10.8	11.4	11.8
lsd 1.9	EFB1	11	11	11.1	11.7
VDM prodn t/ha 1990		**K0**	**K1**	**K2**	**K3**
	EFB0	14	14.4	15.5	15.9
lsd 2.1	EFB1	14.8	15.6	15.7	15.5
VDM prodn t/ha 1990		**N0**	**N1**	**N2**	**N3**
	EFB0	13	14.8	15.6	16.4
lsd 2.1	EFB1	15	15.2	15.3	16.1

Figure 45: Trial 311 Yields 89/90

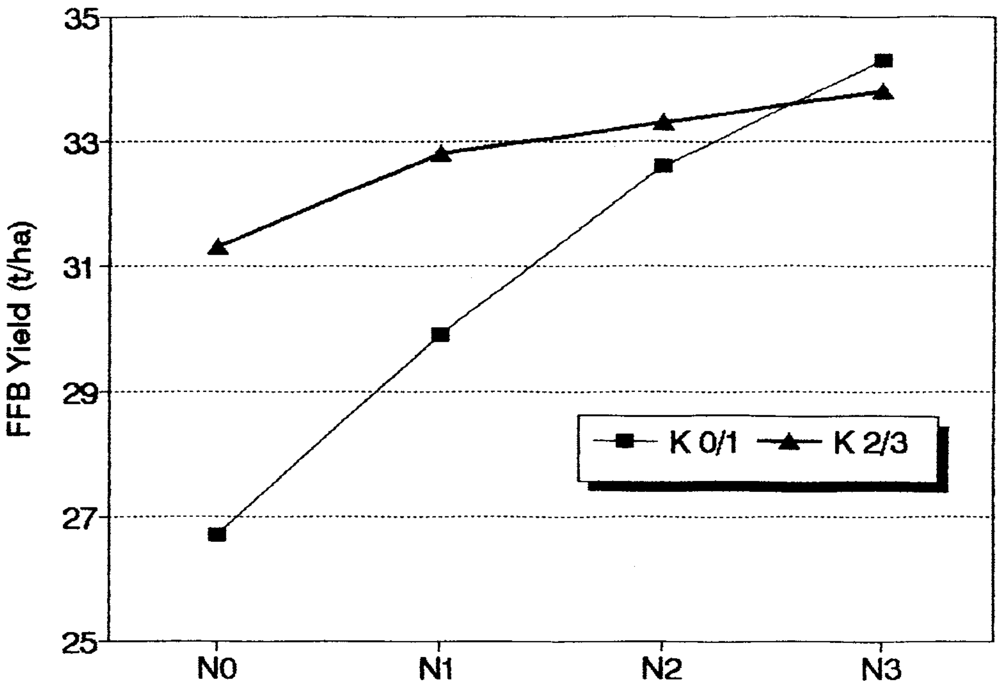
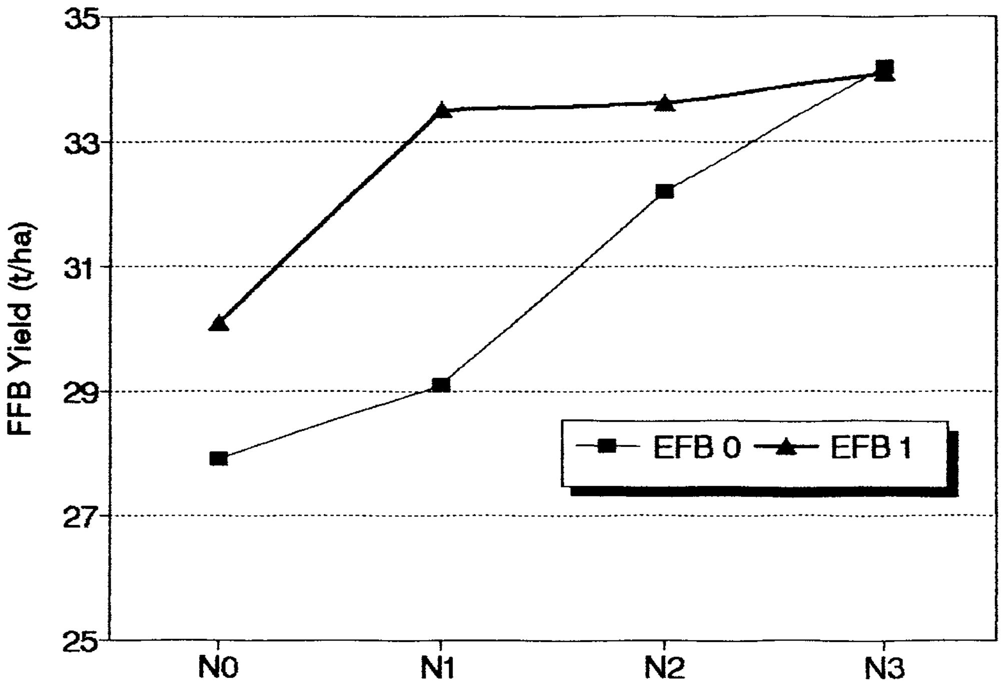


Figure 46: Trial 311 Yields 89/90



2. Growth

Table 62 indicates the 1990 palm growth data. SOA achieved a marked response in terms of increased TDM production, through a significant stimulation of leaf production and increased frond weights. As in other trials, MOP also increased FW, but not to a statistically significant extent in 1990.

Table 62: Trial 311 Growth and conversion data 1990

TRTMNT	2/90 Height m (VH)	1990 Leaf prodn (n)	1990 Frond wt (FW)	1990 Frond dm (FDM)	1990 Bunch dm (BDM)	1990 Veg. dm (VDM)	1990 Total dm (TDM)	1990 Bunch index (BI)
N 0	5.34	**22.0**	**3.62**	10.1	**24.8**	**14.0**	**38.8**	0.638
N 1	5.44	**23.0**	**3.74**	10.9	**26.2**	**15.0**	**41.2**	0.635
N 2	5.45	**23.5**	**3.87**	11.3	**26.9**	**15.5**	**42.4**	0.635
N 3	5.47	**23.7**	**3.91**	11.8	**28.6**	**16.2**	**44.8**	0.638
K 0	5.37	22.6	**3.62**	10.4	**25.8**	14.4	**40.1**	0.641
K 1	5.59	23.1	**3.74**	11.0	**25.1**	15.0	**40.1**	0.625
K 2	5.4	23.0	**3.87**	11.3	**27.3**	15.6	**42.8**	0.637
K 3	5.33	23.6	**3.79**	11.3	**28.4**	15.7	**44.1**	0.643
EFB 0	5.39	22.9	3.71	10.8	26.1	15.0	41.1	0.635
EFB 1	5.46	23.1	3.80	11.2	27.1	15.4	42.5	0.638
lsd (EFB)	0.14	0.67	0.30	1.0	1.5	1.1	1.8	0.02
lsd (NK)	0.18	0.9	0.44	1.4	2.1	1.5	2.6	0.03
c.v.	3	3.5	10	11	7	9	5	4

3. Leaf and Soil Analyses

Table 63 indicates the initial soil and leaf data collected prior to commencement of the trial.

Table 63: Trial 311 Initial soil and frond data 1988

SOIL												
Block	Bulk Density g/ml	pH	P µg/ml	Extractable cations m.e./100g K	Ca	Mg	Na	CEC	OM %	P retn %	Total N %
Blk 1	1.035	6.52	5.1	0.141	7.337	1.143	0.077	11.06	2.112	17.18	0.136
Blk 2	1.028	6.65	4.5	0.129	8.187	1.345	0.066	12.12	2.837	20.81	0.131
Mean	1.03	6.59	4.81	0.14	7.76	1.24	0.07	11.59	2.48	19.00	0.133

	LEAF							RACHIS APRIL'88		
	N%	P%	K%	S%	Ca%	Mg%	Cl%	K%	Ca%	Mg%
Blk 1	2.269	0.148	0.795	0.16	0.959	0.246	0.327	0.996	0.423	.076
Blk 2	2.194	0.146	0.758	0.154	0.916	0.253	0.327	0.888	0.401	.090
Mean	2.23	0.15	0.78	0.16	0.94	0.25	0.33	0.940	0.410	.083

4. Discussion

The marked initial EFB benefit in trial 311 was less clear in 1990, although the overall yield advantage remained. In the presence of EFB, response to the lower fertilizer levels appeared to be maximised, enabling yields comparable to those at maximum fertilizer input to be obtained with far lower fertilizer inputs.

Application of 2 kg of MOP with low N or without EFB depressed yields by up to 2.5 t, whilst with high N or with EFB it increased yield by up to 1.9 t. This form of response is broadly in line with the results in 305 and 306, where MOP response is now largely limited to the plots receiving SOA. Whilst the variable responses to MOP in the trials are still not fully understood, the response in trial 311 would indicate that it is possible for application of MOP in combination with an inadequate supply of other nutrients to reduce yield, possibly producing a nutrient imbalance through the stimulation of an excessive uptake of Ca at the expense of other nutrients.

The response to MOP in the presence of EFB confirms the existence of a response to Cl, since EFB alone is able to supply adequate amounts of K. It is possible that the Cl boosts uptake of nutrients from the EFB, as well as being of value in its self, so that AMC would appear to be an ideal fertilizer for application in combination with EFB.

Since both EFB and Cl also affect water relationships in different ways, there must be considerable scope for interactions to affect palm production in a variety of ways depending upon complex relationships between involving rainfall and moisture stress, which will vary from season to season and site to site.

The application of EFB has not raised the N requirement: rather it appears to have improved the yields attained with moderate N applications.

The linear form of the response to SOA and MOP (particularly in the absence of EFB) offers scope for further yield increases by raising fertilizer rates above their current levels.

SUMMARY

Responses in trial 311 have developed rapidly, against a background of generally high yields.

There have been significant overall responses to SOA (5 t/ha), MOP (2.9 t/ha) and EFB (2 t/ha).

Response to SOA and MOP has followed a largely linear pattern up to the maximum of 6kg/palm of applied fertilizer, indicating increases in yield up to the maximum application rates in the trial.

For both N3 and K3 rates maximum yields attained the exceptional level of 34 t/ha, and the combined N3K3 treatment yielded 35 t/ha.

At lower fertilizer levels there was a substantial response to EFB.

With higher fertilizer levels of 4kg of more the EFB response was largely lost.

As a result, for maximum yield without EFB levels of N3 and K3 were required, whilst with EFB high yields (33.5 t/ha) were attained with the N1 and K1 levels of fertilizer application.

In the absence of EFB and at low N rates the K1 application depressed yield by up to 2.5 t., indicating that there is a risk that application of MOP in combination with an inadequate supply of other nutrients can reduce yield, possibly through nutrient imbalances due to uptake of Ca at the expense of other nutrients.

There response to MOP in addition to EFB confirms the MOP response as largely due to Cl, since EFB alone is able to supply adequate amounts of K.

AMC would appear to be an ideal fertilizer for application in combination with EFB.

The contribution of EFB (and organic matter) in the Higaturu soils is important, and measures to maintain organic matter are likely to maintain good yields at moderate fertilizer input levels.

<u>**Table 64: Trial 311 Progressive changes in yield and nutrient status**</u>

N K EFB			AAR	AAR	MEAN
0 0 0		88	89	90	
Plot	Yield		26.4	24.4	25.4
31	N%	2.5	2.08	1.96	2.18
	P%	0.15	0.137	0.133	0.14
	K%	0.79	0.68	0.79	0.75
	Mg%			0.16	0.16
	Ca%	0.89	0.73	0.71	0.78
	Cl%	0.32	0.16	0.16	0.21
	Cl% rc			0.12	0.12
	K% rc	0.82	1.05	0.93	0.93
	K% TB			30	30
	Mg% TB			19	19
N K EFB					
0 0 1		88	89	90	AVG
Plot	Yield		30.3	32.8	31.55
8	N%	2.3	2.11	2.19	2.2
	P%	0.14	0.144	0.15	0.14
	K%	0.75	0.73	0.8	0.76
	Mg%			0.17	0.17
	Ca%	0.98	0.7	0.81	0.83
	Cl%	0.37	0.24	0.19	0.27
	Cl% rc			0.15	0.15
	K% rc	1.03	1.23	1.3	1.19
	K% TB			28	28
	Mg% TB			19	19

(Table 64 contd.)

N K EFB

0 2 0		88	89	90	AVG
Plot	Yield		30.2	32.7	31.45
7	N%	2.2	2.11	2.05	2.12
	P%	0.15	0.143	0.142	0.15
	K%	0.79	0.68	0.72	0.73
	Mg%			0.16	0.16
	Ca%	1.01	0.87	0.82	0.9
	Cl%	0.31	0.32	0.31	0.31
	Cl% rc			0.62	0.62
	K% rc	0.87	1.28	1.38	1.18
	K% TB			26	26
	Mg% TB			18	18

N K EFB

2 0 0		88	89	90	AVG
Plot	Yield		30.4	34.1	32.25
13	N%	2.4	2.23	2.24	2.29
	P%	0.15	0.152	0.144	0.15
	K%	0.79	0.82	0.82	0.81
	Mg%			0.14	0.14
	Ca%	0.97	0.7	0.69	0.79
	Cl%	0.27	0.21	0.14	0.21
	Cl% rc			0.11	0.11
	K% rc	0.85	0.88	0.91	0.88
	K% TB			32	32
	Mg% TB			17	17

(Table 64 contd.)

N K EFB

2 0 1		88	89	90	AVG
Plot	Yield		35	31.7	33.35
26	N%	2.2	2.16	2.2	2.19
	P%	0.14	0.145	0.148	0.14
	K%	0.82	0.71	0.8	0.78
	Mg%			0.16	0.16
	Ca%	0.93	0.69	0.73	0.78
	Cl%	0.32	0.23	0.18	0.24
	Cl% rc			0.11	0.11
	K% rc	0.97	1.16	0.96	1.03
	K% TB			29	29
	Mg% TB			19	19

N K EFB

3 3 0		88	89	90	AVG
Plot	Yield		31.7	36	33.85
25	N%	2	2.12	2.17	2.1
	P%	0.14	0.143	0.139	0.14
	K%	0.68	0.68	0.77	0.71
	Mg%			0.13	0.13
	Ca%	0.9	0.76	0.68	0.78
	Cl%	0.32	0.35	0.38	0.35
	Cl% rc			0.65	0.65
	K% rc	0.79	1.2	1.38	1.12
	K% TB			31	31
	Mg% TB			17	17

(Table 64 contd.)

N K EFB

3 3 1		88	89	90	AVG
Plot	Yield		35.8	36.6	36.2
12	N%	2.3	2.3	2.31	2.3
	P%	0.15	0.152	0.148	0.15
	K%	0.8	0.8	0.79	0.8
	Mg%			0.14	0.14
	Ca%	0.89	0.73	0.78	0.8
	Cl%	0.25	0.38	0.37	0.33
	Cl% rc			0.86	0.86
	K% rc	0.99	1.4	1.43	1.27
	K% TB			29	29
	Mg% TB			16	16

TRIAL 312, N, K, EFB FERTILIZER FACTORIAL, AMBOGO

PURPOSE:

To provide more detailed understanding of responses to N and K fertilizers, and their interaction with EFB, in order to provide guidance on fertilizer policy.

SITE DETAILS :

Location: Ambogo Estate HOPPL, block 80.E.2.
Genetic material: Dami commercial DxP crosses.
Soils: Ambogo family, which is of recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam subsoil, with seasonally high water tables.
Planting date: 1980.
Density: 143 points/ha.
Size: The trial comprises 32 plots totalling 1407 palms, including the guard rows, and is surrounded by additional areas fertilized by OPRA to ensure separation from estate fertilizing.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 312 is a randomised incomplete block factorial design, with one replicate and 2 blocks, comprising 4x4x2 treatments for NxKxEFB.
Layout: The plots consist of a core of 16 recorded palms, surrounded by a guard row, making a total of 36 palms per plot. Additional guard palms have been introduced during 1990 outside the existing plots where practicable, to provide double guard rows.
Trial commencement: April 1988.
Trial progress: Ongoing.
Treatments in kg/palm/year:

Fertilizer		Level			
		0	1	2	3
N	SOA	0	2	4	6
K	MOP	0	2	4	6

EFB: EFB 0 receives no EFB. EFB 1 receives EFB. The EFB was first applied by hand between 29th November and 15th December 1988 at 333 kg (fresh ex-mill weight) per treated palm, as a mulch between palm circles. At 143 palms/ha, this equates to 35.75 t/ha/yr. During 1990 the second application was due in April, but was mainly undertaken in July. The application rate was 500 kg per treated palm, at which rate application is intended to be repeated biennially.

RESULTS :

1. Yield

Table 65 indicates the summarised yields for 1989 and 1990, and Table 66 the production for particular fertilizer combinations.

Table 66: Trial 312 Yield data

TRTMNT	1990 Wt of bunches t/ha	1990 No of bunches /ha	1990 s.b.w kg	89-90 Wt of bunches t/ha
N 0	**32.3**	1851	**17.5**	**28.8**
N 1	**37.1**	1930	**19.2**	**33.3**
N 2	**37.3**	1938	**19.3**	**34.5**
N 3	**38.3**	1973	**19.5**	**34.1**
K 0	35.3	1903	18.5	33.0
K 1	36.5	1927	18.9	32.0
K 2	36.4	1947	18.6	33.0
K 3	36.8	1925	19.3	32.8
EFB 0	35.8	1977	18.6	32.9
EFB 1	36.7	1929	19.1	32.5
lsd (EFB)	1.7	124	0.9	2.2
lsd (NK)	2.5	175	1.3	3.2
c.v.	6	8	6	8

Table 66: Expt.312, FFB Yield in t/ha/yr 1990

	K0	K1	K2	K3
N0	30.7	31.5	30.1	36.9
N1	36.0	36.7	39.4	36.3
N2	39.6	38.4	36.1	34.9
N3	35.0	39.2	39.8	39.3
	lsd = 4.9			
	K0	K1	K2	K3
EFB0	33.8	35.8	35.8	37.6
EFB1	36.9	37.1	36.9	36.1
	lsd = 3.5			
	N0	N1	N2	N3
EFB0	31.3	36.8	36.3	38.6
EFB1	33.4	37.3	38.2	38.0
	lsd = 3.5			

Figure 47: Trial 312 Yield 1990

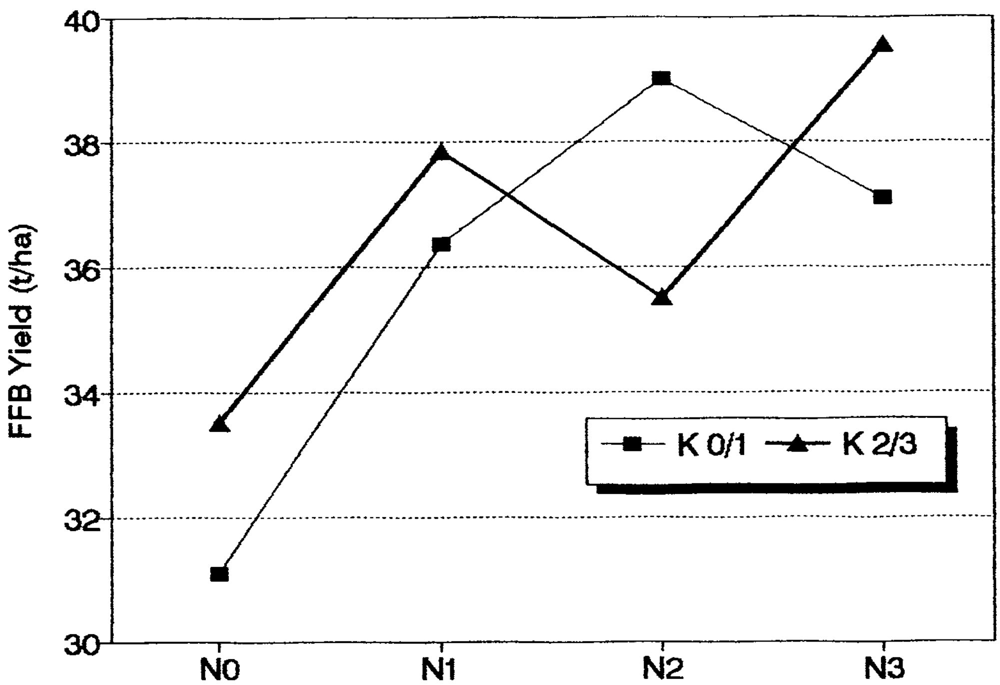


Figure 48: Trial 312 Yield 1990

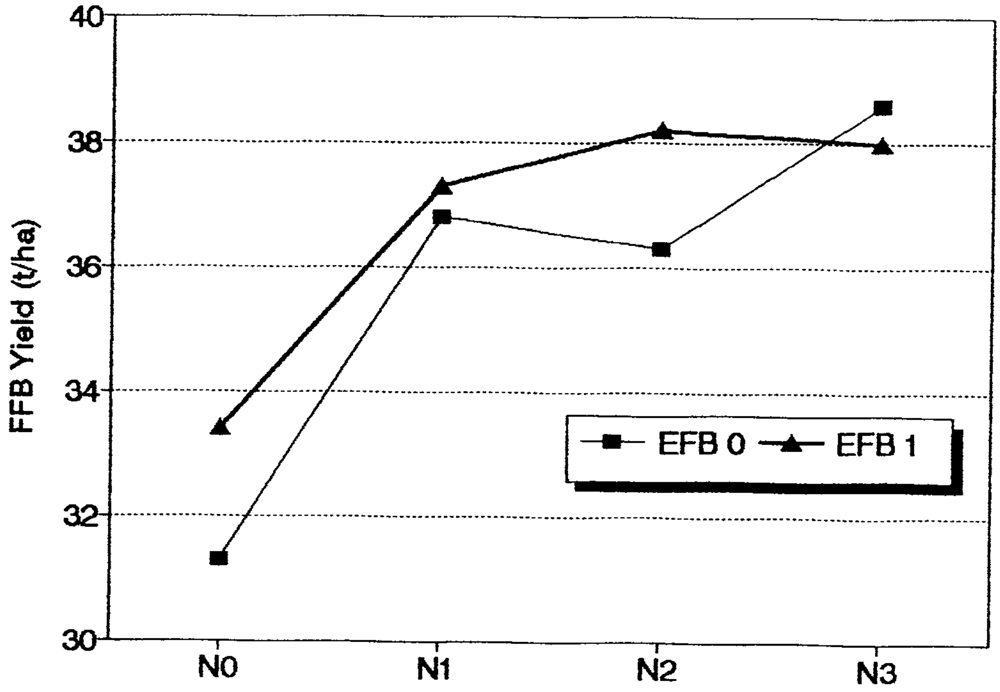
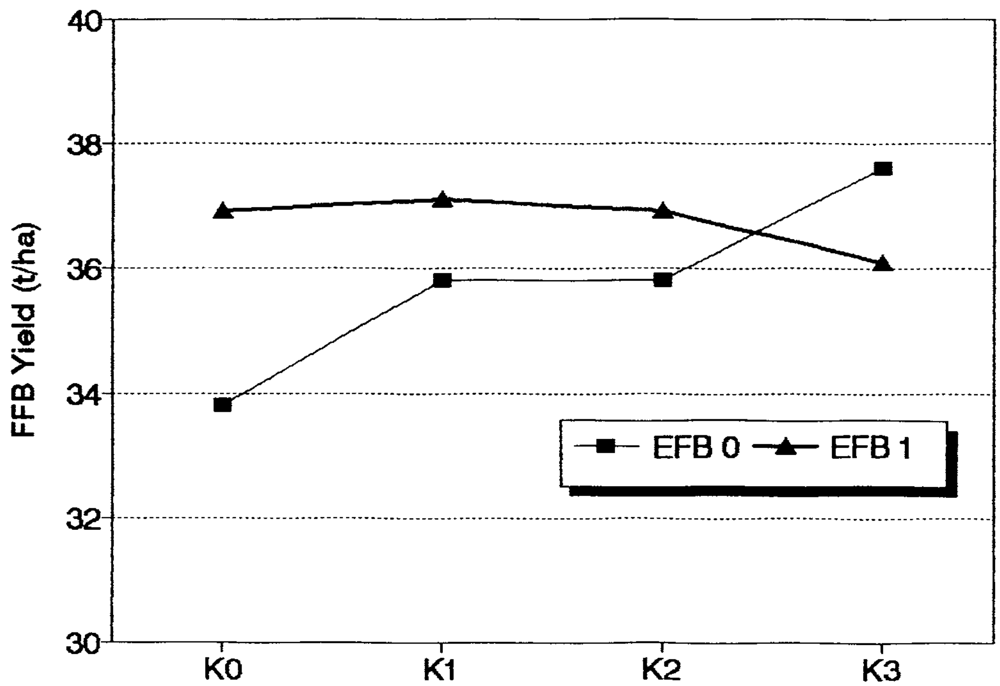


Figure 49: Trial 312, Yield 1990



The yield data indicated an over-riding response to SOA and a developing response to EFB. No clear response to MOP has been identified.

1990 yields have been exceptional. At N0K0 30.7 t/ha was attained, at N3K0 35 t/ha, and at N3 with K levels of 1-3, 39 t/ha.

The greatest response recorded was to SOA at the N1 rate, with an increase of 4.8 t (raising yield to 37.1 t), with further marginal yield increases right up to the maximum N3 rate, which averaged 38.3 t.

A definite response to EFB appears to be developing: whilst in 1989 EFB1 yields averaged 1.7 t less than EFB0, this variation was reversed in 1990 to give an increase of 0.9 t. Effectively this indicates an overall response in the order of 2.5 t during 1990.

Table 66 indicates that responses to EFB of 1-3 t were observed at fertilizer rates up to N2 and K2, but completely disappeared at the maximum N3 and K3 rates. This confirms the trial 311 results in indicating the major EFB benefit at lower fertilizer rates.

Although response to MOP was not marked in 1990, it appeared to be greater in the absence of EFB and with low N: higher MOP rates in the presence of EFB or high N may even have depressed yield. With high N the K1 rate gave the greatest response in a similar manner to that observed in trial 311.

Since Cl is involved with water regulation, its effects would be expected to vary from year to year, possibly being at a minimum in high yielding years such as 1990, when stress would be expected to be at a minimum.

2. **Growth**

The typical effects of SOA and MOP were confirmed in trial 312: SOA increased leaf production, MOP raised FW and FDM. EFB also lead to an increase in FDM. Whilst all 3 sources increased VDM and TDM, the SOA effect was again over-riding.

3. **Leaf and Soil Analyses**

Table 68 indicates the initial soil and leaf data collected prior to commencement of the trial.

Table 67: Trial 312 Growth and conversion data

TRTMNT	11/90 Height m (VH)	1990 Leaf prodn (n)	1990 Frond wt (FW)	1990 Frond dm (FDM)	1990 Bunch dm (BDM)	1990 Veg. dm (VDM)	1990 Total dm (TDM)	1990 Bunch index (BI)
N 0	3.91	**24.0**	4.10	**12.5**	**23.5**	**16.8**	**43.3**	0.613
N 1	4.19	**25.3**	4.09	**13.1**	**30.4**	**17.9**	**48.4**	0.629
N 2	4.06	**26.0**	4.14	**13.6**	**30.6**	**18.5**	**49.1**	0.622
N 3	4.09	**25.2**	4.33	**13.8**	**31.4**	**18.9**	**50.3**	0.625
K 0	4.17	25.3	**3.97**	**12.7**	29.0	**17.4**	**46.3**	0.624
K 1	3.98	25.0	**4.10**	**13.0**	29.9	**17.8**	**47.7**	0.627
K 2	4.15	25.0	**4.19**	**13.3**	29.8	**18.1**	**47.9**	0.621
K 3	3.94	25.1	**4.40**	**14.0**	30.2	**18.9**	**49.1**	0.616
EFB 0	4.1	24.9	4.05	**12.8**	29.3	**17.5**	**46.8**	0.626
EFB 1	4.03	25.3	4.28	**13.7**	30.1	**18.6**	**48.7**	0.618
lsd (EFB)	0.22	0.8	0.25	0.9	1.4	0.9	1.7	0.016
lsd (NK)	0.32	1.2	0.35	1.2	2.0	1.3	2.4	0.023
c.v.	7	4	7	8	6	6	4	3

Table 68: Trial 312, Total dry matter production (t/ha TDM) for different fertilizer combinations in 1990

	K0	K1	K2	K3
N0	40.9	42.1	40.0	50.1
N1	46.8	47.7	51.0	47.9
N2	50.9	49.9	48.6	46.9
N3	46.8	50.9	52.1	51.4
	lsd = 4.8			
	K0	K1	K2	K3
EFB0	44.9	46.5	47.6	48.3
EFB1	47.8	48.8	48.3	49.9
	lsd = 3.4			
	N0	N1	N2	N3
EFB0	41.1	48.1	48	50.1
EFB1	45.5	48.6	50.2	50.5
	lsd = 3.4			

Table 69: Trial 312 Initial leaf and rachis data 1988

	LEAF							RACHIS APRIL'88		
	N%	P%	K%	S%	Ca%	Mg%	Cl%	K%	Ca%	Mg%
Blk 1	2.475	0.174	0.844	0.18	0.893	0.279	0.362	1.169	0.352	.080
Blk 2	2.513	0.174	0.837	0.18	0.923	0.249	0.345	1.313	0.319	.068
Mean	2.49	0.17	0.84	0.19	0.91	0.26	0.35	1.24	0.34	.074

SUMMARY

A major response to SOA (6 t/ha) and a developing response to EFB have emerged in 1990.

No clear response to MOP was identified.

Response to SOA was most marked at the N1 rate, with an increase of 4.8 t to 37.1 t.

At higher N rates further marginal yield increases were obtained, up to a maximum yield at N3 of more than 39 t/ha, in the presence of MOP.

At lower fertilizer levels there was a benefit from EFB.

With the highest fertilizer levels of 6kg the EFB response was lost.

EFB did not lead to an increased requirement for other fertilizers.

The data confirm the importance of organic matter in the Ambogo soils.

Table 70: Trial 312 Progressive changes in yield and nutrient status

N K EFB					
0 0 0		88	89	90	AVG
Plot	Yield		34.4	28.6	31.5
22	N%	2.7	2.2		2.45
	P%	0.17	0.154		0.16
	K%	0.83	0.83		0.83
	RK%	1.68	1.13		1.4
	Ca%	0.88	0.63		0.76
	Cl%	0.36	0.25		0.31
N K EFB					
0 2 0		88	89	90	AVG
Plot	Yield		22.9	29.6	26.25
7	N%	2.6	2.17		2.38
	P%	0.18	0.15		0.17
	K%	0.88	0.89		0.89
	RK%	1.41	1.32		1.37
	Ca%	0.86	0.62		0.74
	Cl%	0.35	0.37		0.36
N K EFB					
0 0 1		88	89	90	AVG
Plot	Yield		16.5	32.9	24.7
4	N%	2.5	2.26		2.38
	P%	0.18	0.151		0.17
	K%	0.86	0.93		0.9
	RK%	1.07	1.28		1.18
	Ca%	0.89	0.61		0.75
	Cl%	0.43	0.32		0.38

(Table 70 contd.)

N K EFB

2 0 0		88	89	90	AVG
Plot	Yield		35.5	35.3	35.4
3	N%	2.5	2.28		2.39
	P%	0.18	0.15		0.17
	K%	0.88	0.88		0.88
	RK%	1.04	1.22		1.13
	Ca%	0.9	0.62		0.76
	Cl%	0.45	0.28		0.37
N K EFB					
2 0 1		88	89	90	AVG
Plot	Yield		33.1	43.9	38.5
29	N%	2.5	2.37		2.44
	P%	0.17	0.158		0.16
	K%	0.85	0.87		0.86
	RK%	1.34	1.35		1.35
	Ca%	0.98	0.73		0.86
	Cl%	0.32	0.29		0.31
N K EFB					
3 3 0		88	89	90	AVG
Plot	Yield		37.6	41.7	39.65
31	N%	2.5	2.37		2.44
	P%	0.17	0.154		0.16
	K%	0.78	0.92		0.85
	RK%	1.14	1.38		1.26
	Ca%	0.97	0.65		0.81
	Cl%	0.4	0.49		0.45

(Table 70 contd.)

N K EFB

3 3 1		88	89	AVG
Plot	Yield		31.5	31.5
5	N%	2.4	2.34	2.37
	P%	0.17	0.159	0.16
	K%	0.88	0.92	0.9
	RK%	1.16	1.66	1.41
	Ca%	0.9	0.69	0.79
	Cl%	0.33	0.41	0.37

TRIAL 314 , SMALLHOLDER DEMONSTRATION SITES, NORTHERN PROVINCE

PURPOSE:

1. To demonstrate the value of fertilizer applications, for the benefit of all smallholders.

2. To monitor the selected sites so as to obtain agronomic data (e.g. soil, leaf and yield) in order to improve understanding of the basic agronomy for all smallholder areas.

3. To provide an assessment of fertilizer response and requirement for smallholder locations.

SITE DETAILS :

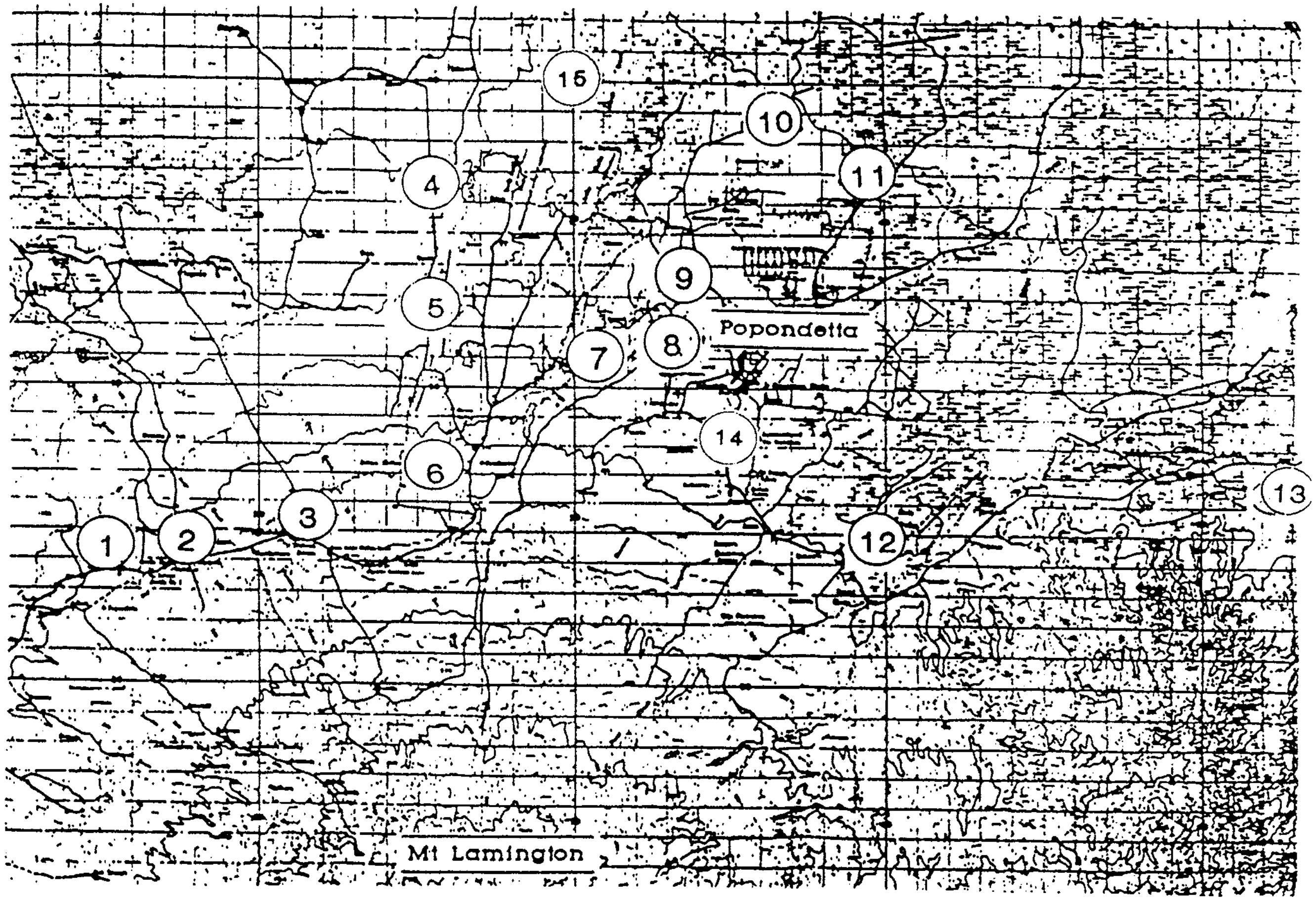
Location: Currently at 20 sites up to 60km apart and throughout the major smallholder oil palm areas of Northern Province. Locations are marked on the map in Fig.50.
Genetic material: Dami commercial DxP crosses.
Soils: Soils have been categorised into 3 major groupings.
The 'sandy' group of soils approximate to the Ambogo and Penderetta families as outlined for estate trial 306.
The 'volcanic' group are characterised by high organic matter levels and high phosphate retention levels. The top soil, which is often deep, is a black loam.
The remainder of the soils are less easily characterised as a group, and generally possess clay loam topsoils and deep subsoils also with a clay component. Some have an alluvially re-worked origin, whilst others have been formed in situ with weathered pyroclastic material.
They have been named the 'clay loam' group.
Classification of the most recently developed sites has not yet been completed.
Planting dates: Various.
Density: 120 points/ha.
Size: The trial presently comprises 20 sites: 19 of 4 ha and 1 of 2 ha - total 78 ha. At each site the entire block is fertilized. On the 4 ha holdings there are normally 6 experimental plots (150 experimental points, 294 points with guards). On the 2 ha holding there are only 4 plots.

DESIGN AND TREATMENT DETAILS :

Statistical background: Each smallholder block provides a single replicate. Within this there are 6 plots, comprising 2 with overall treatments, and 4 with systematic applications of N and K fertilizers, each applied in a gradient at right angles to the other. Two of these 4 plots also receive TSP, and two do not.

Fig.50 : Location of smallholder demonstration trials

Block No.	Area Name	Map Number
030309	E Ambogo	9
040266	Sorovi	11
040232	Sorovi	11
050157	Sangara	7
080079	Isavene	5
101179	Isavene	5
111578	Igora	6
111611	Igora	6
121779	Sorovi	11
220010	Awowota	12
230003	Ahora	10
280004	Popondetta	14
260002	Dobuduru	8
300029	Waseta	1
320012	Saiho	2
390001	Agenahambo	3
520003	Waru	4
520011	Waru	4
580007	Kipore	15
881111	Embi	13



Layout: To clarify details of the layout refer to the map of a typical smallholder demonstration block in Figure 51, and Table 71 indicating the arrangement of the systematic treatments.

Table 71: Trial 314, Example of Systematic fertilizer treatment allocation (Waru)

Block S-1

Palm no:	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K
32	4	1	0	33	3	1	0	34	2	1	0	35	1	1	0	36	0	1	0	37	0	1	0	38	0	1	0
31	4	1	0	5	3	1	0	6	2	1	0	15	1	1	0	16	0	1	0	25	0	1	0	39	0	1	0
30	4	1	0	4	3	1	0	7	2	1	0	14	1	1	0	17	0	1	0	24	0	1	0	40	0	1	0
29	4	1	1	3	3	1	1	8	2	1	1	13	1	1	1	18	0	1	1	23	0	1	1	41	0	1	1
28	4	1	2	2	3	1	2	9	2	1	2	12	1	1	2	19	0	1	2	22	0	1	2	42	0	1	2
27	4	1	3	1	3	1	3	10	2	1	3	11	1	1	3	20	0	1	3	21	0	1	3	43	0	1	3
26	4	1	4	49	3	1	4	48	2	1	4	47	1	1	4	46	0	1	4	45	0	1	4	44	0	1	4

Block S-2

Palm no:	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K
32	0	0	4	33	0	0	4	34	0	0	4	35	1	0	4	36	2	0	4	37	3	0	4	38	4	0	4
31	0	0	2	5	0	0	2	6	0	0	2	15	1	0	2	16	2	0	2	25	3	0	2	39	4	0	2
30	0	0	3	4	0	0	3	7	0	0	3	14	1	0	3	17	2	0	3	24	3	0	3	40	4	0	3
29	0	0	1	3	0	0	1	8	0	0	1	13	1	0	1	18	2	0	1	23	3	0	1	41	4	0	1
28	0	0	0	2	0	0	0	9	0	0	0	12	1	0	0	19	2	0	0	22	3	0	0	42	4	0	0
27	0	0	0	1	0	0	0	10	0	0	0	11	1	0	0	20	2	0	0	21	3	0	0	43	4	0	0
26	0	0	0	49	0	0	0	48	0	0	0	47	1	0	0	46	2	0	0	45	3	0	0	44	4	0	0

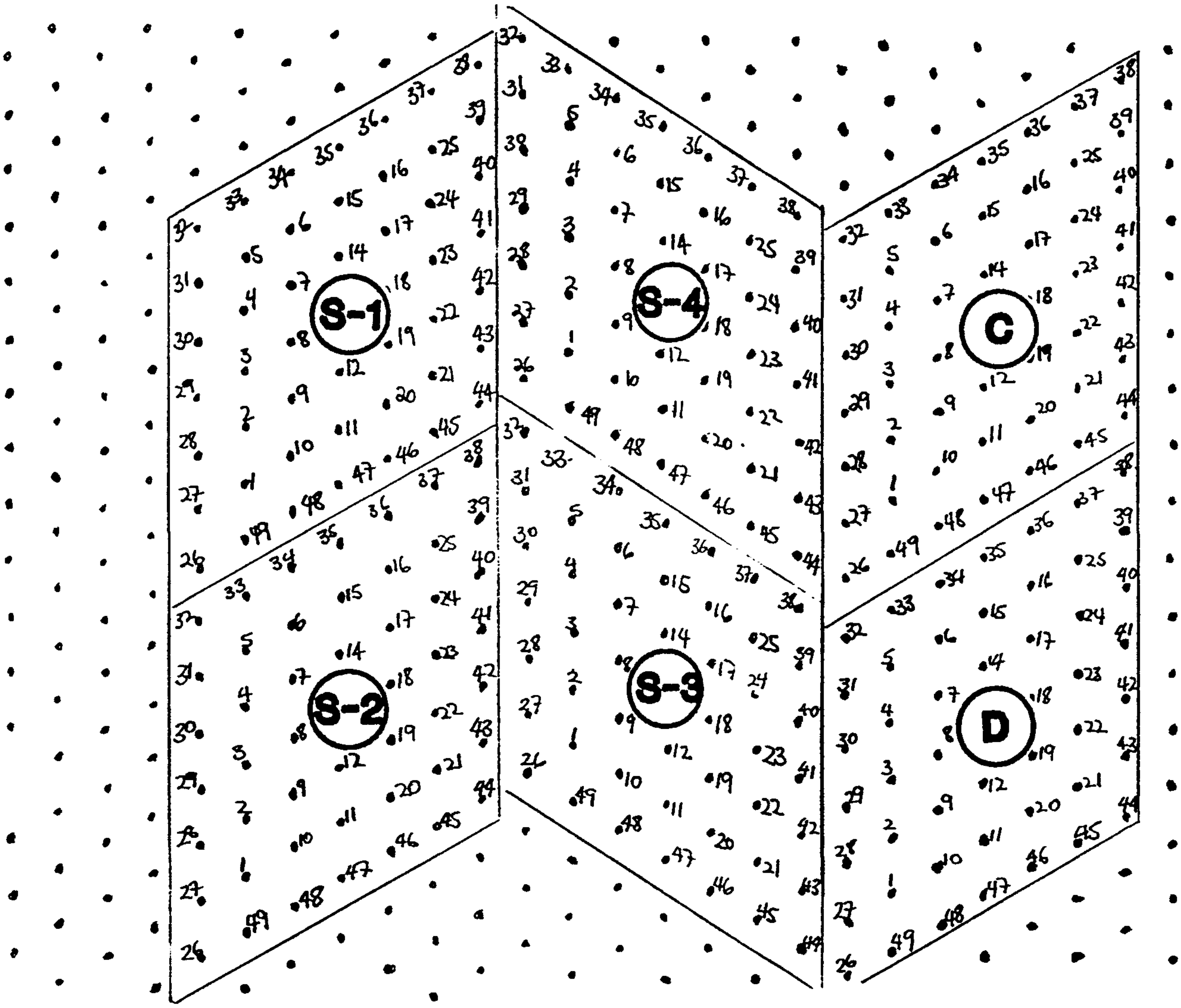
Block S-3

Palm no:	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K
32	4	1	0	33	4	1	0	34	4	1	0	35	4	1	1	36	4	1	2	37	4	1	3	38	4	1	4
31	2	1	0	5	2	1	0	6	2	1	0	15	2	1	1	16	2	1	2	25	2	1	3	39	2	1	4
30	3	1	0	4	3	1	0	7	3	1	0	14	3	1	1	17	3	1	2	24	3	1	3	40	3	1	4
29	1	1	0	3	1	1	0	8	1	1	0	13	1	1	1	18	1	1	2	23	1	1	3	41	1	1	4
28	0	1	0	2	0	1	0	9	0	1	0	12	0	1	1	19	0	1	2	22	0	1	3	42	0	1	4
27	0	1	0	1	0	1	0	10	0	1	0	11	0	1	1	20	0	1	2	21	0	1	3	43	0	1	4
26	0	1	0	49	0	1	0	48	0	1	0	47	0	1	1	46	0	1	2	45	0	1	3	44	0	1	4

Block S-4

Palm no:	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K	Plm	N	P	K
32	0	0	4	33	0	0	3	34	0	0	2	35	0	0	1	36	0	0	0	37	0	0	0	38	0	0	0
31	0	0	4	5	0	0	3	6	0	0	2	15	0	0	1	16	0	0	0	25	0	0	0	39	0	0	0
30	0	0	4	4	0	0	3	7	0	0	2	14	0	0	1	17	0	0	0	24	0	0	0	40	0	0	0
29	1	0	4	3	1	0	3	8	1	0	2	13	1	0	1	18	1	0	0	23	1	0	0	41	1	0	0
28	2	0	4	2	2	0	3	9	2	0	2	12	2	0	1	19	2	0	0	22	2	0	0	42	2	0	0
27	3	0	4	1	3	0	3	10	3	0	2	11	3	0	1	20	3	0	0	21	3	0	0	43	3	0	0
26	4	0	4	49	4	0	3	48	4	0	2	47	4	0	1	46	4	0	0	45	4	0	0	44	4	0	0

Fig 51: Trial 314, example of trial block layout (Waru)



The plots consist of a core of 25 recorded palms, surrounded by a guard row, making a total of 49 palms per plot. The systematic gradients have a zero fertilizer guard row around the plot and on both sides of the 0 treatment the guard row beyond the highest treatment receives an incrementally higher rate. There are no guards between the remaining treatments which are in equal increments. On each plot there are 5 recorded palms receiving each of the 4 rates for individual fertilizers, and 1 palm for each of the 16 combination of the 2 fertilizers. These are replicated 4 times at each site.
Trial commencement: June 1988 to December 1990 and ongoing.
Trial progress: Ongoing.

Treatments:

1. The "control" plot receives no fertilizer.
2. The "demonstration" plot (and all perimeter palms) are fertilized according to the current recommendation for the specific site, rather than any overall fixed rate, so that flexibility is built into the trial.

Application frequency for N and K fertilizers is twice a year, but TSP is applied in a single annual application of 1kg per palm.

<u>Table 72: Fertilizer rates for demonstration plots: kg/palm in 1988/89</u>

Fertilizer		Location (W or E of the Ambogo river West	East
N	SOA	2.5	2.5
K	MOP	1	2

<u>Table 73: Fertilizer rates for demonstration plots: kg/palm 1990</u>

Fertilizer		Soil classification Clay loam	Sandy	Volcanic organic
N	SOA	1.25	1.25	2
N	AMC	1	1	0
K	MOP	0	0	1

Table 74: Fertilizer rates for demonstration plots: kg/palm 1991

Fertilizer		All areas
N	SOA	1.25
N	AMC	1

Table 75: Systematic component rates in kg/palm/year

		Level			
		0	1	2	3
Fertilizer					
N	SOA	0	1.25	2.5	3.75
K	MOP	0	1.25	2.5	3.7

RESULTS :

1. Yield

Yield results obtained in 1990 are summarised in Tables 76, 77 and 78 and illustrated in Figs 52, 53 and 54. In each table the overall (o'all) block yield obtained from the transport company records is compared with the yield from neighbouring (n'bour) blocks.

An exceptional response was obtained to nitrogen fertilizer during the second year of recording in 1990, amounting to almost double that seen in the first year (Table 75). This contrasts with the low yield response observed in new trials in their first year of recording in 1990 (Table 77).

Without fertilizer yields averaged 12-13 t/ha, which is typical of blocks adjoining the demonstration blocks, and also of the general smallholder production levels. Application of the modest demonstration fertilizer rate provided an average response of 59%, with yields boosted from control levels of 12.8 t/ha up to 20.3t/ha.

With the maximum fertilizer application of 3.75 kg of SOA on the systematic component, higher yields were attained, particularly on the sandy soils, where the response averaged 12.8 t doubling yield to 25.6 t/ha. The organic soil category appeared the least responsive, but even here yield increases in the order of 50% were obtained.

The response to SOA application was virtually linear up to the maximum rate of 3.75 kg of SOA, although the initial application of 1.25 kg tended to provide a slightly greater boost to yield, with an average 35% response.

Table 76: Trial 314, Year 2 Block Yield data summaries 1990

	Overall		Sandy		Organic/ Volcanic		Clay loam	
TRTMNT	Wt of bunches t/ha	%	Wt of bunches t/ha	%	Wt of bunches t/ha	%	Wt of bunches t/ha	%
N0	12.69	100	12.79	100	12.54	100	12.76	100
N1	17.14	135	18.85	147	15.52	124	17.49	137
N2	19.20	151	20.66	162	17.15	137	20.16	158
N3	21.92	173	25.63	200	19.17	153	21.88	171
K0	16.12	100	15.94	100	15.03	100	17.35	100
K1	16.68	103	19.66	123	15.38	102	15.74	91
K2	17.72	110	18.37	115	16.15	107	18.81	108
K3	18.74	116	21.16	133	17.10	114	18.57	107
P0	17.19	100	18.75	100	16.12	100	17.07	100
P1	17.36	101	18.54	99	15.29	95	18.56	109
C	12.76	100	11.74	100	13.49	100	12.79	100
D	20.32	159	21.47	183	19.93	148	19.86	155
O'all	19.11	159	19.04		18.17		20.09	
N'bour	11.99	100	9.95		10.38		15.12	
D>C%	165.2		185.33		148.75		166.5	
D-C	7.57		9.74		6.44		7.08	
O>N%	250.8		211.67		388.75		142.25	
O-N	7.12		9.09		7.79		4.97	

Table 77: Trial 314, Year 2 block yield summaries 1990

Period: 1990 YEAR 2					FFB t/ha			
	VOLCANIC							
Site:	Waseta 300029	Waru 520003	Igora 111578	Isavene 101179	Mean	%	Overall Mean	%
N0	19.56	6.93	10.82	12.86	12.54	100	12.69	100
N1	20.48	10.49	14.00	17.13	15.52	124	17.14	135
N2	21.79	12.73	15.69	18.38	17.15	137	19.20	151
N3	21.34	16.64	18.10	20.61	19.17	153	21.92	173
K0	18.73	10.73	13.62	17.02	15.03	100	16.12	100
K1	22.52	9.34	12.66	17.02	15.38	102	16.68	103
K2	20.71	11.65	15.71	16.51	16.15	107	17.72	110
K3	21.95	11.33	15.07	20.04	17.10	114	18.74	116
P0	21.38	10.53	14.20	18.38	16.12	100	17.19	100
P1	20.00	11.14	14.04	15.96	15.29	95	17.36	101
C	15.52	10.72	15.47	12.25	13.49	100	12.76	100
D	21.94	18.18	23.00	16.59	19.93	148	20.32	159
O'all	20.21	14.05	19.52	18.89	18.17		19.11	159
N'bour	19.4	1.30	10.80	10.02	10.38		11.99	100
D/C %	141	170	149	135	148.7		165.2	
D-C	6.42	7.46	7.53	4.34	6.44		7.57	
O/N %	104	1081	181	189	388.7		250.8	
O-N	0.81	12.75	8.72	8.87	7.79		7.12	

(Table 77 contd.)

1990	SANDY			FFB t/ha	
Site:	Dobuduru 260002	E Ambogo 030309	Embi 881111	Mean	%
N0	10.47	9.47	18.42	12.79	100
N1	15.52	16.63	24.40	18.85	147
N2	18.61	19.71	23.67	20.66	162
N3	21.91	25.75	29.23	25.63	200
K0	12.09	16.10	19.62	15.94	100
K1	17.09	17.47	24.43	19.66	123
K2	17.62	16.42	21.08	18.37	115
K3	18.60	15.81	29.06	21.16	133
P0	16.32	17.00	22.94	18.75	100
P1	15.20	16.66	23.77	18.54	99
C	9.96	12.42	12.826	11.74	100
D	21.05	24.82	18.547	21.47	183
O'all	19.11	21.55	16.47	19.04	
N'bour	7.15	15.56	7.15	9.95	
D/C %	211	200	145	185.5	
D-C	11.09	12.4	5.72	9.74	
O/N %	267	138	230	211.6	
O-N	11.96	5.99	9.32	9.09	

(Table 77 contd.)

1990 CLAY LOAM					FFB t/ha	
Site:	Sangara 050157	Igora 111611	Awowota 220010	Ahora 230003	Mean	%
N0	16.13	14.07	9.40	11.44	12.76	100
N1	20.86	17.45	17.60	14.03	17.49	137
N2	20.59	20.43	21.50	18.14	20.16	158
N3	24.78	20.28	19.80	22.65	21.88	171
K0	20.89	16.75	13.90	17.85	17.35	100
K1	19.27	16.86	14.80	12.01	15.74	91
K2	21.02	19.34	17.70	17.20	18.81	108
K3	21.67	17.78	18.10	16.73	18.57	107
P0	19.30	18.64	14.10	16.25	17.07	100
P1	21.32	16.28	20.60	16.02	18.56	109
C	11.30	9.56	17.70	12.58	12.79	100
D	25.42	18.70	15.40	19.92	19.86	155
O'all	22.91	21.25	15.57	20.65	20.09	
N'bour	18.83	17.90	7.86	15.90	15.12	
D/C %	225	196	87	158	166.5	
D-C	14.12	9.14	-2.30	7.34	7.08	
O/N %	122	119	198	130	142.2	
O-N	4.08	3.35	7.71	4.75	4.97	

Table 78: Trial 314, Year 1 block yield summaries 1990

	Period:	1990	YEAR 1			FFB t/ha	
	Isavene	Sorovi	Saiho	Agnhmbo	Sorovi		
Site:	080079	040266	320012	390001	121779	Mean	%
N0	24.05	22.68	28.57	31.50	15.30	24.42	100
N1	31.57	22.96	26.05	30.16	13.87	24.92	102
N2	27.10	26.16	28.41	29.12	17.12	25.58	105
N3	27.17	24.95	27.01	35.23	12.26	25.32	104
K0	27.99	21.77	24.82	33.58	14.03	24.44	100
K1	27.57	26.84	27.87	32.42	15.21	25.98	106
K2	27.09	22.84	29.66	29.68	14.12	24.68	101
K3	25.51	24.38	28.20	28.24	15.29	24.32	100
P0	25.37	24.97	26.17	32.13	16.10	24.95	100
P1	29.44	22.52	28.42	29.94	12.92	24.65	101
C	30.63	22.23	24.67	31.05	23.13	26.34	100
D	29.83	25.80	28.03	28.91	16.29	25.77	102
O'all	18.27	20.56	21.83	30.42	23.50	22.92	208
N'bour	10.65	10.69	9.14	12.58	12.12	11.04	100
D/C %	97	116	114	93	70	98	
D-C	-0.80	-3.57	3.36	-2.14	-6.84	-3.34	
O/N %	172	192	239	242	194	207.8	
O-N	7.62	9.87	12.69	17.84	11.38	11.88	

Figure 52: Trial 314, Average FFB Yields on different soil group 1990

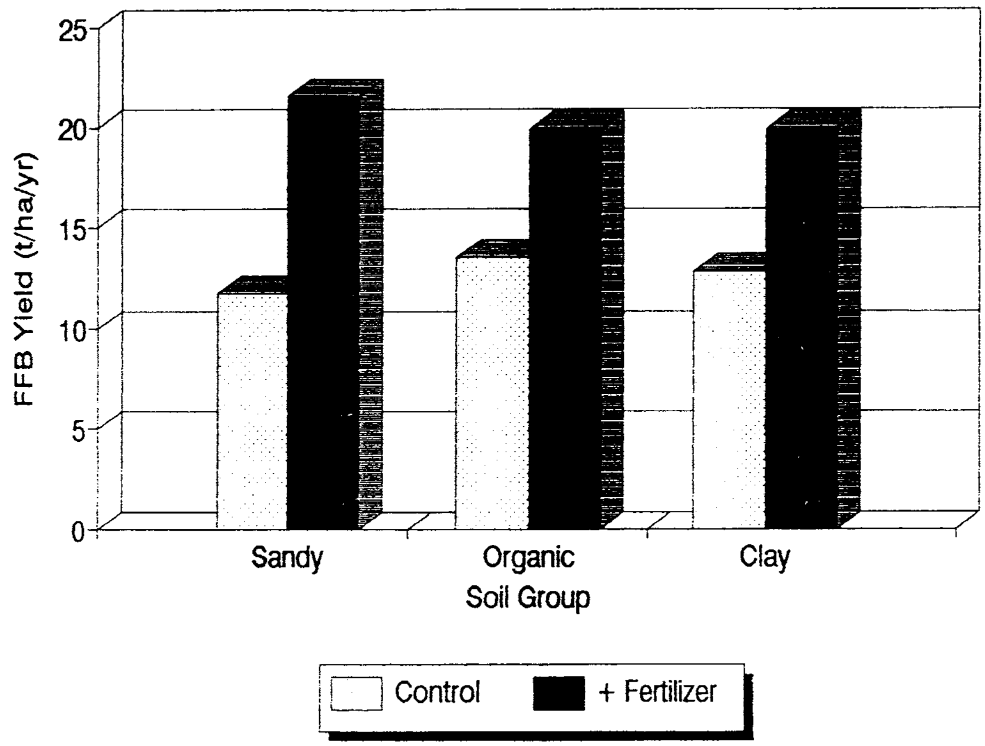


Fig. 53: Trial 314, Average FFB Yield Response to N Fertilizer, 1990

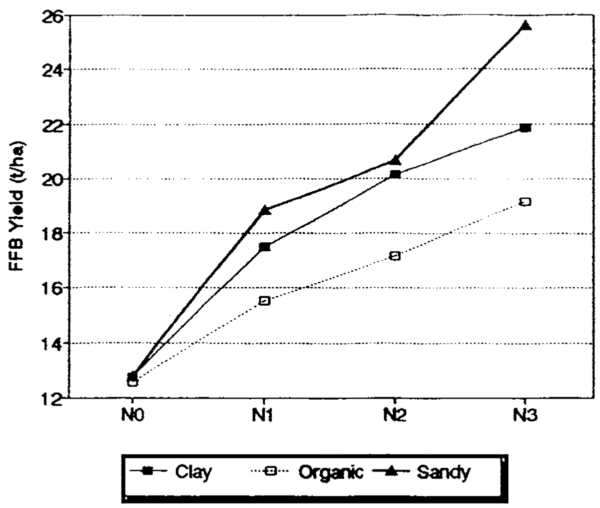
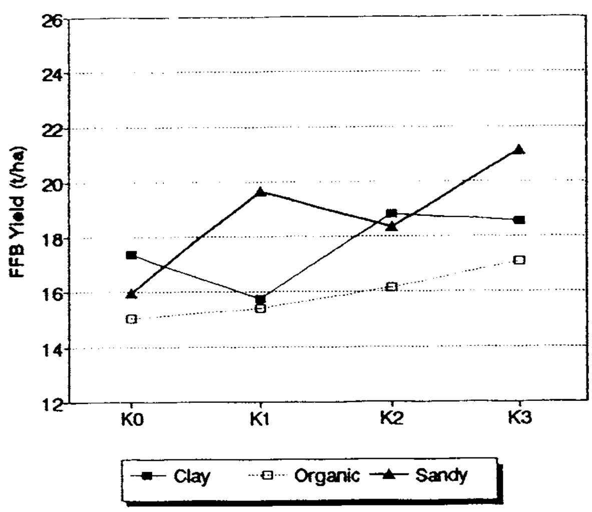


Fig. 54: Trial 314, Average FFB Yield Response to KCl Fertilizer, 1990



No clear response was observed to MOP or to TSP in 1990. There is a possibility of a response to MOP on the sandy soils. In this case the benefit is likely to be due to Cl with its role in water regulation, as these soils would be the most likely to suffer from water stress. Application of AMC would provide the benefit of this response without the additional expense of separate MOP application.

The new OPRA blocks for which recording commenced in 1990 were specifically selected as younger plantings, to maximise the possible duration of the trials. These blocks differ markedly from the more exhausted soils in the older plantings, and are sustaining yields of 18 - 30 t without fertilizer. Fertilizer response during the first year of recording has not been observed on these blocks, and ongoing monitoring will be important as a guide to whether fertilizer should be recommended for the younger blocks, or whether it can only offer an economic response when soil nutrients become exhausted.

2. Plant Analysis

Leaf data for 1990 are shown in Tables 79 and 80 .

The control plots confirm generally low levels of N.

Several differences are apparent between the 3 groups of blocks. In comparison between the sandy and the organic groups, the sandy soils have higher K, P and Mg and lower Ca and Cl levels. The clay loam soils generally have intermediate levels.

Treatment effects have been generally minor, with the greatest increases being in N and Cl levels.

Nearly all blocks had low Cl levels, and for this reason inclusion of Ammonium chloride in the fertilizer programme is desirable. The blocks on the volcanic soils have relatively low K levels, but until a clear response emerges in the trial, the expense of application can not be recommended.

3. Soils

The soils have been categorised into 3 major groupings.

The "sandy" group of soils approximate to the Ambogo and Penderetta families as outlined for estate trial 306, with black sandy loam top soils of approximately 25 cm depth, overlying sand or sandy loam sub soils.

The "volcanic organic" group are characterised by high organic matter levels and high phosphate retention levels. The top soil, which is often deep, is a black loam.

Table 79: Trial 314, Leaf data 1990 for 2nd year blocks

SANDY		% N	% P	% K	% K/TB	% Ca	% Ca/TB	% Mg	% Mg/TB	Cl	me/100g TB
030309	D	2.21	0.16	0.85	26	0.88	53	0.21	21		82
Ambogo	C	1.88	0.15	0.82	24	0.92	52	0.25	24		86
040232	D	2.23	0.12	0.9	29	0.72	45	0.24	25		78
Sorovi	C	2.07	0.13	0.91	30	0.68	42	0.27	28		78
260002	D	2.08	0.14	0.9	28	0.73	44	0.28	28	0.18	81
Dobudur	C	1.83	0.13	0.71	23	0.66	41	0.34	36	0.1	78
881111	D	2.01	0.13	0.8	27	0.7	45	0.26	28		76
Embi	C	1.88	0.13	0.75	23	0.78	45	0.33	32		84
CLAY LOAM		**N**	**P**	**K**	**% TB**	**Ca**	**% TB**	**Mg**	**% TB**	**Cl**	**TB**
50157	D	2.16	0.15	0.77	24	0.9	54	0.21	21		81
Sangara	C	1.78	0.15	0.82	24	0.85	49	0.28	27		85
111611	D	2.16	0.16	0.87	27	0.83	49	0.25	25		83
Igora	C	1.87	0.12	0.78	22	0.9	49	0.32	29		90
230003	D	1.87	0.13	0.76	27	0.68	46	0.24	27	0.2	72
Ahora	C	1.82	0.13	0.72	25	0.69	45	0.27	30	0.07	74

(Table 79 contd.)

VOLCANIC		N	P	K	% TB	Ca	% TB	Mg	% TB	Cl	TB
101179	D	2.05	0.15	0.79	24	0.89	51	0.26	25		85
Isavene	C	2.01	0.15	0.67	21	0.84	51	0.27	28		80
111578	D	2.21	0.15	0.82	25	1.02	59	0.16	16		84
Igora	C	2.13	0.15	0.73	22	1.04	59	0.2	19		86
300029	D	2.53	0.17	0.77	24	0.92	55	0.21	21		82
Waseta	C	2.31	0.16	0.7	19	1.02	54	0.3	27		92

OVERALL		N	P	K	% TB	Ca	% TB	Mg	% TB	Cl	TB
MEAN	D	2.15	0.15	0.82	25	0.83	50	0.23	23		89
	C	1.96	0.14	0.76	23	0.85	49	0.28	27		81
MEAN	D	2.13	0.14	0.86	25	0.76	46	0.25	25		79
SANDY	C	1.91	0.14	0.8	25	0.76	45	0.3	30		82
MEAN	D	2.06	0.15	0.8	26	0.8	49	0.23	24		78
CLAY	C	1.82	0.13	0.77	23	0.81	47	0.29	28		83
MEAN	D	2.26	0.16	0.79	24	0.94	55	0.21	20		83
VOLCAN.	C	2.15	0.15	0.7	20	0.97	54	0.26	24		86

Table 80: Trial 314, Leaf data 1990 for 1st year blocks

SANDY		N	P	K	% TB	Ca	% TB	Mg	% TB	TB
040266	D	2.3	0.15	0.88	27	0.83	49	0.25	25	83
Sorovi	C	2.1	0.16	0.96	30	0.77	46	0.23	23	81
121779	D	2.33	0.16	1	31	0.79	47	0.22	22	82
Sorovi	C	2.36	0.15	0.99	32	0.63	39	0.27	28	78
VOLCANIC		N	P	K	% TB	Ca	% TB	Mg	% TB	
080079	D	2.42	0.12	0.95	29	0.83	49	0.22	22	83
Isavene	C	2.27	0.16	0.98	30	0.84	50	0.2	20	82
320012	D	2.61	0.15	0.81	25	0.91	53	0.23	22	84
Saiho	C	2.34	0.14	0.78	24	0.84	49	0.27	27	83
390001	D	2.47	0.16	0.66	17	1.06	54	0.34	29	96
Agenaham.	C	2.53	0.17	0.86	23	1.02	51	0.31	26	97
MEANS		N	P	K	% TB	Ca	% TB	Mg	% TB	
MEAN	D	2.41	0.15	0.88	26.3	0.87	50	0.25	23.9	85
	C	2.3	0.16	0.93	28.3	0.8	46.3	0.26	24.9	84
MEAN	D	2.32	0.16	0.94	29	0.81	48	0.24	23.5	83
SANDY	C	2.23	0.16	0.98	31	0.7	42.5	0.25	25.5	79
MEAN	D	2.5	0.14	0.81	23.7	0.93	52	0.26	24.3	87
VOLCAN	C	2.38	0.16	0.87	25.7	0.9	50	0.26	24.3	87

The remainder of the soils are less easily characterised as a group, and generally possess clay loam topsoils and deep subsoils also with a clay component. Some have an alluvially re-worked origin, whilst others have been formed in situ with weathered pyroclastic material.
They have been named the 'clay loam' group.

Table 81 indicates the chemical characteristics of the 3 soil groups.

Table 81: Trial 314 Soil Group data

	Grouping:		
Detail	Sandy	Volcanic organic	Clay loam
pH	> 6.2	< 6.2	> 6.1
O.M. %	< 5	> 7.5	< 6
P retention %	< 50	> 74	< 50
CEC me/100g	< 14	> 13	Variable

4. Discussion

The data highlights the essential requirement for N fertilizer to ensure reasonable yields in all trial areas.

On the basis of the limited existing data, realistic preliminary smallholder fertilizer recommendations would be the same as for the demonstration plots:

All Areas		
	Fertilizer	kg/palm
N	SOA	1.25
N	AMC	1

Application at these rates has enabled yields of onver 20 tonnes to be obtained within 3 years from the initial treatment. Application at higher rates up to the equivalent of 3.75 kg of SOA (1.875 SOA & 1.5 AMC) would result in further increases in yield of a similar order.

Application at lower rates would also achieve responses, but with proportionally lower yields.

Successful operation of a trial of this nature is more complex than work on the estates, and the good will and co-operation of the block owners must always be maintained. In this context OPRA are completely dependent upon the transport company to arrange efficient collection of the fruit from the blocks on the special harvesting schedule which has been agreed.

Under some circumstances regular harvesting for yield recording is not possible, and in these cases it is intended that the yield potential will be derived from vegetative measurements, by means of the bunch index data which is available from the regularly recorded blocks.

An important objective of the trial is for the demonstration blocks to provide the basis for extension work to encourage correct fertilizer use by other block owners. From early 1990 a successful programme of regular field days has been arranged for all block-owners by DAL using the OPRA blocks and the trial results. The field days in the various areas have been attended by DAL representatives to promote fertilizer, an OPRA representative to demonstrate the trial results, and also representatives from the Transport Company and HOPPL.

In addition OPRA have arranged field days, attended by demonstration block owners and DAL OiCs, at which the results of the demonstrations are discussed and awards are presented to the owners of the best blocks.

SUMMARY :

An exceptional response was obtained to nitrogen fertilizer during the second year of recording in 1990, amounting to almost double that seen in the first year.

Application of the modest demonstration fertilizer rate provided an average response of 59%, with yields boosted from control levels of 12.8 t/ha up to 20.3 t/ha.

The response to SOA application at different rates was virtually linear up to the maximum of 3.75 kg, with yields of up to 25.6 t/ha.

No clear response was observed to MOP or to TSP in 1990.

Leaf analyses indicate generally low Cl levels, and since responses are more likely to Cl rather than to K, inclusion of AMC as a component of the fertilizer programme is recommended.

Until a clear response emerges in the trial, the expense of application of MOP can not be recommended.

The new OPRA blocks on younger plantings are sustaining yields of 18 - 30 t without fertilizer. Ongoing monitoring will be important as a guide to whether fertilizer should be recommended for the younger blocks, or whether it only offers an economic response when soil nutrients become exhausted.

On the basis of the available data, up to date fertilizer annual recommendations for all areas would be:

N: 1kg/palm AMC plus 1.25kg/palm SOA.

From early 1990 a successful programme of regular field days has been arranged for all block-owners by DAL using the OPRA blocks and the trial results.

Table 82: Trial 314: Baseline performance data

Area	Block	First Hvst	Prev. fert.	Year	Yield	PCS D	PCS C
Waseta	300029	19/7/82	1kgMOP 8/88	1988	17.4	21.9	17
Waru	520003	11/9/80	1 kg MOP 1988	1988	7.5	34.7	30
Waru	520011	1989 (?)		1990	15.8	28	28.2
Saiho	320012	6/12/86	1kg MOP & 0.5 kg SOA 1988; 1kg SOA 1989	1989	21.6	28.2	24.3
Agena-hambo	390001	1987	1 kg MOP 1988 1 kg SOA 1988	1989	24.3	24.4	24
Kipore	580007	15/7/85		1990	23.3	25.4	21.6
Isavene	080079	2/9/80	0.8kg MOP & 0.4 kg SOA 1988; 0.8kg MOP & 0.6kg AMC 1989	1989	12.9	24.0	25.7
Isavene	101179	6/5/81	None	1988	12.1	26.1	27.2

(Table 82 contd.)

Area	Block	First Hvst	Prev. Fert.	Year	Yield	PCS D	PCS C
Igora	111578	21/5/82	1 kg MOP 8/88	1988	15.8	37.8	31.6
Igora	111611	26/2/82	BA 2.5 kg 10/87	1988	18.2	20.9	23.7
Sangara	050157	12/10/82	1 kg SOA 10/88	1988	18.6	24.9	27.4
Dobuduru	260002	10/9/82	?	1988	11.1	20.2	19.1
E Ambogo	030309	2/9/80	0.5 kg SOA 1988	1988	12	24.5	29.4
Ahora	230003	8/7/81	SOA 1kg/plm 9/88	1988	12.5	27.0	
Sorovi	040232	30/1/81	BA 1 kg 1/88	1988	7.9	33.4	37.5
Sorovi	040266	13/3/81	0.5 kg MOP 1989	1989	16.2	78.1	76.1
Sorovi	121779	1984	None	1989	22.6	26.4	25.1
Awowota	220010	21/8/81	?	1988	16	30.9	23.1
Popondetta	280004	21/11/86		1990	16.5	23.5	26.2
Embi	881111	27/8/82	1 kg MOP 1987 2 kg SOA 1988	1988	7.3	30.8	25.6

Table 83: Trial 314: Baseline leaf data

Area	Block	Plot	Previous fertilizer	Year	Yield	N%	P%	K%	Ca%	Mg%	S%	Cl%
WEST												
Waseta	300029	C	1 kg MOP 8/88	1988	17.4	2.3	0.148	0.76	1.18	0.31	0.17	0.09
		D				2.3	0.153	0.76	1.03	0.28	0.16	0.11
Waru	520003	C	1 kg MOP 1988	1988	7.5	1.6	0.138	0.79	0.95	0.33	0.13	0.32
		D				1.7	0.137	0.8	0.87	0.29	0.14	0.28
Saiho	320012	C	1kg MOP & 0.5 kg SOA	1989	21.6	2.4	0.144	0.87	0.8	0.25		0.27
		D	1988; 1 kg SOA 1989			2.7	0.16	0.92	0.98	0.26		0.27
Agenaham	390001	C	1 kg MOP 1988	1989	24.3	2.6	0.156	0.76	1.07	0.29		0.39
		D	1 kg SOA 1988			2.5	0.149	0.78	0.79	0.19		0.48
Kipore	580007	C	?	1990	23.3	2.48	0.15	0.82	0.93	0.36		
		D				2.51	0.15	0.91	0.83	0.21		
Isavene	080079	C	0.8kg MOP & 0.4 kg	1989	12.9	2.3	0.146	0.98	0.75	0.21		0.26
		D	SOA 1988; 0.8kg MOP			2.4	0.144	0.96	0.85	0.2		0.24
			& 0.6kg AMC 1989									
Isavene	101179	C	None	1988	12.1	2.0	0.13	0.82	0.89	0.31	0.14	0.17
		D				1.9	0.13	0.88	0.9	0.33	0.13	0.14
Igora	111578	C	1 kg MOP 8/88	1988	15.8	1.9	0.142	0.79	1.04	0.23	0.14	0.28
		D				1.9	0.139	0.88	0.83	0.19	0.13	0.22
Igora	111611	C	BA 2.5 kg 10/87	1988	18.2	2.2	0.144	0.96	0.89	0.26	0.15	0.23
		D				2.1	0.136	0.87	0.85	0.26	0.17	0.26
Sangara	050157	C	1 kg SOA 10/88	1988	18.6	2.0	0.167	1.03	0.8	0.21	0.18	0.15
		D				2.1	0.166	1.0	0.89	0.22	0.17	0.19
EAST												
Dobuduru	260002	C	?	1988	11.1	1.8	0.151	0.63	0.9	0.39	0.14	0.16
		D				2.0	0.156	0.74	0.94	0.34	0.15	0.15
E Ambogo	030309	C	0.5 kg SOA 1988	1988	12.0	1.8	0.142	0.84	0.83	0.22	0.13	0.09
		D				1.9	0.146	0.83	0.82	0.26	0.14	0.1
Ahora	230003	C	SOA 1kg/plm 9/88	1988	12.5	1.7	0.147	0.84	0.91	0.36	0.15	0.11
		D				1.7	0.142	0.8	0.94	0.37	0.14	0.19
Sorovi	040232	C	BA 1 kg 1/88	1988	7.9	2.4	0.147	1.09	0.81	0.34	0.18	0.29
		D				2.1	0.135	1.05	0.77	0.36	0.16	0.3
Sorovi (Biru)	040266	C	0.5 kg MOP 1989	1989	16.2	2.3	0.151	0.1	0.81	0.23		0.16
		D				2.2	0.147	0.93	0.84	0.24		0.18
Sorovi	121779	C	None	1989	22.6	2.2	0.149	0.95	0.74	0.24		0.15
		D				2.4	0.157	1.03	0.64	0.26		0.15
Awowota	220010	C	?	1988	16.0	2.3	0.156	0.81	0.81	0.29	0.17	0.27
		D				1.7	0.142	0.86	0.82	0.3	0.16	0.22
Popon-detta	280004	C	?	1990	16.5	2.45	0.17	1.01	0.89	0.29		
		D				2.47	0.14	1.0	0.91	0.25		
Embi	881111	C	1 kg MOP 1987	1988	7.3	2.0	0.143	0.83	0.82	0.24	0.14	0.28
		D	2 kg SOA 1988			1.9	0.147	0.88	0.78	0.28	0.15	0.29

Table 84: Trial 314, Summary of site soil profiles

Block No	Name	Group	Depth cm	Description:	Estate soil family
030309	E Ambogo	Sandy	0-25	Black sandy loam	Ambogo
			25+	Sand	
040266	Sorovi	Sandy	0-25	Brown clay loam	Ambogo
			25-80	Grey brown sandy loam	
040232	Sorovi	Sandy	0-22	V. dark brown sandy loam	Penderetta
			22+	Sand	
050157	Sangara	Clay loam	0-27	V. dark brown silty clay loam	Arame ?
			27-81	Medium brown sandy loam	
080079	Isavene	Volcanic			
101179	Isavene	Volcanic	0-21	Black organic silt loam	Ohita
			21-54	Black silt loam/loam	
			54-70	Dark brown sandy organic loam	
			70-98	Sand	
111578	Igora	Volcanic	0-27	Black loam	Arame ?
			27-65	Brown sandy clay loam	
			65-80	Brown sand/sandy loam	
111611	Igora	Clay loam	0-21	Black silty clay loam	Higaturu
			21-45	Brown sandy clay	

(Table 84 contd.)

Block No.	Name	Group	Depth cm	Description	Soil family
121779	Sorovi	Sandy	0-20	Brown silty clay loam	Penderetta
			20-69	Grey brown sandy loam	
			69-105	Khaki brown silty loam	
220010	Awowota	Clay loam	0-23	Black silty clay loam	Higaturu
			23-86	Brown sandy clay loam	
230003	Ahora	Clay loam	0-18	Light brown silty clay	Comment : Young alluvial soil
			18-72	Light brown silty clay (alluvial; mottled)	
			72-102	Light grey sandy silt/silty loam	
			102+	Buried horizon	
260002	Dobuduru	Sandy	0-25	Dark brown sandy loam	Ambogo
			25+	Sand	
280004	Popondetta	Clay loam	0-35	Black organic silty clay loam	Higaturu
			35-100	Light brown clay loam	
300029	Waseta	Volcanic	0-21	Dark brown silt loam	
			21-82	Olive brown sandy silt loam	
320012	Saiho	Volcanic			
390001	Agenahambo	Volcanic			

(Table 84 contd.)

Block No.	Name	Group	Depth cm	Description	Soil family
520003	Waru	Volcanic	0-52	Black organic silt loam	Ohita
			52-97	Brown sand and pummice	
520011	Waru	Volcanic	0-28	Brownish black clay loam	Higaturu
			28-56	Brown sandy clay loam	
			56-90	Greyish brown sandy clay loam	
580007	Kipore	Clay loam	0-25	Chocolate brown clay loam	Higaturu
			25-54	Orange brown clay loam	
			54-105	Reddish brown sandy clay	
881111	Embi	Sandy	0-24	Black silty clay loam	
			24-51	Greyish brown (tan) sandy loam	
			51-76	Black clay loam	Comment : Buried horizon

Table 85: Trial 314, Baseline soil data

							Extractable cations			CEC	OM	P	Total
					pH	P	m.e./100g			m.e.	%	retn	N%
Area	Block	Plot	Year	Yield		μg/m	K	Ca	Mg	100g		%	
Waseta	300029	C	1988	17.4	6.0	3.0	0.23	9.4	1.35	18.0	9.4	82	0.58
		D			6.1	4.0	0.19	7.7	1.25	16.0	7.6	77	0.44
Waru	520003	C	1988	7.5	5.7	3.0	0.18	1.9	0.36	22.0	15.4	96	0.61
		D			5.3	4.0	1.33	2.8	0.62	24.0	16.6	96	0.59
Waru	520011	C	1990	15.8	6.1	12.0	0.62	12.1	2.51	26.0	8.6	81	0.43
		D			6.2	6.0	0.43	8.7	1.56	15.0	3.0	22	0.18
Saiho	320012	C	1989	21.6	6.1	4.0	0.12	5.9	1.18	18.0	9.0	88	0.6
		D			6.0	3.0	0.12	4.3	0.93	17.0	9.7	90	0.56
Agenaham	390001	C	1989	24.3	6.7	5.0	0.09	20.4	1.68	22.0	8.4	90	0.49
		D			6.5	6.0	0.1	11.3	2.4	21.0	8.1	86	0.53
Kipore	580007	C	1990	23.3	5.2	7.7	0.16	5.5	2.04	14.3	4.9	33	0.27
		D			6.5	7.0	0.14	11.0	1.93	13.7	2.6	27	0.17
Isavene	080079	C	1989	12.9	6.5	5.0	0.16	11.9	2.22	18.0	5.2	50	0.32
		D			6.5	5.0	0.2	15.6	3.0	25.0	7.2	66	0.45
Isavene	101179	C	1988	12.1	5.0	4.0	0.74	1.3	0.36	27.0	15.4		0.56
		D			5.3	9.0	0.42	0.9	0.23	23.0	13.5		0.42
Igora	111578	C	1988	15.8	6.1	3.0	0.11	4.2	0.56	15.0	9.1	90	0.46
		D			6.2	4.0	0.1	4.6	0.63	14.0	8.5	86	0.37
Igora	111611	C	1988	18.2	6.3	3.0	0.25	7.3	1.3	13.0	2.9	28	0.2
		D			6.2	3.0	0.15	7.2	1.3	12.0	2.8	25	0.16
Sangara	050157	C	1988	18.6	6.3	25.0	0.13	9.1	1.33	15.0	4.7	34	0.16
		D			6.4	7.0	0.12	6.8	1.04	11.0	3.5	23	0.14
Dobuduru	260002	C	1988	11.1	6.2	10.0	0.07	5.2	0.65	9.0	4.3	37	0.2
		D			6.4	7.0	0.07	5.8	0.83	10.0	4.3	34	0.24
E Ambogo	030309	C	1988	12.0	6.9	46.0	0.07	9.2	0.72	11.0	3.8	18	0.13
		D			6.9	36.0	0.08	8.7	0.82	11.0	3.3	15	0.16
Ahora	230003	C	1988	12.5	6.4	29.0	0.4	24.5	8.59	38.0	4.3	35	0.25
		D			6.5	27.0	0.34	26.1	6.56	38.0	5.5	34	0.33
Sorovi	040232	C	1988	7.9	6.3	5.0	0.28	6.1	1.73	12.0	4.3	29	0.28
		D			6.2	4.0	0.32	5.8	1.48	13.0	4.4	42	0.21
Sorovi	040266	C	1989	16.2	6.4	7.0	0.13	10.9	2.66	17.0	3.1	19	0.19
		D			6.5	15.0	0.1	10.6	2.27	16.0	2.8	17	0.18
Sorovi	121779	C	1989	22.6	6.5	7.0	0.16	8.7	5.48	17.0	2.6	13	0.15
		D			6.4	12.0	0.15	8.6	2.67	15.0	2.6	15	0.18
Awowota	220010	C	1988	16.0	6.1	5.0	0.08	6.9	1.52	13.0	3.2	40	0.14
		D			6.2	3.0	0.08	7.8	1.26	13.0	3.3	41	0.12
Popondetta	280004	C	1990	16.5	5.8	32.2	0.78	12.3	2.71	19.7	5.7	39	0.25
		D			6.2	28.3	0.58	15.7	3.08	21.8	5.2	38	0.26
Embi	881111	C	1988	7.3	6.3	4.0	0.07	1.7	0.33	7.0	4.5	46	0.15
		D			6.3	4.0	0.08	1.7	0.49	8.0	4.6	52	0.2

TRIAL 317: N, P, K, Mg FERTILIZER FACTORIAL, LOWER TERRACE, KOMO ESTATE, MAMBA

PURPOSE: To provide an indication of fertilizer response on Lower Terrace soils, for guidance on commercial fertilizer practice.

SITE DETAILS :

Location: Komo Estate, Mamba, block 27.
Genetic material: Dami commercial DxP crosses.
Soils: Lower Terrace 2 landform. These soils consist of a dark topsoil derived from airfall ash, overlying coarse alluvial horizons. P retention is high, and CEC and base saturation are low.
Planting date: October 1985.
Density: 130 points/ha (9.42 m triangular spacing).
Size: The trial comprises 36 plots and a total of 467 palms including the guard palms.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 317 is a factorial design, with one replicate and 3x2x3x2 treatments for NxPxKxMg.
Layout: The plots consist of a core of 10 recorded palms, normally separated from adjoining plots by a trench of 1 m depth. The trenches are intersected at intervals by soil infill, with 0.8 mm plastic inserts to prevent access by roots from neighbouring plots. At the perimeter and where space permits there are guard palms.
Trial commencement: March 1990.
Trial progress: Ongoing.
Treatments in kg/palm/year:

		Level		
Fertilizer		0	1	2
N	SOA	0	2.5	5
P	TSP	0	2.5	
K	MOP	0	2.5	5
Mg	Kieserite	0	2.5	

RESULTS :

1. Production

Yield recording did not commence until January 1991, so that the initial data are provided by growth measurements obtained at the end of 1990, which are presented in Tables 86 and 87 and illustrated in Fig. 55, on an annualised basis.

Considering the short duration of the trial, the initial responses are marked. SOA provided an overall significant response with the N1 rate increasing yield and the N2 rate depressing it.

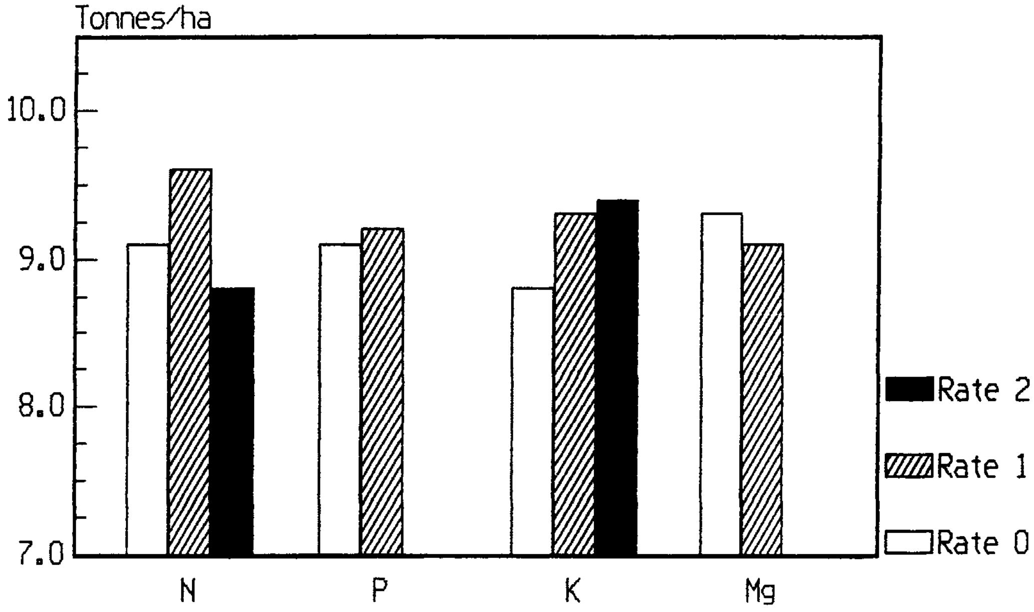
Table 86: Trial 317 Palm growth and conversion data for 1990

Period	12/90	1990	1990	1990
TRTMNT	Height m (VH)	Leaf prdn (n)	Dry Frond weight kg (FW)	Frond DM tha (FDM)
N 0	1.62	20.7	**3.07**	**9.1**
N 1	1.56	21.3	**3.15**	**9.6**
N 2	1.49	21.1	**2.94**	**8.8**
P 0	1.56	20.9	3.05	9.1
P 1	1.55	21.1	3.06	9.2
K 0	1.58	**20.4**	3.03	8.8
K 1	1.54	**21.2**	3.08	9.3
K 2	1.56	**21.4**	3.05	9.4
Mg 0	1.58	20.9	3.11	9.3
Mg 1	1.54	21.2	3.00	9.1
lsd(N&K)	0.15	1.1	0.14	0.6
lsd(P&Mg)	0.13	0.9	0.12	0.5
c.v.	11	6	5.4	7.8

Table 87: Trial 317, Production for different fertilizer combinations 1990

	P0	P1	Frond weight	
K0	2.99	3.07		
K1	3.18	2.98		
K2	2.98	3.12	lsd	0.20
	Mg0	Mg1	Frond weight	
N0	3.03	3.11		
N1	3.30	3.01		
N2	3.00	2.88	lsd	0.20
	Mg0	Mg1	Frond dry matter	
N0	8.70	9.40		
N1	10.10	9.10		
N2	8.80	8.90	lsd	0.82
	K0	K1	Frond dry matter	
N0	8.60	9.10		
N1	9.50	9.50		
N2	8.30	9.50	lsd	1.07

Figure 55: Trial 317 FDM Values 1990



There were a number of significant interactions, indicating additional responses to MOP and kieserite in certain fertilizer combinations. At this stage there is no response to TSP.

The response to kieserite was lost in the presence of SOA, as in the trials at Higaturu. This might indicate the response as being at least partially due to the sulphate content of the kieserite rather than to the Mg.

Although plant K levels are below those at Higaturu, they do not appear unduly low, so that the response to MOP is likely to be due to Cl, which has been found to be capable of promoting uptake of bases and increasing leaf P levels. These effects could be valuable at Mamba. At the N0 and N2 levels there appeared to be a quadratic response to MOP, similar to that seen to SOA. At the N1 level, this response was not apparent.

2. **Leaf and Soil data**

Tables 88, 89 and 90 indicate the leaf, rachis and soil analyses for the trial area prior to trial commencement. In each case the trial was divided into 3 areas, and composite samples were bulked from each area.

Whilst the leaf analyses are broadly similar to those at Higaturu apart from lower rachis K levels, the soil analyses, as might be expected, are markedly different, with a much lower base saturation reflected primarily in reduced levels of Ca and Mg. Conversely the organic matter levels, and P retention are much higher at Mamba.

3. Discussion

The low levels of cv and rapid identification of initial responses confirm the potential of the trial design which has been adopted.

The response to SOA on the lower terrace soil at Mamba appears to be markedly quadratic, rather than linear as in the trials at Higaturu. This would indicate a requirement for precision in fertilizing on the lower base saturation soils at Mamba, with the possibility of substantial depression of yield from excessive fertilizer applications.

Overall the initial data would indicate that the optimum response has been obtained with the application of SOA alone at the rate of 2.5 kg. The possibility of a Cl response would suggest that AMC would have a part to play in commercial oil palm fertilizer programmes.

Table 88: Leaf analysis of blocks prior to trial commencement: February 1990

	Block 1	2	3	Mean
N%	2.8	2.76	2.76	2.77
P%	0.177	0.179	0.176	0.177
K%	0.91	0.91	0.9	0.91
% K/TB	25	25	24	25
Mg%	0.22	0.19	0.2	0.2
% Mg/TB	20	17	17	18
Ca%	1.02	1.06	1.15	1.08
% Ca/TB	55	58	59	57
Cl%	0.3	0.31	0.37	0.33

At this stage the data are very limited, so that the results should be subject to further confirmation before definite conclusions are drawn.

SUMMARY

A marked initial vegetative response has been obtained, with SOA increasing FDM production at 2.5 kg, and depressing it at 5 kg.

There were apparent responses to MOP and kieserite in certain fertilizer combinations, but no response to TSP.

The quadratic responses to SOA and MOP indicate that particular care is necessary in fertilizing, since incorrect applications could reduce production.

The response to MOP appears to be a Cl response, indicating that AMC would be an important component in commercial oil palm fertilizer programmes for the Mamba valley.

At this stage the data are very limited, so that the results should be subject to further confirmation before definite conclusions are drawn.

The rapid initial responses and the reasonable c.v. levels confirm the potential of the innovative trial design which has been adopted.

Table 89: Rachis analysis prior to trial commencement: February 1990

	Block 1	2	3	Mean
N%	0.25	0.29	0.26	0.27
P%	0.061	0.068	0.057	0.062
K%	0.65	0.83	0.61	0.7
% K/TB	33	41	27	34
Mg%	0.11	0.12	0.12	0.12
% Mg/TB	18	19	17	18
Ca%	0.49	0.41	0.65	0.52
% Ca/TB	49	40	56	48
Cl%	0.19	0.39	0.33	0.3

Table 90: Soil analysis prior to trial commencement: February 1990

	Block 1	2	3	Mean
pH	5.5	5.6	5.6	5.6
Bulk Den. g/ml	0.93	0.83	0.75	0.84
P μg/ml	12	6	8	8.7
K me/100g	0.11	0.15	0.19	0.15
Ca me/100g	1.1	1.7	2	1.6
Mg me/100g	0.13	0.23	0.24	0.2
Na me/100g	0.04	0.1	0.13	0.09
CEC me/100g	11	15	17	14.3
OM %	4.3	8.2	7.5	6.7
P retn %	65	96	95	85
Ttl N %	0.33	0.58	0.48	0.46

TRIAL 318: N, P, K, Mg Fertilizer Factorial, River Terrace, Komo Estate, Mamba

PURPOSE:

To provide an indication of fertilizer response on River Terrace soils, for guidance on commercial fertilizer practice.

SITE DETAILS :

Location: Komo Estate, Mamba, block 39.
Genetic material: Dami commercial DxP crosses.
Soils: River Terrace landform. These soils consist of a dark topsoil overlying coarse alluvial horizons. P retention is moderately high, and CEC is low.
Planting date: October 1985.
Density: 130 points/ha (9.42 m triangular spacing).
Size: The trial comprises 36 plots with a total of 474 palms including the guard palms.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 318 is a factorial design, with one replicate and 3x2x3x2 treatments for NxPxKxMg.
Layout: The plots consist of a core of 9 recorded palms, normally separated from adjoining plots by a trench of 1 m depth. The trenches are intersected at intervals by soil infill, with 0.8 mm plastic inserts to prevent access by roots from neighbouring plots. At the perimeter and where space permits there are guard palms.
Trial commencement: March 1990.
Trial progress: Ongoing.
Treatments in kg/palm/year:

Fertilizer		Level		
		0	1	2
N	SOA	0	2.5	5
P	TSP	0	2.5	
K	MOP	0	2.5	5
Mg	Kieserite	0	2.5	

RESULTS :

1. Yield

Yield recording did not commence until January 1991, so that the initial data are provided by growth measurements obtained at the end of 1990, which are presented on an annualised basis in Tables 91 and 92 and illustrated in Fig. 55.

Considering the short duration of the trial, the initial responses are marked. SOA provided a significant increase in leaf production, whilst TSP provided a significant increase in FDM production.

There were also significant interactions between SOA and TSP, and MOP and TSP, but no response was identified to kieserite.

2. Leaf and Soil data

Tables 93 to 95 indicate the leaf, rachis and soil analyses for the trial area prior to trial commencement. In each case the trial was divided into 3 areas, and composite samples were bulked from each area.

Whilst the leaf analyses are broadly similar to those at Higaturu apart from lower rachis K levels, the soil analyses, as might be expected, are markedly different, with a much lower base saturation reflected primarily in reduced levels of Ca and Mg. Conversely the organic matter levels, and P retention are much higher at Mamba.

3. Discussion

The low levels of c.v. and rapid identification of initial responses confirm the potential of the innovative trial design which has been adopted.

In comparing 317 and 318, production levels are slightly higher in trial 317.

Although initial plant N levels in trial 318 were high, responses to SOA were still observed, with negligible depression of yields at N2 compared with trial 317, indicating a potentially higher N requirement on the river terrace soils.

The benefit from TSP application was only found in trial 318. The river terrace soils are shallower than the lower terrace, and P levels are lower, although the P fixation is also lower. Thus the soil reservoir of P (and indeed other nutrients) is probably more limited than on the deeper lower terrace soils.

Table 91: Trial 318 Palm growth and conversion data for 1990

Period	12/90	1990	1990	1990
TRTMNT	Height m (VH)	Leaf prdn (n)	Dry Frond weight kg (FW)	Frond DM tha (FDM)
N 0	1.38	21.0	2.85	**8.6**
N 1	1.44	22.1	2.92	**9.2**
N 2	1.42	21.9	2.90	**9.1**
P 0	1.46	21.3	2.84	**8.7**
P 1	1.37	21.9	2.94	**9.2**
K 0	1.38	21.4	2.91	**8.9**
K 1	1.39	21.9	2.89	9.0
K 2	1.48	21.7	2.87	8.9
Mg 0	1.39	21.4	2.85	8.7
Mg 1	1.43	21.9	2.93	9.1
lsd(N&K)	0.16	0.9	0.18	0.6
lsd(P&Mg)	0.13	1.0	0.14	0.5
c.v.	13.3	4.7	7.2	7.7

Table 92: Trial 318 Production for different fertilizer combinations 1990

Frond weight		P0	P1		
	K0	2.74	3.09		
	K1	2.89	2.88		
	K2	2.90	2.84	lsd	0.25
Frond weight		P0	P1		
	N0	2.80	2.90		
	N1	3.00	2.85		
	N2	2.74	3.06	lsd	0.20
Frond dry matter		P0	P1		
	N0	8.4	8.7		
	N1	9.2	9.2		
	N2	8.4	9.7	lsd	0.84
Frond dry matter		K0	K1		
	N0	8.3	8.5		
	N1	8.9	9.4		
	N2	9.5	9.2	lsd	1.03

Figure 56: Trial 318 FDM Values 1990

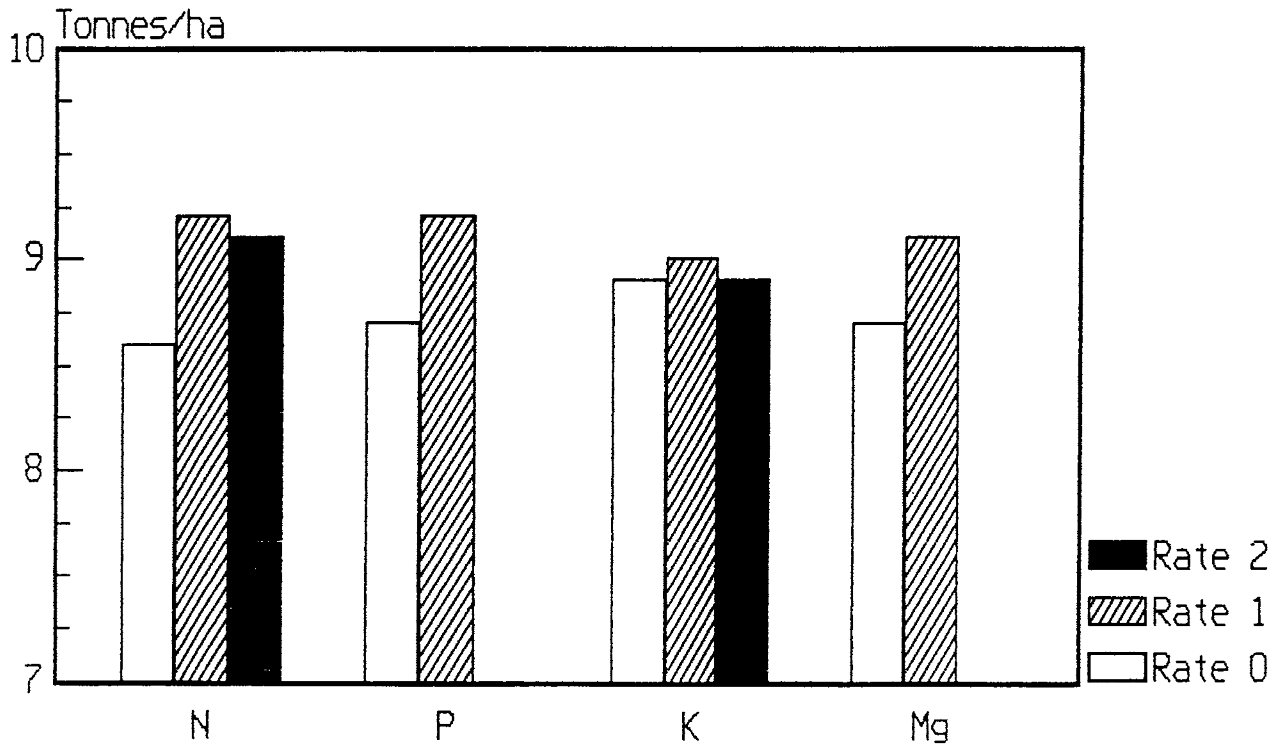
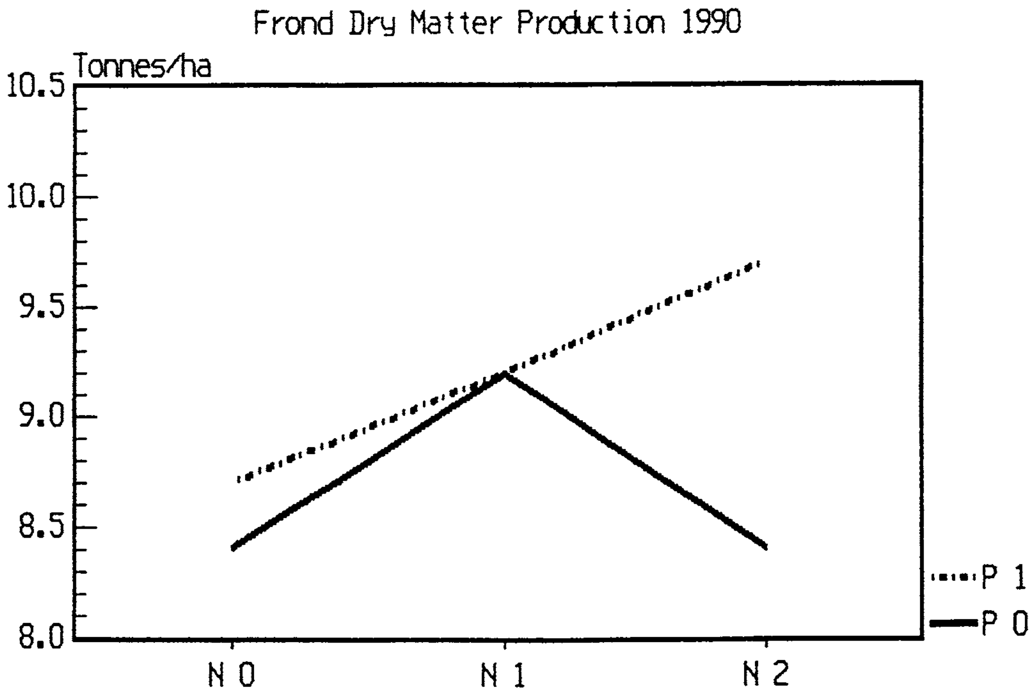


Figure 57: Trial 318 FDM Values 1990



Response to SOA appeared to be enhanced in the presence of TSP and also of MOP (see figures b31890 and c31890). There was a significant interaction between TSP and MOP: response to TSP was lost in the presence of MOP and response to MOP was lost in the presence of TSP. Since Cl can increase levels of P and Mg in the plant it is possible that this interaction involves P levels being increased by 2 separate mechanisms. The benefit is therefore more likely to be due to Cl than to K. Plant K levels were similar to trial 317, and do not appear unduly low.

Overall the initial data would indicate that the optimum response was obtained with the application of 2.5 kg of SOA. At K0 this provided 8.9 t of FDM, whilst at K1 this was increased to 9.4 t, indicating the likelihood of a Cl response. This would indicate potential for AMC applications as a component of commercial fertilizer programmes.

At this stage the data are very limited, so that the results should be subject to further confirmation before definite conclusions are drawn.

SUMMARY

Marked initial vegetative responses have been obtained: SOA increased leaf production and TSP increased FDM production.

There were also responses to MOP in certain fertilizer combinations, but no response to kieserite.

There are indications of a potentially higher N requirement on the river terrace soils than on the lower terraces.

The response to MOP is likely to be due to Cl rather than K, indicating that AMC would be an important component in commercial oil palm fertilizer programmes for the Mamba valley.

At this stage the data are very limited, so that the results should be subject to further confirmation before definite conclusions are drawn.

The rapid initial responses and the reasonable c.v. levels confirm the potential of the innovative trial design which has been adopted.

Table 93: Leaf analysis prior to trial commencement: February 1990

	Block 1	2	3	Mean
N%	3.06	3.04	2.94	3.01
P%	0.185	0.19	0.184	0.186
K%	0.94	0.98	0.98	0.97
% K/TB	25	27	26	26
Mg%	0.26	0.26	0.25	0.26
% Mg/TB	22	23	21	22
Ca%	1.00	0.96	1.01	0.99
% Ca/TB	52	51	52	52
Cl%	0.36	0.33	0.32	0.34

Table 94: Rachis analysis prior to trial commencement: February 1990

	Block 1	2	3	Mean
N%	0.27	0.28	0.27	0.27
P%	0.062	0.061	0.067	0.063
K%	0.71	0.49	0.96	0.72
% K/TB	32	31	47	37
Mg%	0.11	0.11	0.11	0.11
% Mg/TB	16	23	16	18
Ca%	0.6	0.37	0.4	0.46
% Ca/TB	52	46	38	45
Cl%	0.24	0.19	0.29	0.24

Table 95: Soil analysis prior to trial commencement: February 1990

	Block 1	2	3	Mean
pH	5.3	5.1	5.4	5.3
Bulk Den. g/ml	0.86	0.93	0.93	0.91
P μg/ml	7	10	7	8
K me/100g	0.12	0.07	0.07	0.09
Ca me/100g	0.7	0.6	1.2	0.8
Mg me/100g	0.17	0.11	0.28	0.19
Na me/100g	0.03	0.04	0.05	0.04
CEC me/100g	11	11	9	10.3
OM %	3.6	3.8	2.5	3.3
P retn %	44	47	27	39
Ttl N %	0.26	0.3	0.2	0.25

TRIAL 321, Thinning Trial, Ambogo

PURPOSE:

To obtain information on growth parameters within an area of palms thinned by the estate.

SITE DETAILS :

Location: Ambogo Estate HOPPL, block 79.T.
Genetic material: Dami commercial DxP crosses.
Soils: Penderetta and Ambogo families, which are of recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam subsoil, and with seasonally high water tables.
Planting date: 1979.
Density: 143 points/ha.
Size: The trial comprises 102 plots; each having 2 palms, within a thinned area of 19 ha.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 321 has is a randomised block design, with 102 replicates and 2 treatments (thinned and unthinned).
Layout: The plots consist of 2 adjacent palms, 1 thinned (adjacent to a poisoned palm) and 1 unthinned (surrounded by 6 palms).
Trial commencement: Work by OPRA commenced in November 1989.
Trial progress: Ongoing.

Trial details: Field 79.T was thinned in August 1988 by Ambogo Estate to investigate the effects of thinning. The first poisoning using 100 ml of Grammoxone per palm was not entirely successful, and a second poisoning was carried out in November 1988, using Kiltox.

The thinning was at hexagonal centres (see Figure 58). This work was carried out entirely by HOPPL, and OPRA was not initially consulted or involved. The lack of any experimental design for the thinning rendered it difficult to draw any reliable conclusions from the exercise.

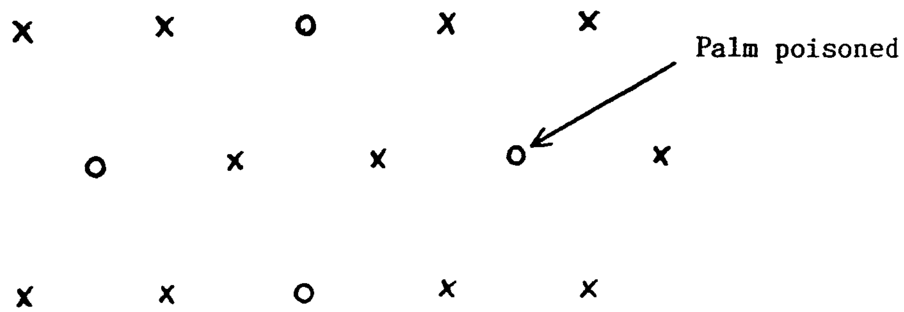
In September 1989 OPRA was requested to undertake monitoring of vegetative parameters in the thinned area. This presented a problem, in that to obtain meaningful results it is necessary to have comparison between treated units and controls.

Survey of the field identified a number of sites where small areas had not been thinned, and 102 pairs of palms were selected, scattered throughout the area, where an unthinned palm was sited adjacent to a thinned palm. These pairs were then mapped, marked and measured, to provide comparison of the vegetative effects of thinning.

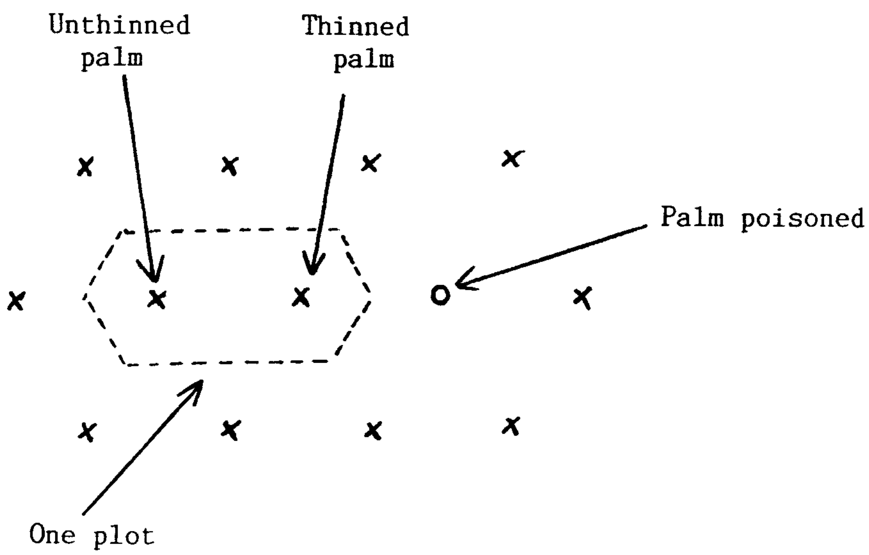
Yield measurements are only conducted by the estate, where separate records of the thinned block and adjacent block are maintained.

Figure 58: Trial 321 Diagrams of the pattern of thinning and plot layout

a) Thinning method



b) Plot layout



RESULTS :

The trial is still at an early stage and long term responses may differ from the initial effects.

Interactions between thinning and plant growth, particularly height increment are of particular interest.

Height is normally measured to frond 41, which indicates height attained approximately 2 years previously. In order to gain a rapid assessment of thinning effects, an additional height measurement was made to frond 9 as a measurement of the most recent height increment. Growth data for 1989/90 is shown in Table 96.

Although the initial effect of thinning was a significant increase in the vertical growth of the thinned palms, this has now been reversed, so that overall vertical growth is now virtually identical for both treatments. If the present trend continues, subsequent growth by the thinned palms will be less than by the unthinned.

In terms of individual frond weights and areas there was no statistically significant difference. Calculation of the LAI indicated a substantial reduction due to thinning.

SUMMARY

There was an initial surge in vertical growth by the thinned palms; which was subsequently reversed, so that after 2 years, growth within each treatment is very similar.

The latest records indicate that vertical growth of the thinned palms is diminishing, and it is likely that this effect will continue in the longer term. At this stage it is not statistically significant.

In terms of individual frond weights and areas there is no statistically significant difference. There is however a substantial reduction in the LAI due to thinning.

Table 96: Trial 321 palm growth data 89/90

	11/90	89/90	1990	1990	1989	1989
TRTMNT	Height m (VH)	Frond wt (FW)	Frond 9 from f9 in 1989 cm	Frond 9 from f41 in 1989 cm	Frond area (FA)	LAI
Unthinned	7.14	4.41	60	246	11.1	**6.67**
Thinned	7.18	4.42	53	248	11.3	**5.82**
lsd	0.23	0.188	9.7	10	0.4	0.23

TRIAL 501, Preliminary Fertilizer Trial, Hagita

PURPOSE:

To assess initial nutrient responses at Milne Bay.

SITE DETAILS :

Location: Hagita Estate MBE.
Genetic material: Dami commercial DxP crosses.
Soils: Plantation family, which is of recent alluvial origin, with (sandy) clay loam soils and a seasonally high water table.
Planting date: April 1986.
Spacing: 127 points/ha.
Size: The trial has 58 plots totalling 1364 palms, including guard rows, and is surrounded by additional areas fertilized by OPRA to ensure separation from estate fertilizing.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 501 is a randomised complete block trial, of 3 replicates, each comprising factorial application of 3x2x3 N,P,K treatments. Boron treatments have been superimposed on a split plot basis. There are 4 additional observation plots to monitor effects with zero MOP application, since this treatment has been removed from the trial.
Layout: The plots originally consisted of a core of 16 recorded palms. Guards were introduced in 1988 as a modification to the original unguarded design. The guards were allocated from palms adjoining the original 16 core palms, and in consequence many plots were only guarded on 2 sides. Additional guard palms were introduced in 1990, providing full guard rows for all plots, with a consequent reduction in the recorded core palms to 8 per plot.
Trial commencement: July 1986.
Trial progress: Ongoing.
Treatments:

Age	Date	SOA			TSP		MOP			B	
Mnth		0	1	2	0	1	0	1	2	0	1
3	7/86	0.3	0.3	0.4	0	0	0	0	0	0	0
6	10/86	0	0.3	0.6	0	0.5	0	0.25	0.5	0	0
12	4/87	0	0.6	1.2	0	0.5	0	0.5	1	0	0
18	10/87	0	0.6	1.2	0	0.5	0.5	1.5	2.5	0	.05
24	4/88	0	0.9	1.8	0	0.5	0.5	1.5	2.5	0	0
36	10/88	0	0.9	1.8	0	0.5	0.25	1.25	2.25	0	.05
42	4/89	0	0.9	1.8	0	0.5	0.25	1.25	2.25	0	0

Applications are now continuing at the 36 and 42 month rates.

RESULTS :

1. Production

After delays occasioned by late commissioning of the mill, yield recording finally commenced in July 1990. As shown in Table 97 and Fig. 59, high yields in the order of 20 t/ha have been obtained in the first 6 months of recording, due to stimulation of yield through previous ablation.

Table 97: Trial 501, Yield data for 6 months

TRTMNT	1990 Wt of bunches t/ha	1990 No of bunches /ha	1990 s.b.w. kg
N 0	20.2	1624	12.4
N 1	21.1	1722	12.2
N 2	21.2	1719	12.2
P 0	21.0	1677	12.4
P 1	20.7	1699	12.1
K 0	**18.1**	1641	**10.8**
K 1	**22.5**	1714	**13.1**
K 2	**21.9**	1710	**12.8**
lsd N&K	2.1	120	0.8
lsd P	1.7	98	0.6
c.v.	15	11	9

Overall the major response has been to MOP at the 2.5 kg/palm rate, with some additional benefit from SOA at 1.8 kg/palm.

Considering the combined effects of MOP and SOA shown in Table 98, response to MOP was quadratic, with the maximum K2 rate depressing yield in the absence of SOA. Whilst a maximum response of 30% was obtained with the N1K2 combination, the most economic treatment at this very early stage is clearly K1 alone.

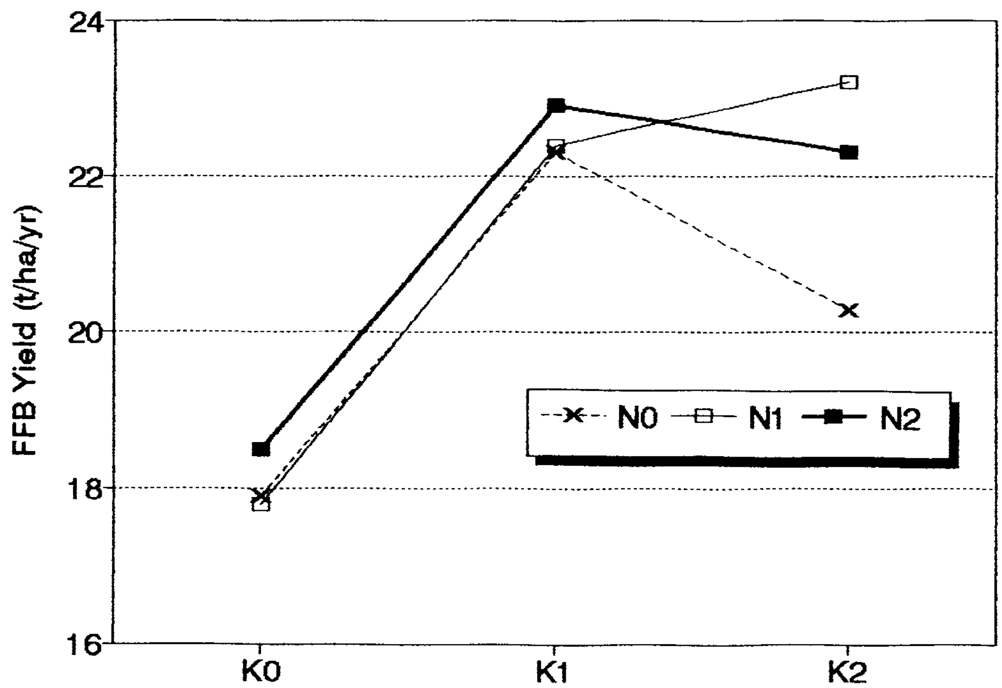
Table 98: Trial 501, FFB Yields in t/ha over 6 months in 1990 for NK combinations

		K0	K1	K2
	N0	17.9	22.3	20.3
	N1	17.8	22.4	23.2
lsd 3.6	N2	18.5	22.9	22.3
Percentage basis:				
		K0	K1	K2
	N0	100	125	113
	N1	99	125	130
	N2	103	128	125

MOP increased yields mainly through a significant increase in bunch weights. Bunch numbers were also increased by both SOA and MOP, but not to a significant extent.

No response to TSP application was observed.

Figure 59: Trial 501 Yields over 6 months: 1990



2. Growth

The latest vegetative measurements shown in Table 99, confirmed previous trends, and were remarkably similar to the yield response, apart from the greater responses to SOA and K2 levels of MOP.

The major response was to MOP alone, with increased benefits during 1990. The K1N0 rate provided a 21% response, whilst the K2N1 rate gave the maximum yield of any combination, with a response of 30%.

Table 99: Trial 501, Palm Growth and Conversion data

Period	89/90 Leaf prdn (n)	89/90 Dry Frond weight kg (FW)	89/90 Frond DM tha (FDM)
N 0	**38.7**	**2.09**	**10.1**
N 1	**39.8**	**2.17**	**10.8**
N 2	**39.7**	**2.23**	**11.0**
P 0	39.2	2.17	10.7
P 1	39.6	2.16	10.7
K 0	39.7	**1.95**	**9.7**
K 1	39.1	**2.26**	**11.1**
K 2	39.3	**2.27**	**11.2**
lsd (N&K)	0.8	0.08	0.5
lsd (P)	0.7	0.07	0.4
c.v.	3	6	7

Table 100: Trial 501, FDM values for NK treatments 1989/90

Frond Dry Matter t/ha 1989/90

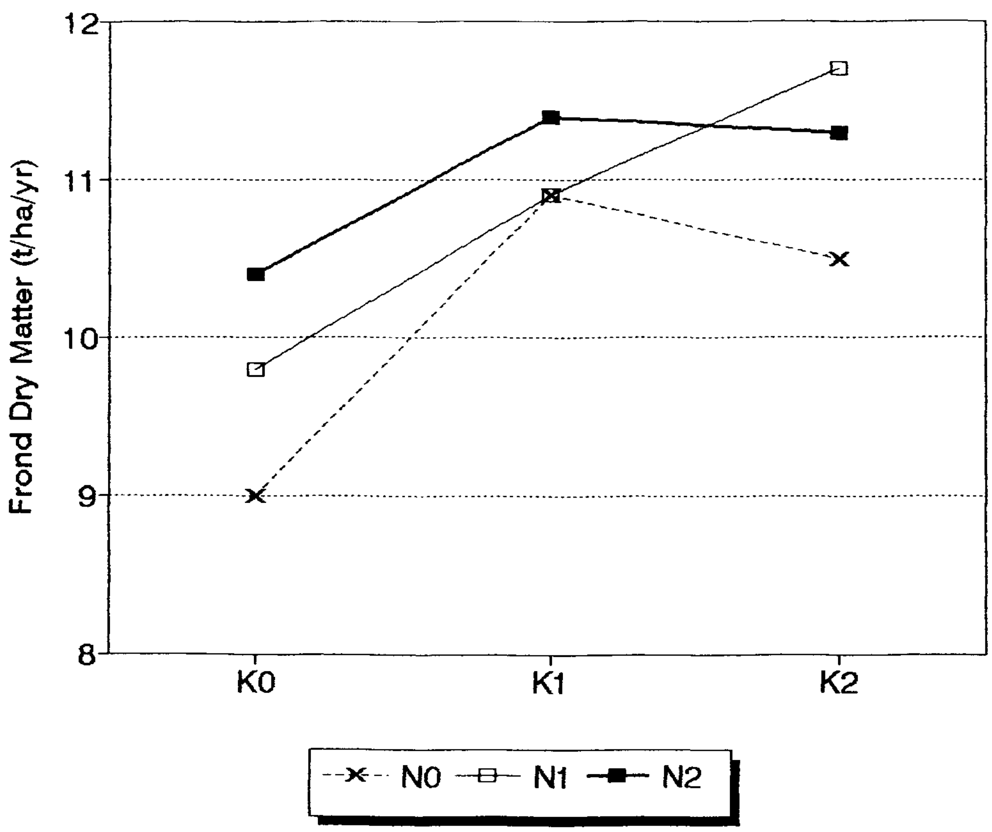
lsd 1.0

	K0	K1	K2
N0	9.0	10.9	10.5
N1	9.8	10.9	11.7
N2	10.4	11.4	11.3

Percentage basis:

	K0	K1	K2
N0	100	121	117
N1	109	121	130
N2	116	127	126

Figure 60: Trial 501 FDM Values for SOA & MOP: 89/90



3. **Plant Analysis**

The latest complete leaf analysis results available are shown in Table 101, whilst more recent results for individual plots are compiled in Table 102. The latter shown that MOP has produced the most noticeable effects, with a doubling of rachis K levels to above 1%, and a substantial increase in Cl levels from below 0.25 to above 0.35. These figures illustrate the importance of MOP rates at least equivalent to K1, for both K and Cl.

SOA application boosted N levels in the leaf, in line with the responses observed.

Boron was also substantially increased in line with application rate, from levels below 9ppm, into the range 12-15 ppm during 1989. However, there was no significant effect on plant performance.

Table 101: Trial 501, Leaf Analysis related to fertilizer treatments: September 1988

									lsd	lsd	cv
	N0	N1	N2	P0	P1	K0	K1	K2	NK	P	%
N%	**2.56**	**2.8**	**2.86**	2.72	2.76	2.68	2.74	2.8	0.126	0.103	7
%	100	109	112	100	101	100	102	104			
P%	0.175	0.181	0.181	0.177	0.184	0.175	0.181	0.181	0.007	0.005	5
%	100	103	103	100	104	100	103	103			
K%	0.777	0.782	0.779	0.788	0.771	**0.636**	**0.84**	**0.862**	0.053	0.043	10
%	100	100	101	100	101	100	132	136			
Ca%	0.888	0.892	0.897	0.886	0.899	0.872	0.893	0.911	0.062	0.051	10
%	100	100	101	100	101	100	102	104			
Mg%	**0.438**	**0.403**	**0.407**	0.415	0.417	**0.437**	**0.404**	**0.407**	0.025	0.02	9
%	100	92	93	100	100	100	92	93			
S%	**0.18**	**0.194**	**0.198**	0.189	0.193	0.189	0.191	0.192	0.008	0.006	6
%	100	108	110	100	102	100	101	102			
Cl%	0.49	0.513	0.499	**0.522**	**0.479**	**0.47**	**0.507**	**0.525**	0.043	0.35	13
%	100	105	102	100	92	100	108	112			

4. **Discussion**

It is possible that the higher responses to fertilizer indicated by the vegetative measurements may be reflected in later yield data, since the first 6 months data following a period of ablation may not be characteristic of subsequent performance. The initial flush may have masked some of the yield differentials, which could become evident as nutrient stress develops subsequent to the commencement of production. In fact initial fertilizer responses of 25% plus are unusual, providing some indication of just how vital potassium nutrition is at Milne Bay.

Response to MOP is generally under-estimated in the trial, as the "K0" treatment receives 0.5 kg of MOP per annum, to avoid the severe impairment initially observed when no MOP was applied.

MOP has improved plant Cl nutrition as well as K levels, which could be an additional benefit. With heavy soils and alternation between water-logging and dry periods, adequate Cl supplies are particularly important for water regulation and reduction of stress.

The most recent data confirm the continued primary requirement for high MOP applications (2.5 to 4.5 kg/palm) with a supplementary benefit from SOA application, particularly at the low 1.8 kg rate.

SUMMARY:

High yields in the order of 20 t/ha have been obtained in the first 6 months of recording, due to stimulation of yield through previous ablation.

The major response to MOP has continued, with the K1 rate boosting yields by 25%.

Maximum yields were obtained with the K2N1 combination which provided a 30% response. However application of K2 rates in the absence of SOA reduced response.

MOP increased yields mainly through an increase in bunch weight.

MOP also improved plant Cl nutrition which could be beneficial during periods of water stress.

Additional benefit from SOA application was observed.

No response to TSP application was found.

The continued primary requirement for MOP application has been confirmed by the early yield results, with the major response provided by the K1 application (2.5 kg/palm MOP). Additional yield responses were obtained by increasing MOP up to 4.5 kg/palm in the presence of 1.8 kg/palm of SOA, but as yet these are not economic. However vegetative responses indicate that higher fertilizer rates are likely to be worthwhile in the future.

Table 102: Trial 501, Progressive changes in yield and nutrient status

N0K0		88	89	90	AVG
P 1	Yield			19.6	19.6
	N%	2.1	2.4	2.8	2.43
	K%	0.72	0.7	0.77	0.73
	K% TB			22	22
	P%	0.159	0.157	0.177	0.16
	Cl%	0.56		0.27	0.42
	Cl% rc			0.19	0.19
	Ca%	0.9	0.79	0.79	0.83
	Mg%	0.53	0.45	0.4	0.46
	Mg% TB			36	36
	K% rc		0.32	0.55	0.44

N1K0		88	89	90	AVG
P 11	Yield			20.5	20.5
	N%	3	2.83	2.84	2.89
	K%	0.68	0.64	0.69	0.67
	K% TB			21	21
	P%	0.195	0.172	0.171	0.18
	Cl%	0.38		0.26	0.32
	Cl% rc			0.16	0.16
	Ca	0.92	0.82	0.79	0.84
	Mg%	0.42	0.36	0.33	0.37
	Mg% TB			33	33
	K% rc		0.28	0.5	0.39

(Table 102: contd.)

N0K1		88	89	90	AVG
P 18	Yield			20.1	20.1
	N%	2.7	2.58	2.84	2.71
	K%	0.87	0.76	0.77	0.8
	K% TB			23	23
	P%	0.181	0.172	0.172	0.17
	Cl%	0.51		0.31	0.41
	Cl% rc			0.46	0.46
	Ca%	1.03	0.84	0.9	0.92
	Mg%	0.44	0.34	0.26	0.35
	Mg% TB			25	25
	K% rc		0.9	1.27	1.09
N2K2		88	89	90	AVG
15	Yield			23.5	23.5
	N%	2.9	2.81	2.74	2.82
	K%	0.82	0.72	0.81	0.78
	K% TB			26	26
	P%	0.18	0.167	0.174	0.17
	Cl%	0.57		0.36	0.47
	Cl% rc			0.57	0.57
	Ca%	0.99	0.84	0.76	0.86
	Mg%	0.41	0.33	0.28	0.34
	Mg% TB			28	28
	K% rc		0.8	1.36	1.08
		ASL	AAR	AAR	

TRIAL 502: Mature Phase Fertilizer Trial, Waigani

PURPOSE:

To assess nutrient responses of mature palms at Milne Bay.

SITE DETAILS :

Location: Waigani Estate MBE.
Genetic material: Dami commercial DxP crosses.
Soils: Plantation family, which is of recent alluvial origin, with (sandy) clay loam soils and a seasonally high water table.
Planting date: 1986.
Density: 127 points/ha.
Size: The trial comprises 48 plots totalling 2080 palms, including the guards, and is surrounded by additional areas fertilized by OPRA to ensure separation from estate fertilizing.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 502 is a randomised complete block trial, of 2 replicates, each comprising factorial application of 3x2x4 N,P,K treatments. Provision has been made for alteration of the treatment structure to allow one additional treatment to be superimposed to convert the trial to a 3x2x4x2 factorial in a single replicate.

Layout: The plots consist of a core of 16 recorded palms, surrounded by a guard row, making a total of 36 palms per plot. A second line of guard palms have also been allocated where practicable.

Trial commencement: Fertilizer application commenced in March 1990.

Trial progress: Ongoing.

Treatments:

Treatments in kg/palm/year	Rate			
	0	1	2	3
Ammonium sulphate	0	2.5	5.0	-
Triple superphosphate	0	2.0	-	-
Muriate of potash	0	2.5	5.0	7.5

RESULTS :

Tables 103 to 105 indicate the leaf, rachis and soil analyses for the trial area prior to trial commencement. In each case composite samples were bulked from the respective areas.

The sample results confirm the typical Milne Bay characteristics of low K and high Mg, in common with trial 501 and the smallholder sites.

Yield recording and vegetative measurement are scheduled to commence in 1991, to identify initial fertilizer responses.

Table 103: Trial 72, Initial Leaf Analyses 1990

SAMPLE	A2	B1	Mean
N%	2.57	2.54	2.55
P%	0.159	0.159	0.159
K%	0.64	0.69	0.67
% TB	18	20	19
Mg%	0.42	0.39	0.41
% TB	37	36	36.5
Ca%	0.83	0.79	0.81
% TB	45	44	44.5
B ppm	14	12	13

Table 104: Trial 502, Initial Rachis analyses 1990

SAMPLE	A2	B1	Mean
N%	0.29	0.25	0.28
P%	0.21	0.098	0.154
K%	0.5	0.42	0.46
%TB	27	23	25
Mg%	0.19	0.2	0.2
% TB	33	35	34
Ca %	0.38	0.39	0.39
% TB	40	42	41
B ppm	6	6	6

Table 105: Trial 502, Initial Soil Analyses 1990

PLOT	1-13	14-33	34-48	Mean
pH	6	6.4	6.4	6.3
Bulk Den. g/ml	0.87	0.82	0.9	0.86
P μg/ml	6	7	8	7
K me/100g	0.19	0.12	0.11	0.14
Ca me/100g	24.3	31.6	31.2	29
Mg me/100g	11.5	16	14.8	14.1
Na me/100g	0.69	0.42	0.54	0.55
CEC me/100g	43	54	53	50

TRIAL 504: MATURE PHASE FERTILIZER AGRO-GENETIC TRIAL, SAGARAI

PURPOSE:

1. To assess nutrient responses of mature palms at Sagarai.

2. To provide a comparison between elite crosses in the local environment.

SITE DETAILS :

Location: Sagarai Estate MBE: blocks 6/10, 6/11, 6/12.
Genetic material: Selection from 17 special Dami DxP crosses.
Soils: Tomanau family, which is of recent alluvial origin, with deep clay loam soils and a reasonable drainage status. This is the predominant soil family on the Sagarai Estate.
Planting date: January 1991.
Density: 127 points/ha.
Size: The trial comprises 104 plots of 16 experimental palms, each surrounded by an additional guard row, to provide a total of 36 palms per plot.

DESIGN AND TREATMENT DETAILS :

Background: Trial 504 is a mature phase agro-genetic trial. As such 16 selected elite crosses will be established in a recorded random allocation on each plot at planting. Differential fertilizer treatments will not be introduced until the palms have completed the establishment phase. Appropriate treatment structures and design/s will be selected nearer to that time in the light of the latest available data and perceived requirements for research. Recording will enable both yield data and comparative genetic data to be derived from the trial. In addition the improved measure of genetic uniformity provided by the planting of a standard set of crosses on each plot will improve experimental precision.
Layout: The plots consist of a core of 16 recorded palms, surrounded by a guard row, making a total of 36 palms per plot.
Trial commencement: The selected crosses were received at Sagarai nursery on 5th May 1990, and planted out in January 1991.
Trial progress: Ongoing.

Progress

The selected crosses were at Sagarai in May 1990. Site identification, field survey, lining, marking, and planning were completed by the end of 1990, and planting and checking carried out in January 1991. Wire collars were required to protect against serious rat attacks occurring in the field.

Soils

Table 106 indicates the background soil data for the trial. In comparison to the Milne Bay trials the soil analysis is virtually identical, apart from P levels 7 times higher, and K levels twice as high (but still of a low level). Characteristically high CEC and Mg values were confirmed at both sites.

Table 106: Soil analysis (0-30 cm) prior to trial commencement: October 1990

Block:	6/10	6/11	Mean
pH	6.7	6.7	6.7
Bulk Den. g/ml	0.84	0.82	0.83
P μg/ml	25	40	32.5
K me/100g	0.32	0.35	0.34
Ca me/100g	23.4	26.9	25.1
Mg me/100g	11.81	13.23	12.52
Na me/100g	0.26	0.22	0.24
CEC me/100g	40	46	43
OM %	5	4.1	4.6
P retn %	40	36	38
Ttl N %	0.24	0.22	0.23

SUMMARY

16 selected elite crosses have been established in a recorded random allocation on 104 plots.

Differential fertilizer treatments and recording will not be introduced until the palms have completed the establishment phase.

Appropriate treatment structures and design/s are to be selected nearer to that time in the light of the latest available data and perceived requirements for research.

Recording will enable both yield data and comparative genetic data to be derived form the trial.

TRIAL 506: SMALLHOLDER DEMONSTRATION SITES, MILNE BAY PROVINCE.

PURPOSE:

1. To demonstrate the value of fertilizer applications, for the benefit of all smallholders.

2. To monitor the selected sites so as to obtain agronomic data (e.g. soil, leaf and yield) in order to improve understanding of the basic agronomy for all smallholder areas.

3. To provide an assessment of fertilizer response and requirement for smallholder locations.

SITE DETAILS :

Location: The initial sites selected were at Kera Kera (adjacent to the south Maiwara block of Hagita Estate) and at Baraga (to the south west of Waigani Estate). Brief site details are given in Table 107 and a map of the locations can be found in the 1989 Annual Report.
Genetic material: Dami commercial DxP crosses.
Soils: Both existing blocks lie on the alluvial Plantation Series soils, which are predominant in the area, and are described under trial 501.
Density: 127 points/ha.
Size: The trial initially comprised 2 sites: both with 2 ha planted. Each site has now increased planting to 4 ha, and the trial plots have consequently been increased in 1990 to 6 at Kera Kera and 5 at Baraga. At each site the entire block is fertilized.
Planting dates: 1987 - 1989.

Table 107 Trial 506, Smallholder Background Data

Area	Location Name	Block	First Planting	Fertilizer kg/palm before trial MOP	SOA	TSP
Gumini	West Baraga	04016	3/6/88	0.17	0.17	0.17
Gumini	South KeraKera	01022	20/7/87	0.55	0.55	0.48

DESIGN AND TREATMENT DETAILS :

For general details, please refer to Trial 314, Oro Province, as details are identical.
Trial commencement: March 1989 and ongoing.
Trial progress: Ongoing.

Treatments:

1. The "control" plot receives no fertilizer whatsoever.

2. The "demonstration" plot (and all perimeter palms) are fertilized according to the current recommendation for the specific site, rather than any overall fixed rate, so that flexibility is built into the trial.

Application frequency for N and K fertilizers is twice a year, but TSP is applied in a single annual application of 1kg per palm.

Trial 506 Annual fertilizer rates in kg/palm			
	MOP	SOA	TSP
Years 1 and 2			
Demonstration	1.25	0.625	0
Control	0	0	0
S-0	0	0	0
S-1	0.625	0.625	0.5
S-2	1.25	1.25	-
S-3	1.875	1.875	-
Year 3 onward			
Demonstration	2.5	1.25	0
Control	0	0	0
S-0	0	0	0
S-1	1.25	1.25	1.0
S-2	2.5	2.5	-
S-3	3.75	3.75	-

RESULTS :

Table 108 shows the results of vegetative measurements made in 1990. These do not indicate any initial response to fertilizer. With the manual clearing on ex bush land it would appear that fertilizer response in the immature stage is therefore less than on the estates, where previous cropping had occurred, and different clearing methods were used.

Table 108: Trial 506 Vegetative measurements 1990

Site:	Leaf Prdn. Kera 2 01022	Baraga 04016	Mean	Mean %
N0	40.2	41	40.6	103
N1	40.6	41.4	41	104
N2	37.8	39.6	38.7	98
N3	39.2	40.4	39.8	101
K0	41	40.2	40.6	103
K1	37.4	40.6	39	98
K2	40.6	40	40.3	102
K3	40.6	40.2	40.4	102
P0	40.6	38.7	39.7	100
P1	40.4	41.2	40.8	103
C	42	37.2	39.6	100
D	39.4	35.8	37.6	95

	Frond Weight Kera 2	Baraga	Mean	Mean %
N0	1.42	1.01	1.21	101
N1	1.47	1.08	1.27	106
N2	1.38	1.07	1.23	103
N3	1.45	1.09	1.27	106
K0	1.45	1.02	1.23	103
K1	1.46	1.08	1.27	106
K2	1.36	1.06	1.21	101
K3	1.48	1.05	1.27	106
P0	1.46	1.06	1.26	105
P1	1.42	1.02	1.22	102
C	1.52	0.88	1.2	100
D	1.42	0.91	1.16	97

(Table 108 contd)

	Frond Dry Matter t/ha			
	Kera 2 01022	Baraga 04016	Mean	Mean %
N0	7.25	5.24	6.25	102
N1	7.58	5.75	6.67	109
N2	6.82	5.41	6.12	100
N3	7.59	5.61	6.6	107
K0	7.54	5.19	6.37	104
K1	7.56	5.6	6.58	107
K2	7	5.39	6.2	101
K3	7.67	5.43	6.55	107
P0	7.53	5.44	6.49	106
P1	7.29	5.35	6.32	103
C	8.12	4.15	6.14	100
D	7.10	4.14	5.62	92

The initial smallholder plant analyses are shown in Table 109. These indicate nutrient balances and low K levels similar to those found on the estates, suggesting that similar responses to fertilizer will develop as the trial progresses. Definite improvements in plant analysis have been obtained with MOP applications, which have raised both K and Cl levels. For N there has been little response.

Table 109: Trial 506: Leaf data 1989

Block	Plot	%N	%P	%K	%Ca	%Mg	%Cl
04016	D	2.38	0.169	0.73	0.92	0.42	0.49
	C	2.35	0.170	0.82	0.85	0.44	0.3
01022	D	2.12	0.142	0.60	0.80	0.42	0.49
	C	2.11	0.144	0.56	0.86	0.43	0.35

The low plant nutrient levels, combined with the marked fertilizer responses continuing on the estates would indicate that continued application of fertilizer on the smallholdings would be wise, even if the initial vegetative data at the 2 existing sites has not indicated a positive response. The primary requirement indicated by leaf analysis, and confirmed by results from the estate trials is for MOP application, with a minimum of 2 kg per palm per annum.

With harvesting commencing in 1991 there will be an increased drain on K and other nutrients in the plant, and fertilizer requirements may have to be revised.

4. Discussion

Successful operation of a trial of this nature is more complex than work on the estates, and the good will and co-operation of the block owners must always be maintained. In this context OPRA have benefitted from close co-operation with the DAL Oil Palm Project staff at Alotau.

One of the objectives of the trial is for the demonstration blocks to be used as the basis for extension work to bring about correct fertilizer use by other block owners. This involves long term commitment: only after economic responses have been recorded on the blocks can the extension services use them to demonstrate the need for fertilizer to other block owners. Since it may take some time to obtain meaningful fertilizer responses on the smallholder blocks, the marked responses on the estates could be used for fertilizer demonstrations for the smallholders in the mean time.

SUMMARY :

The 1990 vegetative measurements did not indicate any fertiliser response on the two monitored smallholdings.

Plant analyses indicated broadly similar nutrition to that on the estates, and in particular, K levels were low.

Fertilizer response is therefore expected to develop, particularly with the increased demand for nutrients which will be imposed with cropping.

As a minimum, application of 2kg of MOP per palm per annum would be recommended for mature plantings.

TRIAL 508: CONTINUOUS LEAF NUTRIENT ASSESSMENT, MILNE BAY.

PURPOSE:

1. To assess fluctuation in leaf nutrient levels at Milne Bay, in order to assist in extrapolation of trial results for the benefit of the commercial growers.

2. To review possible factors leading to leaf fluctuation, to facilitate prediction of likely future variation, and to enable corresponding adjustments and recommendations to be made.

SITE DETAILS :

Location: Trial 508 is being carried out within the area of trial 501. All site details are therefore as for trial 501.

DESIGN AND TREATMENT DETAILS :

Background: Monthly leaf samples are taken from the 3 constant groups of 16 palms (8 palms on 2 plots) under 3 different regimes.
Trial commencement: January 1990.
Trial progress: Ongoing.

Treatments:

	Fertilizer regime: kg/palm/year		
Sample code	SOA	TSP	MOP
000	0	0	0
111	1.8	1	2.5
212	3.6	1	5

RESULTS :

Table 110 indicates that marked monthly variation has occurred for most elements. These results are illustrated in Figs. 62 and 63. The discovery of variation of this order confirms the value of the trial.

The variation in rainfall is shown in Fig. 61. All leaf base levels drop in the very dry month of February. Thereafter, as found elsewhere, the divalent cations tend to increase with rainfall (up to a limit of about 300mm per month) whilst potassium levels fall.

The marked seasonal variation in leaf nutrient levels makes interpretation of leaf analysis data in the Milne Bay area difficult. Further results are required to clarify the seasonal pattern so that the optimum period for collection of leaf samples can be determined.

Table 110: Trial 508: Extremes of nutrient variation Jan-Dec 1990

Nutrient:	Highest values Month	000	111	212	Lowest values Month	000	111	212
N %	10/90	2.8	2.9	2.8	1/90	2.2	2.22	2.19
P %	8/90	0.17	0.181	0.179	6/90	0.153	0.157	0.151
K %	1/90	0.71	0.81	0.84	7/90	0.49	0.59	0.57
S %	5/90	0.18	0.19	0.19	1/90	0.16	0.16	0.15
Ca %	1/90	1.01	1.01	0.97	8/90	0.76	0.89	0.82
Mg %	5/90	0.5	0.38	0.37	11/90	0.35	0.25	0.25
Fe ppm	3/90	296	154	207	5/90	99	87	84
Zn ppm	2/90	27	25	22	4/90	19	16	15
B ppm	5/90	14	15	17	1/90	12	13	12

Figure 61: Hagita rainfall 1990

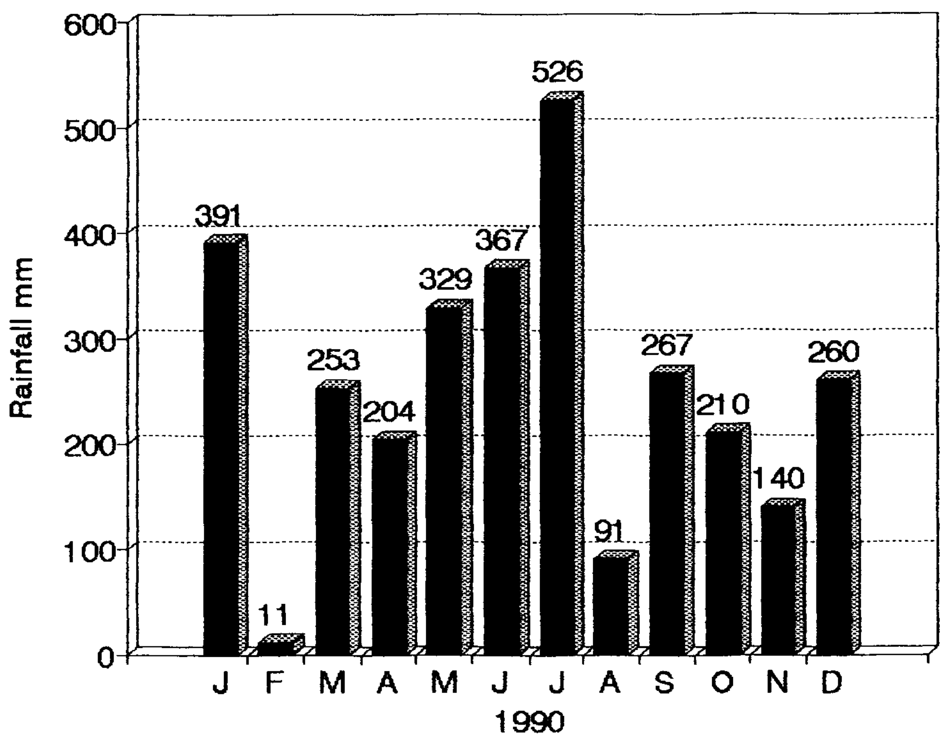


Fig. 62: Trial 508, Leaf N fluctuations in 1990

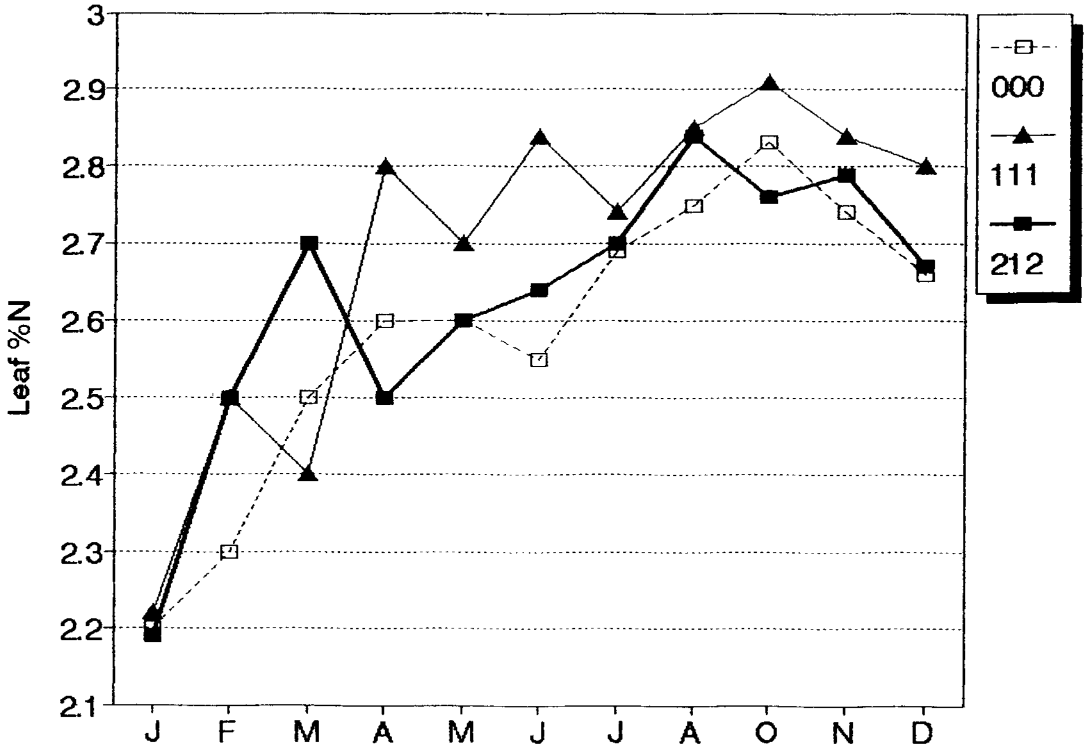
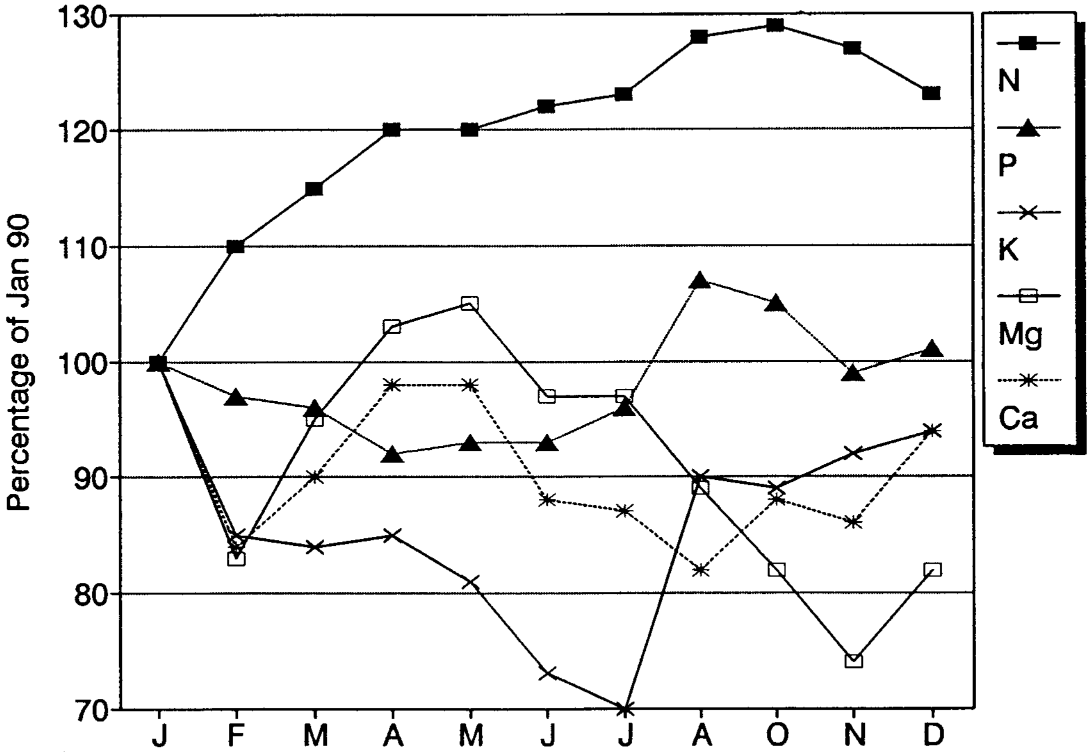


Fig. 63: Trial 508, Percentage leaf nutrient fluctuations in 1990



III. SMALLHOLDER TRIALS.

WEST NEW BRITAIN PROVINCE

(P. Navus)

Fertilizer trials were continued and their number increased on selected smallholder blocks in the mature palm areas (EXPERIMENT 112) in West New Britain Province. 10 additional trial sites were established to cover more extensive areas of the Hoskins (EXPERIMENT 112 and 121), Bialla (EXPERIMENT 207) and Kapiura (EXPERIMENT 403) Projects.

Yield assessment: Recording full harvest every fourth month continued. Also included is the potential palm yield based on frond production count.

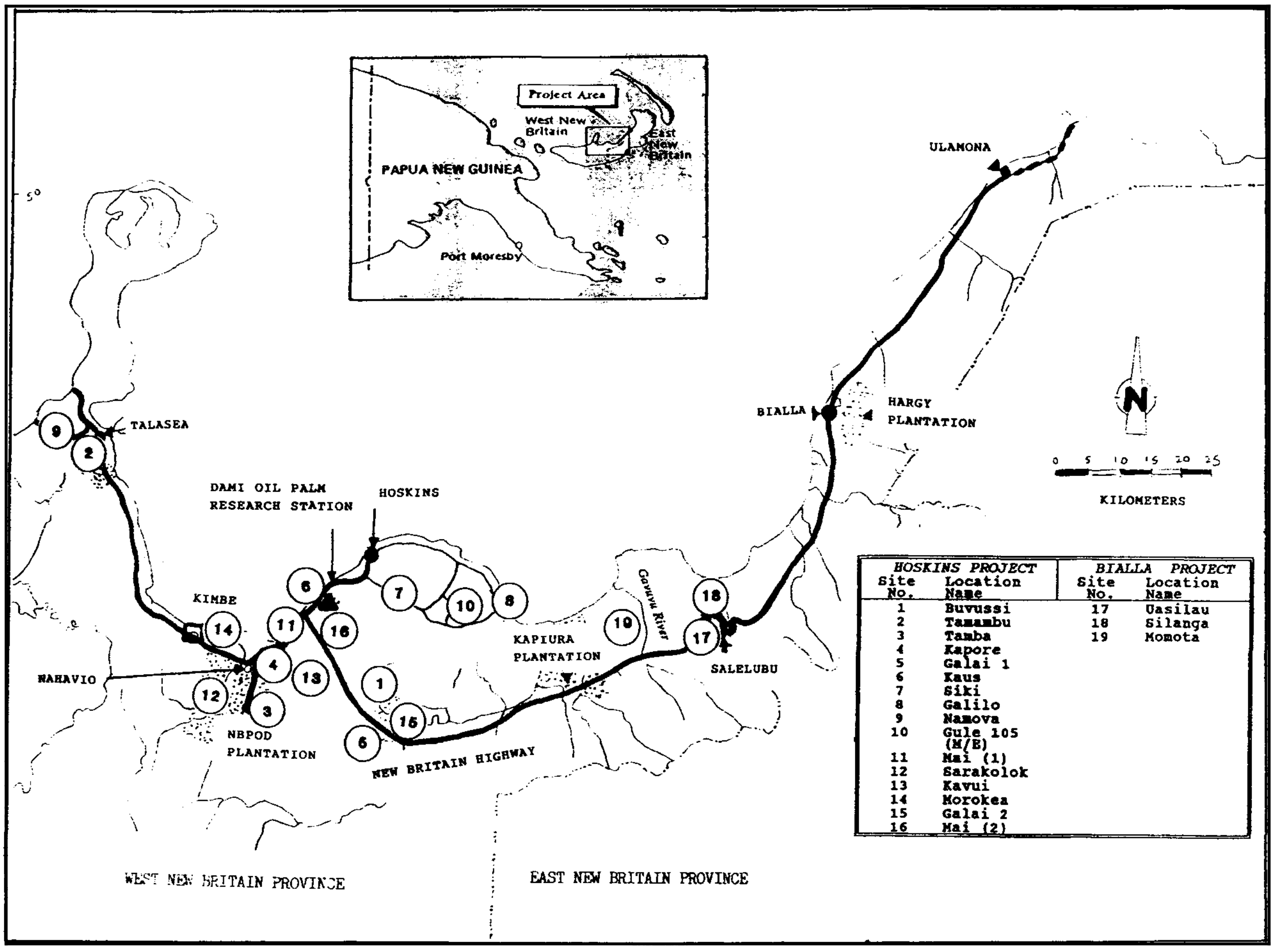
Extension: The passing on of research information to the oil palm farmers is presently confined to a network of on-farm research activities comprising EXPERIMENTS 112, 121 207 and 403. Very close liaison with the DA&L (Oil Palm) extension staff and farmers continued. As a result of increased farmer/research contact it is becoming evident that the adoption of improved technology (fertilizer use and good block management) by farmers is in the majority of cases limited by physical and socio-economic constraints. Beginning with the Hoskins Scheme some of the limiting factors may be highlighted when the current productivity study presently being investigated by an ADB-funded project is completed.

EXPERIMENT 112: NITROGEN AND PHOSPHATE TRIAL

Purpose: Investigations were initially carried out to determine why oil palm growth was so poor in this area as presented by the then DPI (OIL PALM). The Trial was undertaken to demonstrate that poor fertility can be alleviated by fertilizer application. That is, to demonstrate that on problem soils, fertilizer use combined with good management can result in maintaining and/or increasing FFB production.

SITE DETAILS.

Figure 64: Distribution of smallholder demonstrations in West (Hoskins) and Central (Kapiura) Nakanai Oil Palm Schemes.

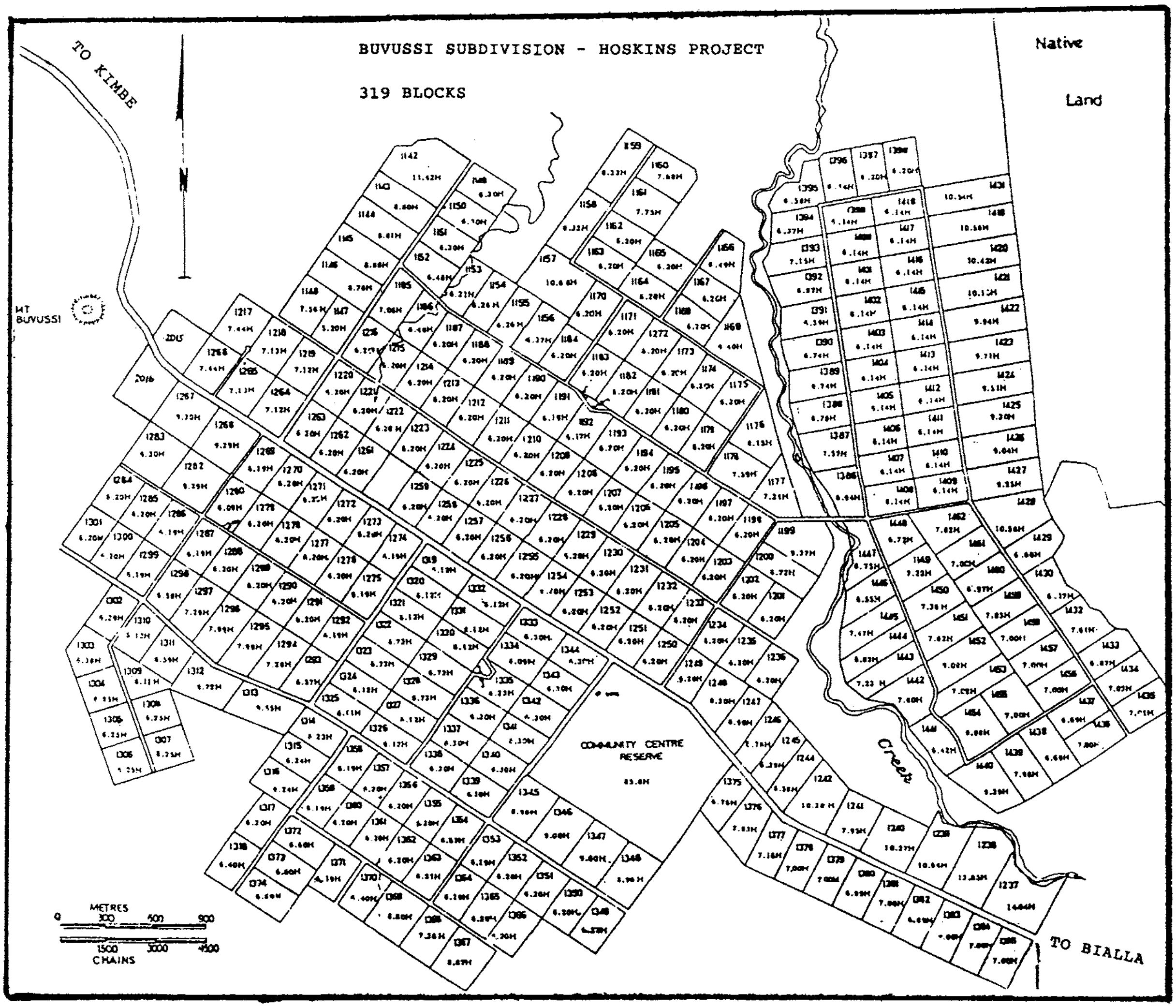


HOSKINS PROJECT Site No.	Location Name	*BIALLA PROJECT* Site No.	Location Name
1	Buvussi	17	Uasilau
2	Tamambu	18	Silanga
3	Tamba	19	Momota
4	Kapore		
5	Galai 1		
6	Kaus		
7	Siki		
8	Galilo		
9	Namova		
10	Gule 105 (M/E)		
11	Mai (1)		
12	Sarakolok		
13	Kavui		
14	Morokea		
15	Galai 2		
16	Mai (2)		

Location and history: Figure 64 shows the location of the Hoskins Project. Experiment 112 covers 8 blocks of small oil palm plantings located at one of the 10 subdivisions within the scheme at Buvussi (Fig. 65). This trial was started as a result of problems associated with the soil conditions in parts of the subdivision. Made up of three clusters, each block provides a single replicate (highlighted on the map) and are about 1.2-1.7km apart: Replicates I-IV, V-VI and VII-VIII, as shown in Figure 65. Despite the distance among the 3 clusters of blocks the physical conditions are sufficiently similar to provide block comparison.

Genetic material: Dami commercial D X P. **Date Planted:** 1980. **Area:** 16ha. **Density:** 120 palms per ha. **Spacing:** 9.75m triangular.

<u>**Figure 65: Typical Settlement Subdivision Layout.**</u>



DESIGN AND TREATMENT DETAILS.

Design: Each block provides a single replicate of 2ha. Within this 2ha there are 3 plots. There are 8 replications each consisting of 3 treatments (- , P, N+P). The layout consist of an average of 16 core palms for recording, surrounded by at least a guard row.

Treatment Details:

FERTILIZER /LEVEL: in kg per palm per year	0	1	2
Ammonium chloride	0	0	2.0
Triple superphosphate	0	1.0	1.0

Date of first treatment: April/May 1986. Revised in November 1988: Ammonium chloride was increased to 2kg/palm/year from 1kg/palm/year. Application frequency: Nitrogen is applied at half the annual rate two times a year in May and November.

Initiated: 1986.

Duration: Ongoing

Progress for 1990:

The following operations were done as scheduled. The annual fertilizer dose was applied to the experimental and perimeter palms. The three partial recordings of harvest (FFB & bunch number per palm) were done including leaf marking and total leaf count between June 1989 and June 1990.

RESULTS:

Table 111 : Expt. 112, Yield Assessment in February, June & October 1990.

Site	F.F.B. tonnes/hectare				Bunch number per hectare				Bunch weight kg			
	(-)	**P**	**N+P**	**Mean**	**(-)**	**P**	**N+P**	**Mean**	**(-)**	**P**	**N+P**	**Mean**
01	07.76	07.00	15.36	10.04	368	296	648	437	21.04	23.64	23.79	22.90
02	13.92	12.76	21.08	15.92	656	564	864	695	21.27	22.66	24.38	22.81
03	17.60	13.20	23.20	18.00	960	772	1124	952	18.33	17.11	20.61	19.08
04	10.16	09.44	14.56	11.39	524	536	588	549	19.33	17.59	24.74	20.58
05	17.96	26.16	24.04	22.72	1000	1072	884	985	17.98	24.22	27.18	23.69
06	08.52	12.44	17.44	12.80	432	640	840	637	19.81	19.41	20.75	19.92
Mean	**12.65**	**13.50**	**19.28**	15.14	**657**	**647**	**825**	709	**19.63**	**20.80**	**23.57**	21.34
LSD	3.38 (P =.05)				163.7 (P =.05)				2.57 (P =.05)			
C.V. %	17.36				17.94				9.37			
07	20.36	20.04	23.76	21.39	1064	972	996	1011	19.11	20.59	23.90	21.20
08	15.88	12.96	16.40	15.08	812	584	680	692	19.55	22.16	24.05	21.92
Mean	18.12	16.50	20.08	18.23	938	778	838	852	19.33	21.38	23.98	21.56
LSD	3.28 (P =.10)				140 (P = .10)				2.28 (P =.05)			
C.V.%	6.16				45.8				2.46			
Grand Mean	**14.02**	**14.25**	**19.48**	15.92	**727**	**680**	**828**	745	**19.55**	**20.95**	**23.67**	21.56
LSD	2.69 (P = 0.05)				110.6 (P = 0.10)				1.84 (P = 0.05)			
C.V. %	15.75				16.9				8.0			

Table 112: Expt. 112, 1990 Yield and leaf nutrient* analysis results taken in Nov 1989

Site No	Treat	Yield t/ha/yr	Response (t/ha/yr)	Bunch Wt (kg)	Bunch No.	N %	P %	K %	Mg %	Ca %	Cl %
01	Fert	15.36		23.79	648	2.32	.146	.74	.14	.91	.41
	Control	7.76	7.60	21.04	368	2.27	.145	.80	.13	.89	.14
02	Fert	21.08		24.38	864	2.21	.134	.77	.16	.97	.31
	Control	13.92	7.16	21.27	656	2.07	.130	.87	.17	1.03	.08
03	Fert	23.20		20.61	1124	2.17	.140	.76	.11	.94	.36
	Control	17.60	5.60	18.33	960	1.94	.125	.88	.15	.87	.06
04	Fert	14.56		24.74	588	2.27	.145	.80	.14	.81	.34
	Control	10.16	4.40	19.33	524	2.14	.140	.91	.13	.88	.08
05	Fert	24.04		27.18	884	2.43	.147	.76	.14	.91	.34
	Control	17.96	6.08	17.98	1000	2.25	.141	.90	.13	.94	.07
06	Fert	17.44		20.75	840	2.24	.146	.87	.17	.96	.33
	Control	8.52	8.92	19.81	432	1.96	.132	.92	.17	.98	.07
07	Fert	23.76		23.90	996	2.36	.150	.70	.16	.93	.38
	Control	20.36	3.40	19.11	1064	2.31	.141	.95	.15	.92	.08
08	Fert	16.40		24.05	680	2.42	.153	.70	.16	.93	.43
	Control	15.88	0.52	19.55	812	2.15	.136	.85	.19	1.01	.06
Treatment	Fert	**19.48**		**23.68**	**828**	**2.30**	**.145**	**.763**	.148	.92	**.36**
Mean	Control	**14.02**	5.46	**19.55**	**727**	**2.14**	**.136**	**.885**	.153	.94	**.08**
Mean		16.75	5.46	21.61	778	2.22	.141	.824	.15	.93	.221
L.S.D.	(P=.05)	2.23		2.12	n.s.	.075	.0049	.052	n.s.	n.s.	.035

(* AAR Values).

Discussion.

Yields during 1990 on average have been markedly increased by the use of fertilizer, particularly nitrogen (N). Plots receiving N fertilizer, as measured by FFB bunch number produced and bunch weight means (Table 111) are very significantly better than the control plots after 10 rounds of fertilizer application. Fertilized plots have continued to give at least 20% more yield than the control plots as shown in Figure 66. Figure 67 illustrates the fertilizer response with time using the mean yield obtained in the six trials (sites 1-6) in the two poorer areas between 1986 and 1990. On average, yield had been improved as a result of fertilizer application by at least 50%.

Leaf number production as shown by Table 113 also illustrates the significant effect of fertilizer in relation to the nil treatment. In contrast to the majority of sites, the control plot, at sites 7 & 8 have both a high bunch number and frond production and hence show no increase in these two parameters. It is not yet clear why sites 7-8 are so different. In 1984 DAL reported that both sites share similar problems concerning declining yield and a compact concretionary layer was generally found at varying depths (10-50cm) at sites located about 2km apart at the sloping undulating foothills of Mt. Otto. Indications are that both proper application of fertilizer and improved management practice will prevent a yield decline as shown in Figure 67.

Table 113: Expt. 112, Leaf production response to treatment (June 1989 - June 1990).

Leaf Production No. of fronds/palm/year				
Site	Treatment (-)	P	N+P	Mean
01	22.33	23.08	22.35	22.59
02	19.54	20.73	21.00	20.42
03	20.88	21.04	22.78	21.57
04	22.62	22.94	23.22	22.93
05	21.96	22.64	23.15	22.58
06	21.25	22.00	21.79	21.68
07	23.50	25.12	24.74	24.45
08	27.39	27.32	26.96	27.22
Mean	**22.43**	**23.11**	**23.25**	22.93
LSD. (5%)		0.54		
C.V. (%)		10.4		

Figure 66: Experiment 112, FFB Production, Jan-Dec 1990.

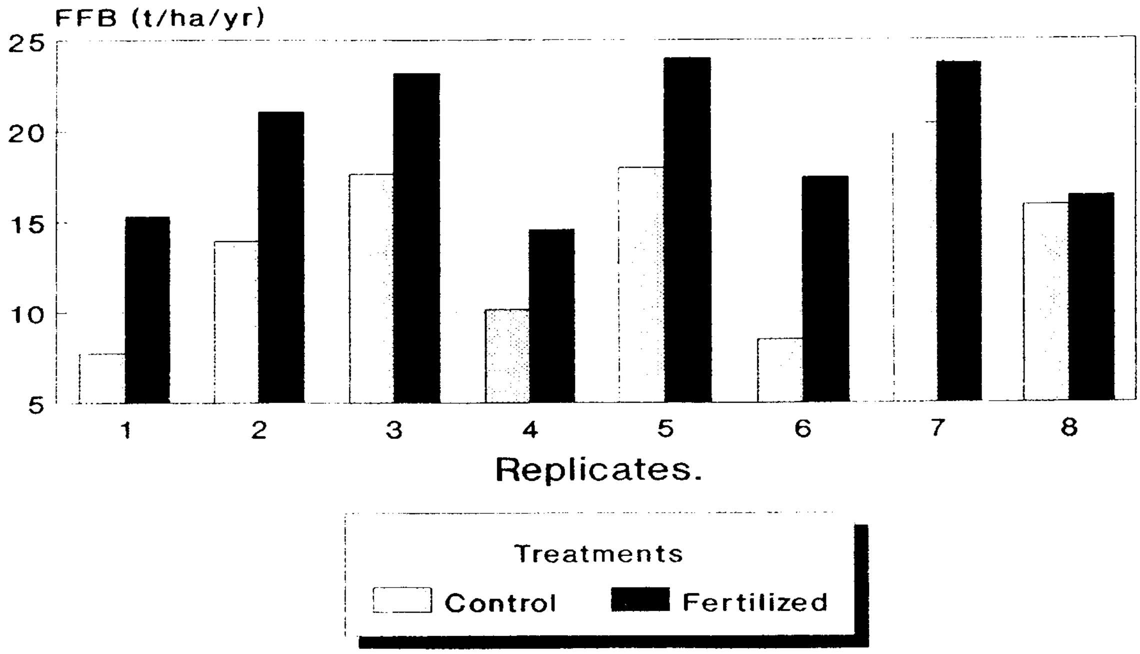
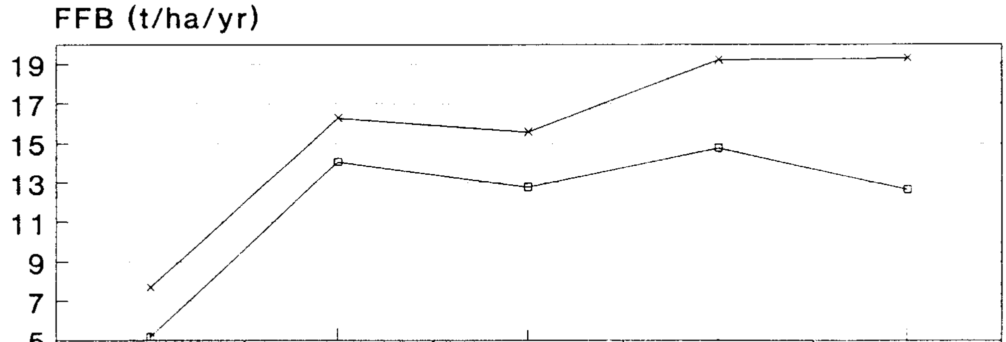


Figure 67: Experiment 112, The Effects of fertilizer & management.



	1986	1987	1988	1989	1990
Control	5.17	14.07	12.77	14.77	12.65
Fertilized	7.7	16.28	15.58	19.21	19.28

TIME

Treatment

Control Fertilized

EXPERIMENT 121: DEMONSTRATION OF RECOMMENDED MANAGEMENT AND FERTILIZER APPLICATION ON OIL PALM SMALLHOLDINGS (HOSKINS).

PURPOSE.

To emphasize the need and the value of adopting an acceptable level of management and to demonstrate applying the recommended doses of inorganic fertilizer. To check the requirement for additional fertilizers.

SITE DETAILS.

Location and history: Experiment 121 covers small oil palm plantings located in the DA&L Hoskins Oil Palm Scheme as is illustrated in Figure 63 . Within this scheme 15 demonstration sites have been established at Kapore, Tamba, Sarakolok, Buvussi, Galai, Siki, and each of the West, Central and Eastern village oil palm subdivisions. Each subdivision OICs has available at least one fertilizer demonstration plot to use in their general extension efforts. These demonstrations cover a range of planting dates. The first seven demonstrations were established in 1989, and an additional eight in 1990 (outlined in Table 114).

Table 114, Expt. 121: The Additional demonstration plots.

Site	Expt Series No	Block No
Namova	09	240001
Gule Mini Estate	10	105
Mai (1)	11	140089
Morokea	12	160031
Sarakolok	13	030920
Kavui	14	061692
Galai 2	15	051654
Mai (2)	16	140087

Genetic material: Dami commercial D X P. **Planted:** Various. **Area:** 30ha. **Density:** 120 palms per ha. **Spacing:** 9.75m triangular.

DESIGN AND TREATMENT DETAILS.

Design: Each 2ha smallholder block provides a single replicate. Within each block (replicate) there are 6 plots; 1 control and 1 demonstration and 3 with the specific purpose of checking N (AC) in the presence of P (TSP), K (MOP) and Mg (Kieserite). One further plot tests a higher rate of N (AC).
Layout: The plots consist of at least 16 core palms for recording, surrounded by at least a guard row making at least 36 palms per plot.

Treatment Details: At each location the CONTROL plots receive no fertilizer whilst the DEMONSTRATION plots receive whatever fertilizer is considered most appropriate for the block. This may vary from time to time. There are 6 treatments in a plot (-, N, N+N, N+P, N+K, N+Mg). The treatment levels are:

FERTILIZER/LEVEL: in kg/palm/year	0	1	2	3	4	5
Ammonium chloride	0	2.0	2.0	2.0	2.0	0
Triple superphosphate	0	0	2.0	0	0	0
Muriate of potash	0	0	0	2.0	0	0
Kieserite	0	0	0	0	2.0	0
Ammonium chloride	0	0	0	0	0	3.0

Date of first treatment: May 1989. The application frequency is at half the annual rate every 6 months in May and November.

Initiated: 1989. **Duration:** ongoing.

Progress for 1990:

The following operations were carried out. The first half of the annual fertilizer dose was applied to the experimental and perimeter palms commencing in May. However due to torrential rain at the year's end some plots did not receive their full application by the end of December 1990. Torrential rain also affected the recording of harvest although for most plots the three partial recordings of harvest (FFB & bunch number per palm) were done. In the Hoskins Scheme, 8 of the planned additional sites have been established (Figure 65). Leaf and soil samples were taken and sent for laboratory analysis at Applied Agricultural Research (AAR) in Malaysia and National Agricultural Chemical Laboratory (NACL) in Konedobu, PNG respectively. Vegetative measurements were also carried out. In the experimental palms, the first fronds were marked, field maps and labelling completed. Signboards conveying the fertilizer message to farmers were also erected in conspicuous positions to allow for maximum exposure to the public; however vandalism of signboards by the general public is a limiting factor which is beyond OPRA's control.

RESULTS:

Table 115 shows yield, and nutrient status of leaf 17 for the first 7 sites (02-08) and the additional 8 sites (09-16) established in 1990.

Table 115: Expt 121, Yield and leaf nutrient status of frond 17 in November 1990.

Site	Treat	Yield t/ha	N %	P %	K %	Mg %	Ca %	Cl %
02.	Fert	08.60	2.46	0.154	0.73	0.12	1.05	0.32
190020	Control	06.40	2.52	0.144	0.81	0.12	0.90	0.20
03.	Fert	26.07	2.29	0.140	0.83	0.12	0.77	0.23
020565	Control	27.30	2.33	0.136	0.87	0.15	0.75	0.10
04.	Fert	13.25	2.39	0.142	0.71	0.20	0.76	0.34
010396	Control	07.74	2.35	0.146	0.89	0.20	0.83	0.29
05.	Fert	14.89	2.46	0.146	0.91	0.14	0.87	0.34
051538	Control	12.80	2.56	0.144	1.11	0.18	0.77	0.08
06.	Fert	15.20	2.29	0.142	0.63	0.16	0.89	0.24
080754	Control	10.86	2.35	0.138	0.83	0.16	0.83	0.17
07.	Fert	23.29	2.38	0.146	0.83	0.16	0.80	0.32
101066	Control	23.28	2.40	0.145	0.81	0.14	0.79	0.19
08.	Fert	08.87	2.47	0.150	0.97	0.19	0.80	0.29
270005	Control	08.82	2.49	0.150	0.99	0.18	0.76	0.14
09. 240001	Baseline	22.90	2.57	0.156	0.89	0.2	1.00	0.25
10. 105	Baseline	16.90	2.30	0.149	1.16	0.18	0.96	0.28
11. 140089	Baseline	13.30	2.50	0.162	0.87	0.23	1.05	0.18
12. 030920	Baseline	12.50	2.32	0.143	0.85	0.16	0.98	0.23
13. 061692	Baseline	24.80	2.42	0.152	0.85	0.24	0.94	0.14
14. 160031	Baseline	05.80	2.60	0.160	0.79	0.23	1.09	0.20
15. 051654	Baseline	13.60	2.56	0.155	0.87	0.20	0.97	0.09
16. 140087	Baseline	24.80	2.46	0.155	0.91	0.19	0.87	0.11

(* AAR values)

Preliminary yield results.

Table 116 shows the first year results of measurements, including yield, leaf area, rachis, leaf weight and leaf 17 nutrient levels in November 1990 for the first 7 sites.

Table 116 , Expt. 121 Year 1 results of yield, leaf 17 measurements and nutrient* status in November 1990.

SITE	TREAT	FFB (t/ha/yr)	Leaf Area (cm^2)	Rachis (cm^2)	Leaf Weight (kg)	N %	P %	K %	Cl %
02	Fert	08.60	09.26	30.7	3.34	2.52	.154	.73	.32
	Control	06.40	10.32	37.4	4.01	2.46	.144	.81	.20
03	Fert	26.07	08.73	31.2	3.40	2.33	.140	.83	.23
	Control	27.03	09.18	31.3	3.41	2.29	.136	.87	.10
04	Fert	13.25	06.33	20.4	2.30	2.35	.142	.71	.34
	Control	07.74	07.71	27.0	2.97	2.39	.146	.89	.29
05	Fert	14.89	07.85	27.1	2.97	2.56	.146	.91	.34
	Control	12.80	08.64	28.0	3.08	2.46	.144	1.11	.08
06	Fert	15.20	08.18	30.6	3.33	2.35	.142	.63	.24
	Control	10.86	09.59	34.3	3.72	2.29	.138	.83	.17
07	Fert	23.29	07.74	28.3	3.10	2.40	.146	.83	.32
	Control	23.28	07.75	27.9	3.06	2.38	.145	.81	.19
08	Fert	08.87	05.67	22.5	2.51	2.49	.150	.97	.29
	Control	08.82	05.72	23.8	2.50	2.47	.150	.99	.14
Mean		14.81	8.05	28.61	3.12	2.41	.145	.85	.23
Grand Mean	Fert	15.73	**8.42**	29.96	3.25	2.43	.146	.801	**.287**
	Control	13.89	**7.68**	27.26	2.99	2.39	.143	.901	**.177**
LSD	(P=.05)	2.28	.54	2.8	0.29	.041	.004	.085	.093
CV (%)		11.7	5.1	7.4	7.2	1.3	2.1	7.4	32.9

(* AAR Values).

At this early stage there are no statistically significant differences due to treatments except for leaf area and chlorine. However there is an indication that the fertilizer treatments have also increased yield, rachis length, leaf weight and leaf % N and P. As would be expected with the application of a chlorine fertilizer, leaf % K has been depressed.

Table 117: Expt. 112, 121 & 207, Pretreatment [1]soil nutrient levels in 1984, 1989/1990.

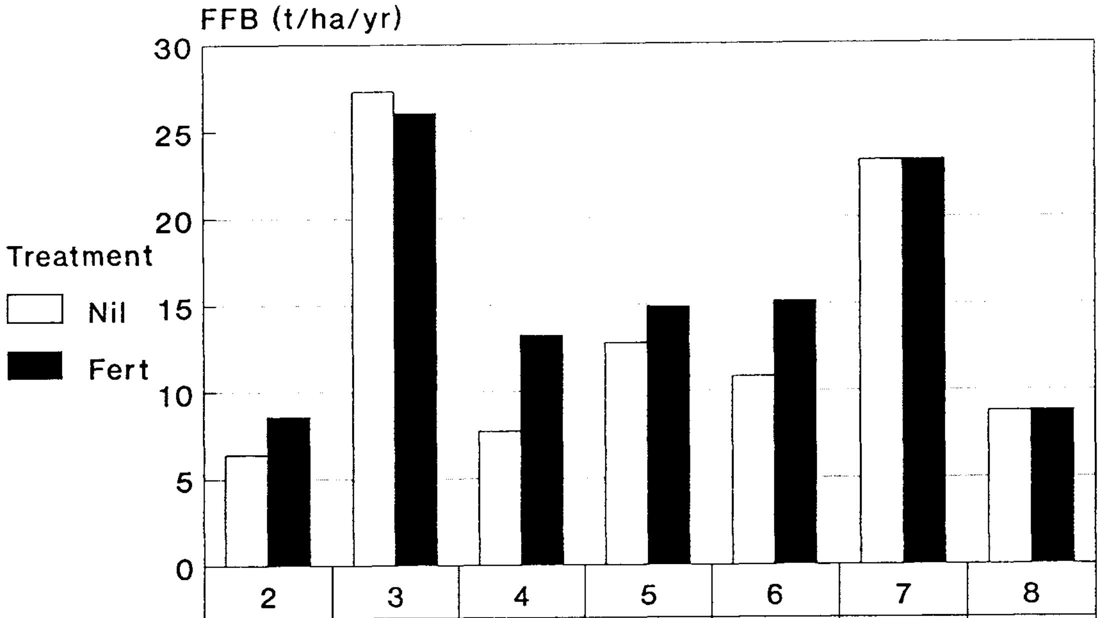
SITE	pH	Ca me/100g	Mg me/100g	K me/100g	Na me/100g	CEC me/100g	P µg/ml	P % RET	OM %	N % Total
					Depth: 0-20cm					
					* EXPERIMENT 112					
01	6.7	14.90	2.26	0.29	0.12	20.00	1.0	65	7.2	na
01	7.1	23.00	1.60	0.25	0.18	25.00	3.0	68	8.5	na
01	6.7	14.90	2.26	0.14	0.12	20.00	1.0	64	7.9	na
					** EXPERIMENT 121					
02	6.0	2.70	0.38	0.29	0.16	7.80		63	2.8	-
03	5.4	7.30	0.50	0.17	0.16	10.80		66	4.3	0.35
04	5.5	13.40	0.65	0.15	0.27	8.70		48	4.3	0.26
05	6.0	6.90	0.88	0.19	0.10	18.00		35	4.3	0.34
06	5.9	6.90	0.65	0.17	0.14	11.30		35	1.8	0.21
07	6.0	6.90	0.34	0.15	0.11	9.50		34	2.0	0.22
08	5.4	9.00	0.88	0.52	0.12	21.70		53	2.0	0.35
09	6.2	12.70	1.86	0.92	0.16	21.30		72	9.9	0.45
10	6.2	12.40	1.93	0.83	0.16	20.60		28	8.3	0.30
11	5.8	11.00	1.66	0.66	0.06	18.90		75	9.8	0.45
12	5.9	11.70	1.63	0.66	0.05	19.30		75	7.7	0.19
13	6.3	10.00	0.86	0.11	0.03	14.70		43	5.0	-
14	6.2	3.00	0.38	0.08	0.08	17.20		59	6.1	-
15	6.2	7.00	0.95	0.12	0.09	12.60		na	na	na
16	6.1	13.90	2.16	0.67	0.07	23.10		na	na	na
					** EXPERIMENT 207					
17	6.1	7.50	1.40	0.47	0.08	15.50		na	na	0.42
18	6.1	7.00	0.95	0.12	0.09	12.60		na	na	0.54
					Depth: 40-60cm					
					** EXPERIMENT 121					
02	6.0	11.70	1.19	0.38	0.15	21.00		72		-
03	5.7	5.40	0.30	0.63	0.51	10.00		67		0.12
04	6.0	2.30	0.26	0.66	0.25	5.00		31		0.06
05	6.2	5.30	0.37	0.77	0.14	8.60		40		0.08
06	5.9	1.80	0.21	0.15	0.14	3.70		32		0.04
07	5.9	3.50	0.32	0.54	0.26	7.80		57		0.11
08	5.8	7.70	0.54	1.16	1.26	18.60		63		0.10
09	6.1	5.50	0.28	0.28	0.18	7.80		26		0.19
10	6.2	7.30	0.37	0.31	0.17	7.30		25		0.18
11	5.7	5.40	0.22	0.29	1.13	6.80		26		0.18
12	5.7	6.10	0.22	0.26	0.11	8.40		22		-
13	6.3	2.00	0.15	0.62	0.04	3.30		18		0.03
14	6.5	4.70	1.56	1.24	0.12	8.50		45		0.10
15	na	na	na	na	na	na		na		na
16	na	na	na	na	na	na		na		na
					** EXPERIMENT 207					
17	6.3	1.40	0.23	0.55	0.11	6.30	2.30	na	na	0.10
18	6.6	2.20	0.39	0.20	0.09	4.50	3.10	na	na	0.04

[1] * ASL values, ** DA&L values.

Discussion.

The 1990 yield estimates for the 7 trials established in 1989 when fertilizers were first applied (Site Nos. 2 - 8) are shown in both Table 115 and Figure 68. On average there were 9 rounds of recorded harvest in 1990 (3 harvests each in March, July & November).

<u>Figure 68: Expt. 121, Preliminary Yield Data in 1990</u>



	2	3	4	5	6	7	8
Nil	6.4	27.3	7.74	12.8	10.86	23.28	8.82
Fert	8.6	26.07	13.25	14.89	15.2	23.29	8.87

REPLICATE

Also included in Table 115 are the 8 additional trials (Site Nos. 9 - 16) started in 1990, which have received only one round of fertilizer application to date. The results are very preliminary but as was reported in the 1989 Annual Report, the levels do highlight the essential requirement for correct fertilization to ensure reasonable yields.

This baseline data indicates the potential value of the trials in providing guidelines regarding nutrition and eventually yield in the various smallholder locations in the Province.

Despite the variations that exist, the leaf nutrient data, plus field observations and reports, confirm the results from the formal trials carried out on the nucleus estate. The major limiting factor is nitrogen, whilst chlorine and magnesium levels are well below recommended minimum. Potassium leaf status is generally better overall.

In the smallholdings sector of the Hoskins Project, the limited leaf nutrition observations made on 7 'demo' plots (Site Nos 2 - 8) shown in Table 115 and 116 indicate that the applied ammonium chloride (AC) has clearly improved the Cl and P status but depressed potassium (K) levels in 1990. Only chlorine was increased significantly. However the observed mean levels of N, Mg and Cl are still very much lower than the recommended minimum if considered with NBPOD oil palm estates. For example, in 1990 NBPOD's mean leaf nutrient status were observed at N=2.44%, Mg=0.20%, Cl=0.45% while the smallholdings were recorded at N=2.41%, Mg=0.16%, and Cl=0.23% respectively.

EXPERIMENT 207: DEMONSTRATION OF RECOMMENDED MANAGEMENT AND FERTILIZER APPLICATION ON OIL PALM SMALLHOLDINGS (BIALLA).

PURPOSE.

To emphasize the need and the value of adopting an acceptable level of management and to demonstrate applying the recommended doses of inorganic fertilizer. To check the requirement for additional fertilizers.

SITE DETAILS.

Location and history: Experiment 207 comprises small oil palm plantings within the DA&L Bialla Oil Palm Scheme (Figure 64). It covers trials east of the Gavuvu river bordering the Kapiura Project. There are 2 out of 3 sites selected to date. One each at Silanga (Block N0 438) and Uasilau Subdivision (Block N0 176).

Genetic material: Dami commercial D X P. **Planted:** 1984/85. **Area:** 4ha. **Density:** 120 palms per ha. **Spacing:** 9.75m triangular.

DESIGN AND TREATMENT DETAILS.

Design: Each 2ha smallholder block provides a single replicate. Within each block (replicate) there are 6 plots; 1 control and 1 demonstration and 3 with the specific purpose of checking N (AC) in the presence of P (TSP), K (MOP) and Mg (Kieserite). One further plot tests a higher rate of N (AC).

Layout: The plots consist of at least 16 core palms for recording, surrounded by at least a guard row making at least 36 palms per plot. Treatment Details: At each location the CONTROL plots receive no fertilizer whilst the DEMONSTRATION plots receive whatever fertilizer is considered most appropriate for the block. This may vary from time to time. There are 6 treatments in a plot.

FERTILIZER/LEVEL: in kg/palm/year	0	1	2	3	4	5
Ammonium chloride	0	2.0	2.0	2.0	2.0	0
Triple superphosphate	0	0	2.0	0	0	0
Muriate of potash	0	0	0	2.0	0	0
Kieserite	0	0	0	0	2.0	0
Ammonium chloride	0	0	0	0	0	3.0

Date of first treatment: November 1990. The application frequency is at half the annual rate every 6 months.

Initiated: 1990. **Duration:** ongoing.

Progress for 1990: Two sites (Nos. 17 & 18) have been established (Figure 64) one each at Uasilau and Silanga subdivisions. The first fronds were marked, field maps and labelling completed. Initial fertilizer was applied. Signboards conveying the fertilizer messàge to farmers were also erected in conspicuous positions to allow for maximum exposure to the public.

Preliminary results: Pretreatment soil and leaf samples were taken and available laboratory analysis results are shown in Tables 117 and 118 respectively. At this stage there is insufficient available data to draw any comment on the general nutrient status of smallholdings in the Bialla Project area. However baseline leaf samples taken at Silanga and Uasilau (Sites 17 & 18) show that most nutrient levels apart from chlorine are reasonably high. Thus there may not be an immediate requirement for fertilizers, but if fertilizers are applied now this should prevent a yield decline in the future.

As in Expt. 121 this baseline data indicates the potential value of the trials in providing guidelines regarding nutrition and eventually yield in the various smallholder locations east of the Kapiura Project.

Table 118: Expt. 207 Yield and Leaf Nutrient* levels in 1990.

Site	Treat	Yield t/ha/yr	N %	P %	K %	Mg %	Ca %	Cl %
Silanga (17)	Base	NA	2.67	.160	1.05	.25	1.07	.18
Uasilau (18)	Base	NA	2.74	.167	1.13	.33	1.09	.26
Mean		NA	2.71	.164	1.09	.29	1.08	.22

(* AAR Values)

EXPERIMENT 403: DEMONSTRATION OF RECOMMENDED MANAGEMENT AND FERTILIZER APPLICATION ON OIL PALM SMALLHOLDINGS (KAPIURA).

PURPOSE. To emphasize the need and the value of adopting an acceptable level of management and to demonstrate applying the recommended doses of inorganic fertilizer. To check the requirement for additional fertilizers.

SITE DETAILS.

Location and history: Experiment 403 includes small oil palm plantings within the DA&L Bialla Oil Palm Scheme (Figure 63). It covers trials west of the Gavuvu river bordering the Bialla Project. At site No. 19, the first block (No. 921) was selected at Mamota subdivision.

Genetic material: Dami commercial D X P. **Planted:** April 1990. **Area:** 2ha. **Density:** 120 palms per ha. **Spacing:** 9.75m triangular.

DESIGN AND TREATMENT DETAILS.

Design: Each 2ha smallholder block provides a single replicate. Within each block (replicate) there are 6 plots; 1 control and 1 demonstration and 4 with the specific purpose of checking other fertilizers; the details are not yet available. **Layout:** The plots consist of at least 16 core palms for recording, surrounded by at least one guard row making at least 36 palms per plot.

Treatment Details: At each location the CONTROL plots will receive no fertilizer whilst the DEMONSTRATION plots receive whatever fertilizer is considered most appropriate for the block. This may vary from time to time. There are 6 treatments in a plot.

FERTILIZER/LEVEL: in kg/palm/year	**0**	**1**	**2**	**3**	**4**	**5**
Ammonium chloride	0	2.0	2.0	2.0	2.0	0
Triple superphosphate	0	0	2.0	0	0	0
Muriate of potash	0	0	0	2.0	0	0
Kieserite	0	0	0	0	2.0	0
Ammonium chloride	0	0	0	0	0	3.0

Initiated: November 1990. **Duration:** ongoing. **Progress in 1990:** Block No 0921 was selected, mapped and labelled as an experimental unit.

IV. GENERAL INVESTIGATIONS

TRIAL 703: Fruitset In Clonal Oil Palms In Different Environments.

(R.N.B. Prior and A.S. Wilkie)

Purpose:

To determine why there are continuing and significant differences in pollination efficiency between West New Britain and Oro Province. Whilst previous studies were done in commercial plantings it is proposed to reduce some of the variation due to the genetic mixture of seed by using clonal material in this study.

Site Details:
Two sites have been identified:

1) Higaturu's Onato Plantation, Oro Province.

This site is close to the previous pollination study on Experiment 306 at Ambogo with similar recent alluvial soils derived from volcanic material.

2) N.B.P.O.D's Bebere Plantation, West New Britain.

This site is near to Experiment 107 fertilizer trial, but no previous pollination studies have been done at this location. Bebere is in the same climatic zone as the previous study.

Proposed Design and Treatments:

At each site two replicates of a 2^2 factorial, Clonal material x Density trial

Plot size approximately 0.5 hectares.
Clonal Material sources:- 1. Unilever U.F 149
2. I.R.H.O No. 52

Planting densities: - 1. 128 palms/hectare
2. 143 palms/hectare

The clonal material is in the nurseries and will be planted out in April 1991.

EXPERIMENT 714: PHOSPHATE REQUIREMENT OF OIL PALM SEEDLINGS AT PLANTING.

(P. Talopa)

Purpose:

The objective is to determine the necessity for placing phosphate fertilizer in the planting hole during field planting.

I. FIELD EXPERIMENT

Details:
Genetic material: Clonal material from Dami.
Location: Dami Plantation, Field F
Date of Planting: 04/10/90.
Proposed date for uprooting and analysis: 04/10/91.

Soils:
The soils are andosols derived from recent volcanic deposits with very little profile development. The depth of organic matter in the surface horizon only extends to a maximum of about 15cm. The soil profile shows alluvial deposits of mineral and pumiceous sands washed by the adjacent creek.

Treatment and Design:

The experiment consists of five different levels of phosphate (0, 100, 200, 300 and 400 grams of TSP palm^{-1}) placed in the planting hole replicated six times. 200 grams palm^{-1} of ammonium chloride at 3 months and 250 grams palm^{-1} of ammonium chloride at 6 months after planting were applied to the 13 month old seedlings planted diagonally between the plantation palms planted 13 months ago.

Proposed procedure for obtaining results:

After 12 months the whole plant will be dug out and dry matter of the stem, leaves and roots will be determined. Vegetative measurements would be done to determine the rate of leaf production, leaf area, leaf length and possibly leaf area growth rate and stalk diameter twice at six months and at 12 months.

Progress in 1990.

200 grams palm^{-1} of ammonium chloride has been applied at three months and 250 grams palm^{-1} yet to be applied at six months after planting.

II. NURSERY EXPERIMENTS

Details:

Genetic material: Dami known cross (DxP).
Planted: 12/10/90
Proposed date for uprooting and sampling: 12/10/91

Soils:

Soils were obtained from the current sites of Experiment 201 at Hargy and Experiment 714 at Dami. Generally Hargy soils are freely draining andosols formed on intermediate to basic volcanic ash. The Dami soils are also andosols derived from recent volcanic activity with deposits of mineral and pumiceous sands washed by the adjacent creek.

Treatment and Design:

The experiment consisted of five levels of phosphate using two soil types replicated six times. The phosphate rates of 0, 100, 200, 300 and 400 grams of TSP bag^{-1} have been mixed throughly with the soil before filling in the bags. An additional 100 grams of ammonium chloride was added to each bag. The germinated seeds were sown and left in the open to grow.

Proposed procedure for obtaining results:

At the end of 12 months the seedlings will be uprooted and their dry matter determined for roots and shoots and analysed for nutrient content. Basic leaf measurements such as rate of leaf production and leaf length would be determined.

The results from the field and nursery experiments at Dami will be compared, to determine if the simple nursery experiment gives a valid indication of P requirement in the field at planting. If so, further nursery experiments using different soils will be carried out in the future.

V. ENTOMOLOGY AND PATHOLOGY

(R.N.B.Prior)

INVESTIGATION 602: POLLINATORS

Purpose:

To screen exotic oil palm pollinators in their country of origin and in Papua New Guinea to test the most promising insects on native plants and subsequently on isolated oil palms.

Progress:

Since the decision not to proceed with research on an additional pollinator was made by the Board in 1988, only the continuing collection of information on what is occurring elsewhere has proceeded. Correspondence with I.R.H.O. has resulted in their observations on our pollination situation in Popondetta which has certain parallels in parts of Africa. They too cannot explain exactly what is happening in every case. Some of their data is very similar to our results.

INVESTIGATION 603: *Elaeidobius kamerunicus* Field Studies

Purpose:

To introduce the insect pollinator *Elaeidobius kamerunicus* to areas of oil palm in Papua New Guinea and monitor its effectiveness in determining fruitset.

Progress:

The original study set up to compare fruitset in different PNG environments was concluded in all areas at the end of 1989, except for the Ambogo site in Oro Province where the possible effect of yield stress on fruitset was investigated further. A third study to examine the effect of fruitset on oil production at Higaturu, Oro Province was also run and compared with data previously collected at Dami, W.N.B. The results of these three trials and investigations are presented here. A fourth trial to further investigate the effects of environment on fruitset and weevil behaviour has been established and is detailed under Experiment 703 in Section IV.

1) Fruitset in different environments

Fruitset has been compared from mid-1987 to end-1989 at Buluma, Dami (1979 Dami material); Hargy, Bialla (1973 IRHO material and 1979 Dami material); and Ambogo, Popondetta (1979 Dami material).

Data from these four sets of 20 palms has now been summarised. Results for fruitset range and bunch production are shown in Tables 119 and 120.

Average bunch weight is very similar at all four sites. The fruitset characteristics of the Dami material at the three different sites are similar, although the average fruitset at Ambogo is the lowest. Very distinctly different ranges of fruitset characteristics occur between Dami and I.R.H.O. material. In particular more than 40% of the I.R.H.O. bunches had a % fruitset >80, whilst less than 10% of the Dami bunches had a fruitset this high. Of particular note are the consistently high range of fruitsets and bunch production in the I.R.H.O. material at Hargy. Further statistical treatment of this data will be presented in a later report.

At Milne Bay the fruitset studies for 1990 shown in Fig. 69 indicate a considerable degree of fluctuation and are similar to those observed at Higaturu in the early phases of development. Certainly fruitset at or below forty percent for six months of the year are not satisfactory. Considerable variation in fruitset has been observed in other parts of the plantation outside the study areas. Probably because ablation was continued for such a prolonged period the effects seen may not be representative of the plantation when under normal harvesting regimes.

The numbers of male and female inflorescenses in anthesis recorded over the same period also show very large variations (see Figs. 70 and 71). Where the male flower count falls below 10 per hectare (7/100 palms), which is rarely exceeded at Waigani, this is generally considered to be less than adequate to support sufficient weevils to pollinate efficiently all the female inflorescenses. The balance of male to female is obviously important in this context and this is borne out by comparing data from Hagita and Waigani plantations. At Hagita the sex ratio is considerably better balanced than at Waigani and this is reflected in the overall fruitset obtained, although it was appalling at Hagita in January/February.

The same problem as encountered at Higaturu, is that large areas planted to the same age of palms are inadequately pollinated when the palms simultaneously switch to a genetically and environmentally induced strong female phase of production. On the plus side, the usually high tonnage per hectare, more than compensates for the poor fruitset.

Table 119: Summary of Fruitset and Bunch Production at Hargy

HARGY SITE - I.R.H.O. Material Planted in 1973

Palm	Mean Fruit set	% Bunches having % Fruitset of: 0-20	20-40	40-60	60-80	80-100	0-60	Male: Female	Abort: Female	Kg Bunch. Prod.	Avg. Bunch Wgt.	Bunch No
1	78.6	0.0	0.0	12.1	30.3	57.6	12.1	1.21	0.06	708	21.5	33
2	79.4	0.0	0.0	5.4	40.5	54.1	5.4	0.62	0.11	924	25.0	37
3	78.9	0.0	2.9	2.9	34.3	60.0	5.7	0.77	0.00	996	28.5	35
4	72.8	0.0	0.0	7.9	68.4	23.7	7.9	0.76	0.13	1204	31.7	38
5	62.2	2.8	5.6	22.2	66.7	2.8	30.6	0.56	0.11	853	23.7	36
6	72.2	0.0	4.7	14.0	44.2	37.2	18.6	0.12	0.16	858	20.0	43
7	78.1	0.0	0.0	6.5	41.9	51.6	6.5	0.94	0.16	587	18.9	31
8	51.1	7.3	14.6	46.3	29.3	2.4	68.3	0.20	0.00	532	13.0	41
9	70.2	3.1	0.0	15.6	62.5	18.8	18.8	0.50	0.09	640	20.0	32
10	73.5	0.0	2.9	8.6	40.0	48.6	11.4	0.57	0.06	827	23.6	35
11	69.9	4.0	8.0	8.0	36.0	44.0	20.0	0.20	0.12	431	17.2	25
12	67.1	2.1	2.1	14.9	70.2	10.6	19.1	0.36	0.09	722	15.4	47
13	81.0	0.0	7.4	3.7	18.5	70.4	11.1	1.26	0.30	619	22.9	27
14	89.4	0.0	0.0	0.0	12.8	87.2	0.0	0.28	0.00	742	15.8	47
15	57.9	0.0	16.1	35.5	48.4	0.0	51.6	0.58	0.19	708	22.9	31
16	56.2	0.0	10.5	52.6	36.8	0.0	63.2	0.50	0.03	776	20.4	38
17	81.8	0.0	0.0	8.6	28.6	62.9	8.6	0.83	0.03	656	18.7	35
18	80.5	0.0	0.0	0.0	43.2	56.8	0.0	0.39	0.02	1282	29.1	44
19	89.1	0.0	0.0	8.0	0.0	92.0	8.0	1.36	0.00	559	22.3	25
20	79.6	0.0	3.8	7.7	19.2	69.2	11.5	1.31	0.08	631	24.3	26
Means	73.5	1.0	3.9	14.0	38.6	42.5	18.9	0.67	0.09	763	21.7	35

HARGY SITE - DAMI Material Planted in 1979

Palm	Mean Fruit set	% Bunches having % Fruitset of: 0-20	20-40	40-60	60-80	80-100	0-60	Male: Female	Abort: Female	Kg Bunch Prod.	Avg. Bunch Wgt.	Bunch No
1	62.4	0.0	3.2	32.3	61.3	3.2	35.5	1.39	0.23	391	12.6	31
2	64.2	0.0	0.0	35.3	64.7	0.0	35.3	3.18	0.00	596	35.0	17
3	60.2	0.0	8.3	33.3	58.3	0.0	41.7	5.00	0.08	321	26.8	12
4	60.9	2.9	8.6	34.3	48.6	5.7	45.7	0.91	0.06	664	19.0	35
5	50.5	4.2	12.5	58.3	25.0	0.0	75.0	1.75	0.21	399	16.6	24
6	49.1	0.0	21.7	65.2	13.0	0.0	87.0	1.57	0.35	412	17.9	23
7	62.5	0.0	0.0	28.6	71.4	0.0	28.6	1.76	0.33	472	22.5	21
8	69.9	3.8	3.8	3.8	69.2	19.2	11.5	1.62	0.27	540	20.8	26
9	69.6	3.2	3.2	12.9	48.4	32.3	19.4	0.74	0.61	601	19.4	31
10	66.6	0.0	5.3	26.3	42.1	21.1	31.6	1.63	0.89	362	19.0	19
11	67.9	0.0	8.3	8.3	75.0	8.3	16.7	3.42	1.83	377	31.4	12
12	56.1	4.5	4.5	36.4	54.5	0.0	45.5	1.36	0.73	570	25.9	22
13	64.2	0.0	5.4	27.0	51.4	16.2	32.4	0.78	0.19	711	19.2	37
14	46.9	5.3	21.1	68.4	5.3	0.0	94.7	1.68	0.21	222	11.7	19
15	51.6	0.0	13.6	68.2	18.2	0.0	81.8	1.09	0.82	315	14.3	22
16	75.4	0.0	2.9	5.7	65.7	25.7	8.6	0.91	0.11	626	17.9	35
17	47.6	5.3	26.3	42.1	26.3	0.0	73.7	2.74	0.74	447	23.5	19
18	62.0	0.0	4.5	36.4	54.5	4.5	40.9	2.05	0.36	539	24.5	22
19	56.2	16.7	4.2	29.2	41.7	8.3	50.0	1.75	0.71	557	23.2	24
20	77.6	3.2	3.2	3.2	22.6	67.7	9.7	1.03	0.23	667	21.5	31
Means	61.1	2.5	8.0	32.8	45.9	10.6	43.3	1.82	0.45	489	21.1	24

Table 120: Fruitset and Bunch Production at Buluma and Ambogo

BULUMA 1979 SITE - Dami Planting material

Palm	Mean Fruit set	% Bunches having % Fruitset of: 0-20	20-40	40-60	60-80	80-100	0-60	Male: Female	Abort: Female	Kg Bunch. Prod.	Avg. Bunch Wgt.	Bunch No
1	66.9	0.0	12.5	16.7	50.0	20.8	29.2	1.46	0.50	948	39.5	24
2	43.2	8.0	20.0	68.0	4.0	0.0	96.0	1.88	0.20	274	11.0	25
3	61.8	0.0	2.4	34.1	63.4	0.0	36.6	0.66	0.05	759	18.5	41
4	56.0	2.3	11.6	41.9	41.9	2.3	55.8	0.95	0.00	733	17.0	43
5	52.9	3.8	7.7	61.5	23.1	3.8	73.1	2.04	0.04	851	32.7	26
6	51.6	3.6	25.0	39.3	28.6	3.6	67.9	1.36	0.18	629	22.5	28
7	38.0	7.7	46.2	43.6	0.0	0.0	97.4	0.64	0.18	703	18.0	39
8	52.8	4.5	22.7	31.8	40.9	0.0	59.1	1.95	0.36	463	21.0	22
9	53.5	0.0	15.4	53.8	30.8	0.0	69.2	1.77	0.27	573	22.0	26
10	70.1	0.0	3.2	9.7	64.5	22.6	12.9	1.55	0.00	731	23.6	31
11	66.1	2.3	2.3	18.6	69.8	7.0	23.3	0.70	0.09	807	18.8	43
12	58.5	3.1	9.4	28.1	56.3	3.1	40.6	1.47	0.13	596	18.6	32
13	62.9	0.0	4.5	22.7	72.7	0.0	27.3	1.64	0.23	306	13.9	22
14	54.1	4.0	12.0	42.0	40.0	2.0	58.0	0.30	0.14	819	16.4	50
15	63.7	4.8	0.0	28.6	52.4	14.3	33.3	2.38	0.00	478	22.8	21
16	65.1	0.0	0.0	40.9	54.5	4.5	40.9	2.68	0.05	629	28.6	22
17	65.5	0.0	9.1	12.1	63.6	15.2	21.2	1.03	0.24	659	20.0	33
18	72.0	0.0	2.1	17.0	48.9	29.8	19.1	0.47	0.06	989	21.0	47
19	65.1	0.0	6.9	13.8	72.4	6.9	20.7	1.59	0.10	496	17.1	29
20	62.1	0.0	0.0	45.2	54.8	0.0	45.2	1.26	0.23	672	21.7	31
Means	59.1	2.2	10.7	33.5	46.6	6.8	46.3	1.39	0.15	656	21.2	32

AMBOGO SITE - DAMI Planting Material Planted in 1979

Palm	Mean Fruit set	% Bunches having % Fruitset of: 0-20	20-40	40-60	60-80	80-100	0-60	Male: Female	Abort: Female	Kg Bunch. Prod.	Avg. Bunch. Wgt.	Bunch No
1	54	0.0	4.8	66.7	28.6	0.0	71.4	1.16	0.16	371	17.7	21
2	58	3.5	10.3	31.0	48.3	6.9	41.4	0.75	0.16	452	15.6	29
3	40	6.1	54.6	36.4	3.0	0.0	97.0	0.68	0.24	685	20.8	33
4	74	0.0	0.0	7.1	64.3	28.6	0.0	1.75	0.25	419	30.0	14
5	70	0.0	6.2	6.3	68.8	18.8	12.5	1.71	0.10	478	29.9	16
6	59	0.0	15.4	46.2	23.1	15.4	53.9	2.07	0.80	295	22.7	13
7	38	16.7	33.3	45.2	4.8	0.0	95.2	0.26	0.13	676	16.1	42
8	43	10.3	24.1	51.7	13.8	0.0	82.8	0.78	0.13	483	16.7	29
9	39	4.5	40.9	54.6	0.0	0.0	100.0	1.04	0.04	462	21.0	22
10	55	11.1	11.1	40.7	25.9	11.1	55.6	0.55	0.31	397	14.7	27
11	51	16.7	16.7	33.3	33.3	0.0	66.7	3.45	0.91	97	16.1	6
12	49	0.0	25.0	53.1	21.9	0.0	78.1	0.68	0.03	491	15.3	32
13	32	13.0	60.9	26.1	0.0	0.0	100.0	0.96	0.48	399	17.4	23
14	52	5.3	21.1	42.1	26.3	5.3	68.4	1.70	0.10	393	20.7	19
15	43	5.6	44.4	41.7	8.3	0.0	91.7	0.49	0.05	527	14.7	36
16	35	10.7	57.1	28.6	0.0	3.6	96.4	0.88	0.03	488	17.4	28
17	58	0.0	0.0	63.6	36.4	0.0	54.6	2.46	0.38	193	17.5	11
18	62	0.0	0.0	50.0	45.5	4.6	40.9	1.73	0.09	497	22.6	22
19	61	0.0	18.5	18.5	55.6	7.4	29.6	0.77	0.10	471	17.5	27
20	42	6.5	35.5	51.6	6.5	0.0	93.6	0.45	0.15	472	15.2	31
Mean	50.8	5.5	24.0	39.7	25.7	5.1	66.48	1.2	0.2	437	18.9	24.1

Figure 69: Fruitset at Milne Bay, 1990

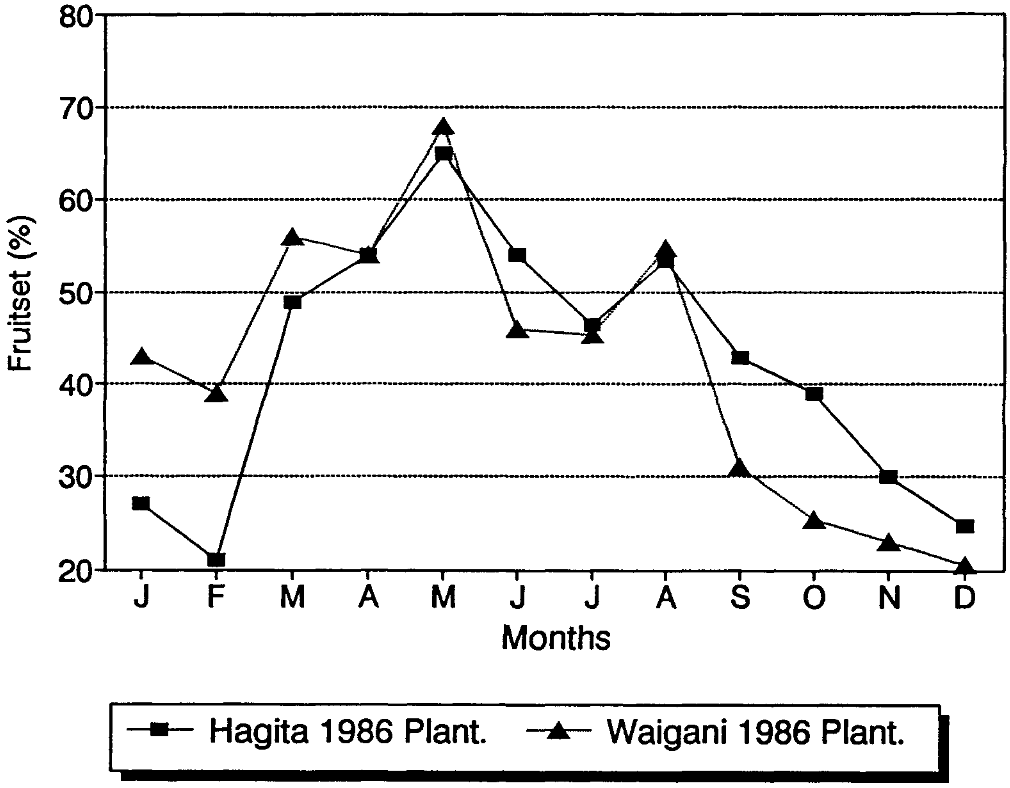


Figure 70: Flower Census, Waigani 1990

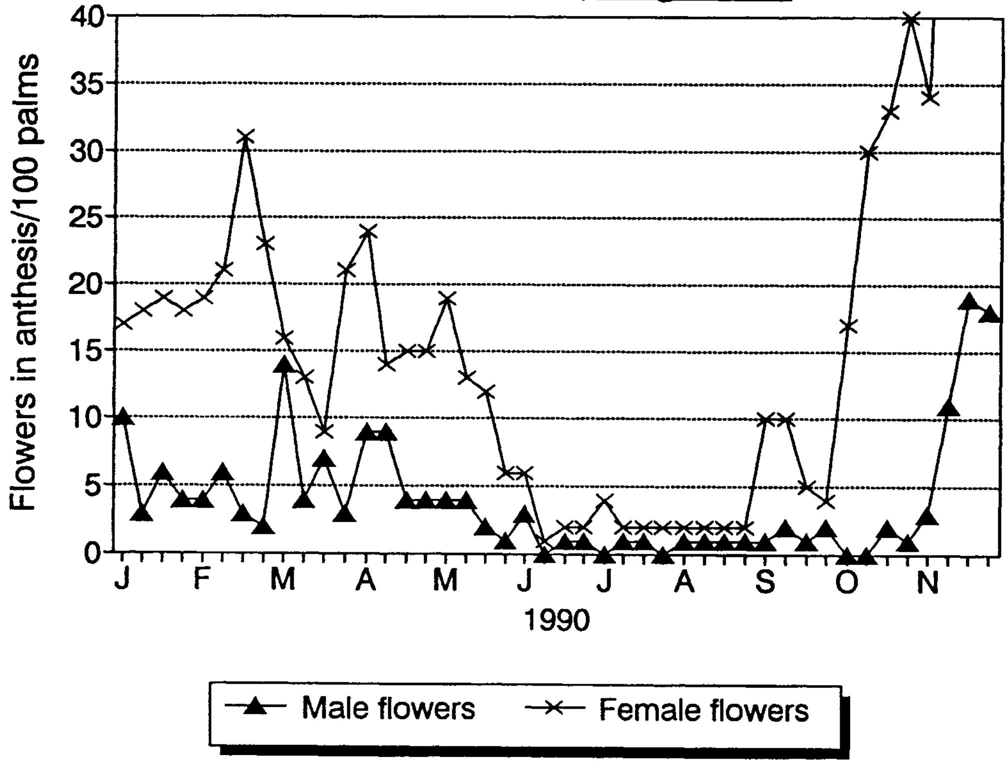
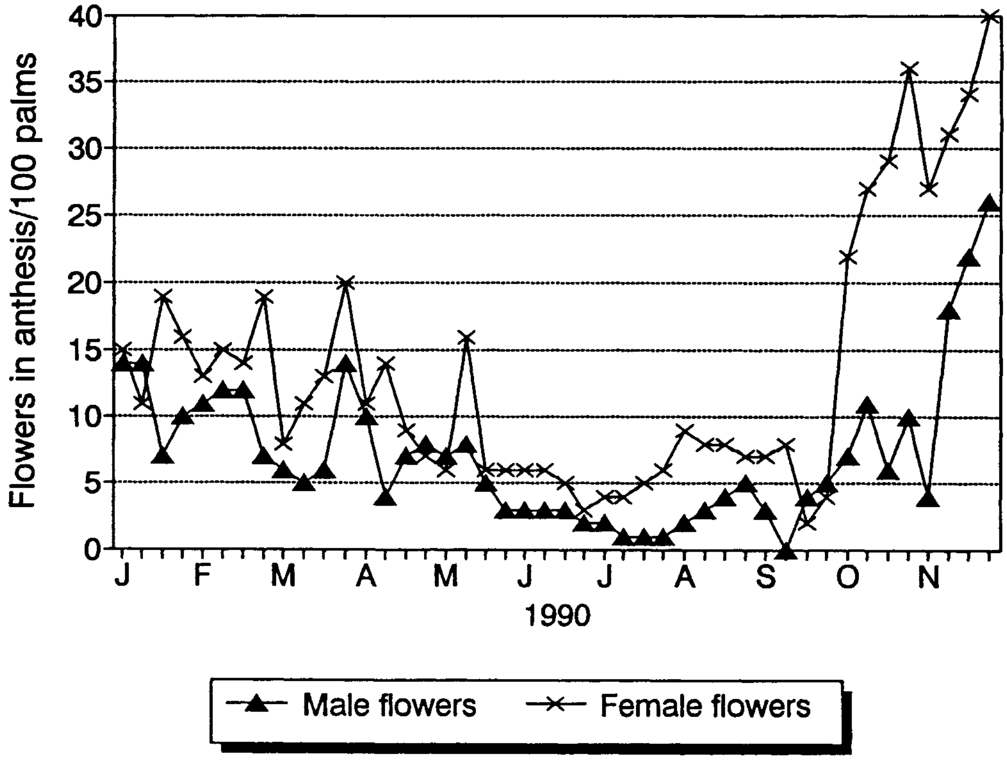


Figure 71: Flower Census, Hagita 1990



2) Effect of yield stress on fruitset

Two sets of 20 adjacent palms which were part of the Ambogo fruitset study (see data from previous study) were harvested and recorded for bunch weight and fruitset.

Removal of production stress on the palm by removing 50 percent of all female inflorescences before they were in anthesis was the treatment to one set of 20 palm. An adjacent set of 20 palms were not treated in this way and were permitted to develop normally whilst having all their bunches analysed. The summary of the data is presented in Table 121.

Table 121: Effect of 50 Percent Ablation of Female Inflorescences on Fruitset in 20 Study Palms Compared with 20 Study Palms in Adjacent rows at Ambogo Plantation, Oro Province.

	Jan-June 1990		July-Dec 1990		L.S.D.
	Normal	Ablated	Normal	Ablated	
Mean Bunch Weight (kg)	**23.2**	**27.6**	**24.2**	**30.5**	3.6
Mean Fruit Set (%)	53.5	55.2	**45.8**	**55.9**	8.2

Results

Ablation commenced in October 1989. During the first half of 1990 this treatment significantly increased the mean weight of the remaining bunches, but because pollination had already taken place, had no effect on fruitset. During the second half of 1990 the difference in mean bunch weight increased and a significant difference in fruitset developed. In contrast to the control plots, the ablated palms did not show the usual seasonal drop in fruitset in the second half of the year.

Conclusion

The results suggest that yield stress is responsible for the seasonal variation in fruitset. However fruitset was still only moderate after the drastic removal of 50 percent of the bunches. The low average fruitset in Oro Province (which is particularly marked in young palms) is therefore still not explained.

3) Effect of Fruitset on Oil Production

Since the first harvest at Higaturu, after the weevil was introduced in 1981, less than adequate fruitset has been obtained in some of the plantations. Consistently poor fruitset was observed on Ambogo plantation in particular, where it initially averaged less than 40% for most of the year. It was considered that as this was a young planting (1979), the poor fruitset should improve with time as the sex ratio levelled out.

Initially a shortage of male flowers was considered to be the main cause of poor fruitset. However data collected on both male flower numbers and weevils trapped visiting female inflorescences indicated that there were more than adequate flowers and weevils to maintain 60 percent fruitset (Syed R.A. personal communication).

On Ambogo plantation, a poor average fruitset of around 40% has been recorded for nearly ten years. Only in 1989/90 has the average fruitset levelled off at $\pm$ 50% but it is still not good by West New Britain standards, where $\pm$ 60-70% is typical.

In order to quantify the loss of oil due to poor fruitset, bunch analysis was carried out on 25 bunches having a wide range of fruitset, collected from the palms in the fruitset study at Higaturu.

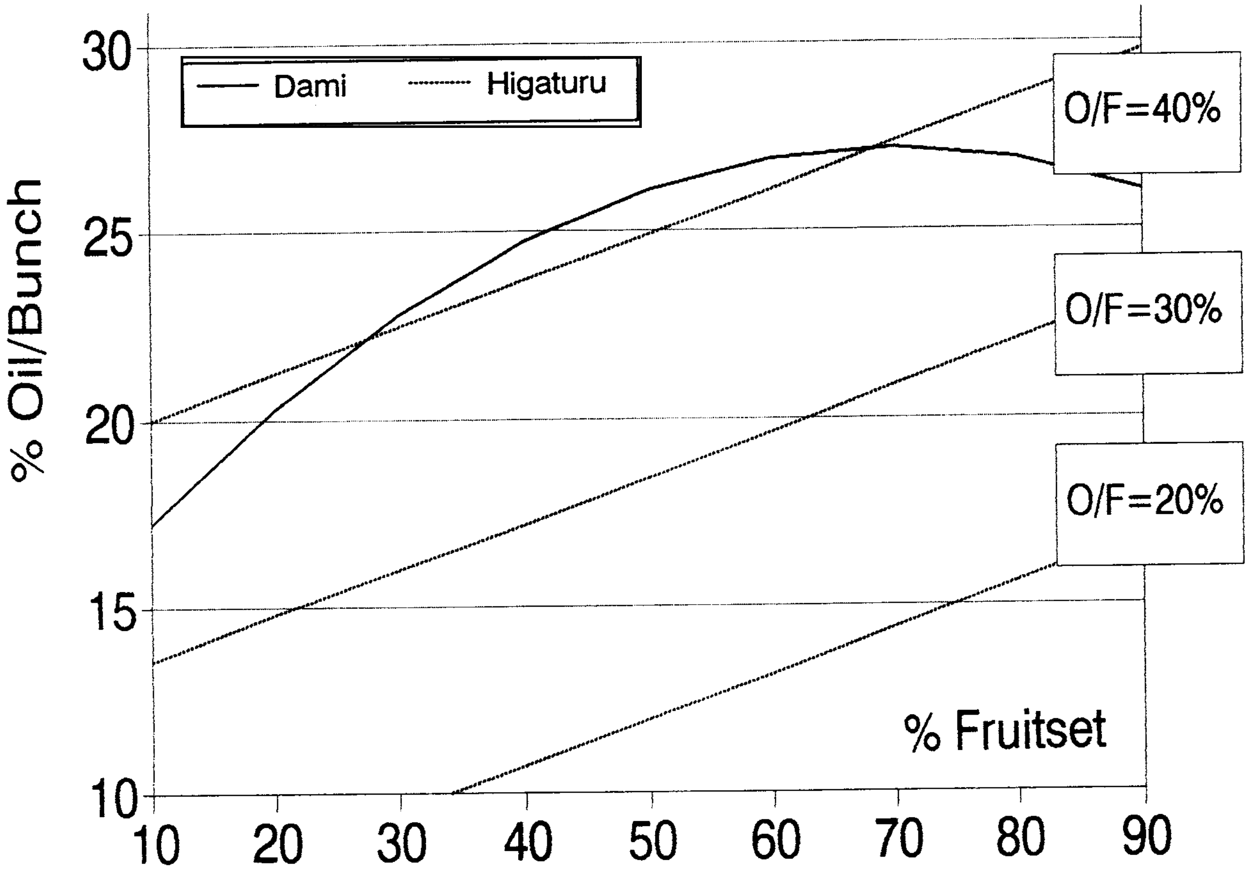
Initial examination of the data indicated that the oil/bunch ratio was mainly determined by the oil content of the fruit ($r=0.797^{***}$). However multiple regression analysis revealed that fruitset also significantly influenced the oil/bunch ratio, the fitted regression equation ($R^2=77.0\%$) predicting:

% Oil/Bunch = 0.647 (% Oil/Fruit) + 0.122 (% Fruitset) - 7.12.

This influence of fruitset on bunch oil content is shown graphically in Fig. 72, at three different levels of oil/fruit representing the range observed in the samples. At an oil/fruit percentage of 40, the predicted relationship is very similar to the curve earlier reported for Dami material (PNGOPRA Annual Research Report 1984). Both sets of results indicate that an increase in fruitset of 10% will improve bunch oil content by about 1%.

As expected the fruit/bunch ratio in the Higaturu samples was significantly correlated with fruitset ($r=648^{***}$) and again the relationship was very similar to that found earlier at Dami, as shown in Fig. 73.

Figure 73: Effect of Fruitset on Bunch Oil Content at Higaturu and Dami



(N.B. Higaturu results shown for different oil/fruit levels)

The implications of these results are best understood if an example is examined. At Higaturu the Ambogo plantation yields were high, at 30 tonnes per hectare; but with a fruitset of 40% average, the oil to bunch ratio will be 20% which gives an oil yield of 6 tonnes per hectare.

Assuming that the same energy for fruit production is available, it can be calculated that an improvement to 80% fruitset, which will increase the oil to bunch ratio to 25%, will give an oil yield of 7 tonnes per hectare. The predicted increase in oil yield with improved fruitset over a range of yield levels (assuming an oil/fruit percent of 35) is shown in Fig. 74. On average there is a gain of a quarter of a tonne of oil per hectare for every 10 percent increase in fruitset.

It therefore remains important to determine the cause of poor fruitset and for plant breeders to select palms with characteristics that assist insect pollination and high fruitset.

Figure 73: Effect of Fruitset on Fruit/Bunch Ratio at Higaturu and Dami

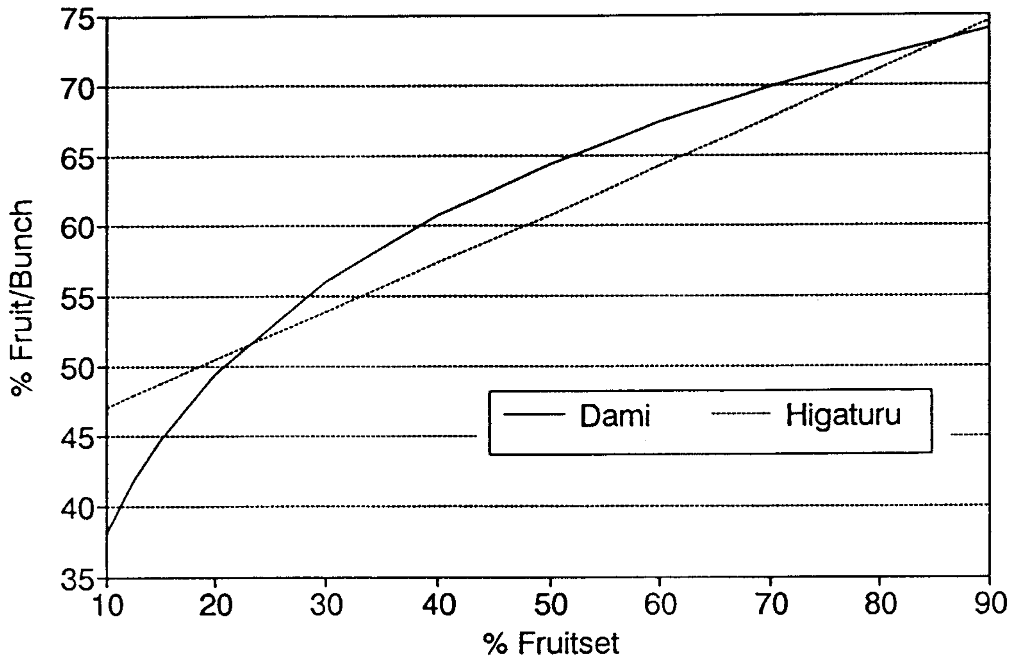
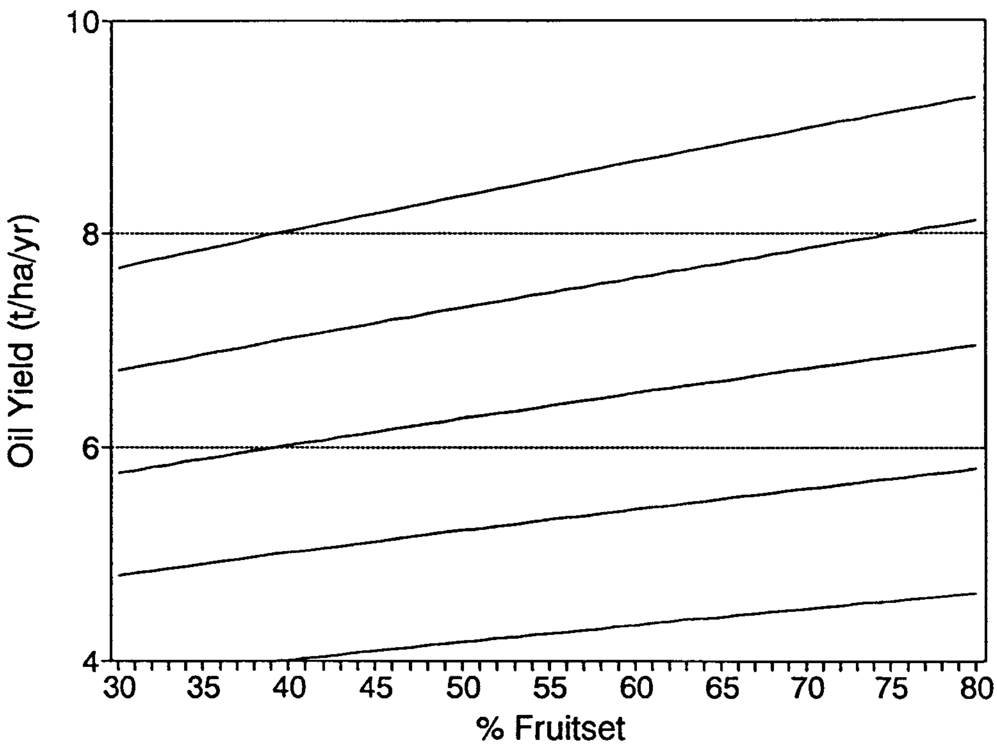


Figure 74: Effect of Fruitset on Oil Yield over a Range of Production Levels



(Effect of fruitset on oil yield is shown for production levels ranging from 4 to 8 tonnes/ha oil at 40 percent fruitset, assuming energy for fruit production remains constant)

Weevil Population Density

The pollinating weevil studies have been discontinued in Popondetta, but are carried out in all new development areas initially to determine their status after release.

The attached graphs (Figures 75 and 76) compare the emergence data from two sites at Milne Bay with West New Britain. They indicate an adequate weevil population throughout the year at Milne Bay, although there are often not enough male flowers per hectare to maintain adequate fruitset. The weevil has yet to be introduced to the Poliamba estates in New Ireland and this is scheduled to be done in April 1991.

Rainfall (Figures 77 to 80)

Overall this year has been one of the wettest on record with Bialla, West New Britain Province recording the highest rainfall with 7125mm. 2429 fell in one month, March, and the driest month was June with less than 150mm. Dami, West New Britain also had a high total of 4745mm caused by above average rainfall in December and March. The wettest month was December with 928mm and the driest September with 91mm.

In Oro Province the range over the various developments was from 2292mm at Embi through 2963mm at Arehe, the National Weather station site; to 4309mm at Mamba and reflects the usual rainfall distribution from the coast to inland areas.

In Milne Bay Province both meteorological sites recorded similar totals of 2889 and 3047mm, fairly evenly distributed. The wettest month, July, recording 500mm for both sites and the driest month, February a very low 11 and 24mm for the two sites.

In New Ireland Province two sites, Lakurumau, which is Poliamba's head office and plantation, and Bolegila which is 40km south of the head office were selected. Both sites recorded similar total rainfall of 3412mm for Lakurumau and 3529mm for Bolegila. There appeared to be two wettest months, April and December recording over 400mm at both sites. The driest month at Lakurumau was October with 144mm and at Bolegila it was August with 100mm.

None of the rainfall recorded at Oro, Milne Bay or New Ireland provinces are likely to have any dramatic effect on pest incidence or weevil activity. However the continuous and very heavy rain in West New Britain has carried over from the previous year and continues to favour Sexava development and halts treatment in the field.

Figure 75: Weevil Emergence, West New Britain 1990

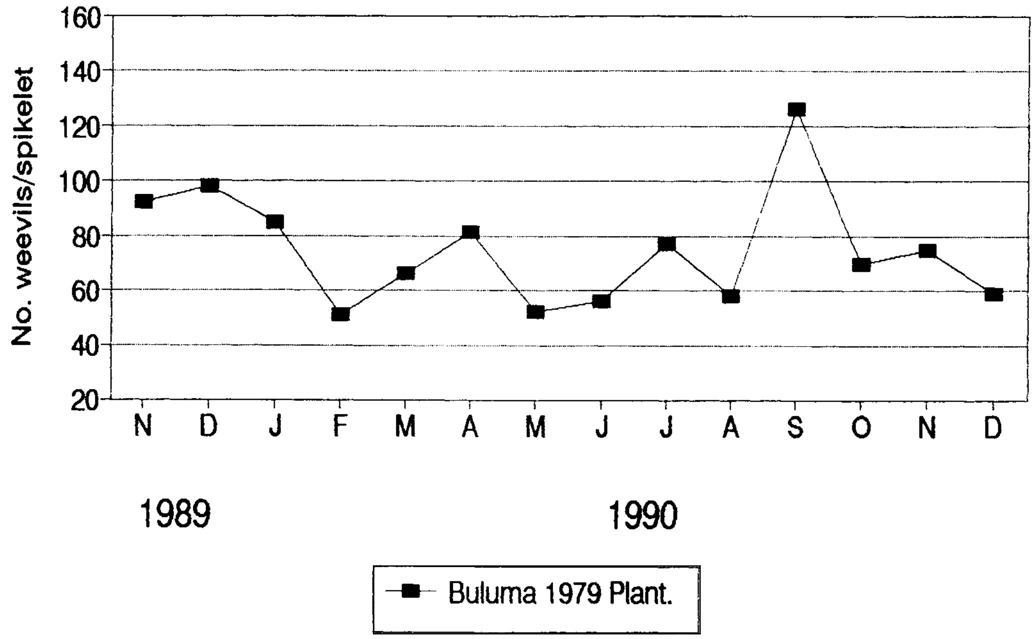


Figure 76: Weevil Emergence, Milne Bay 1990

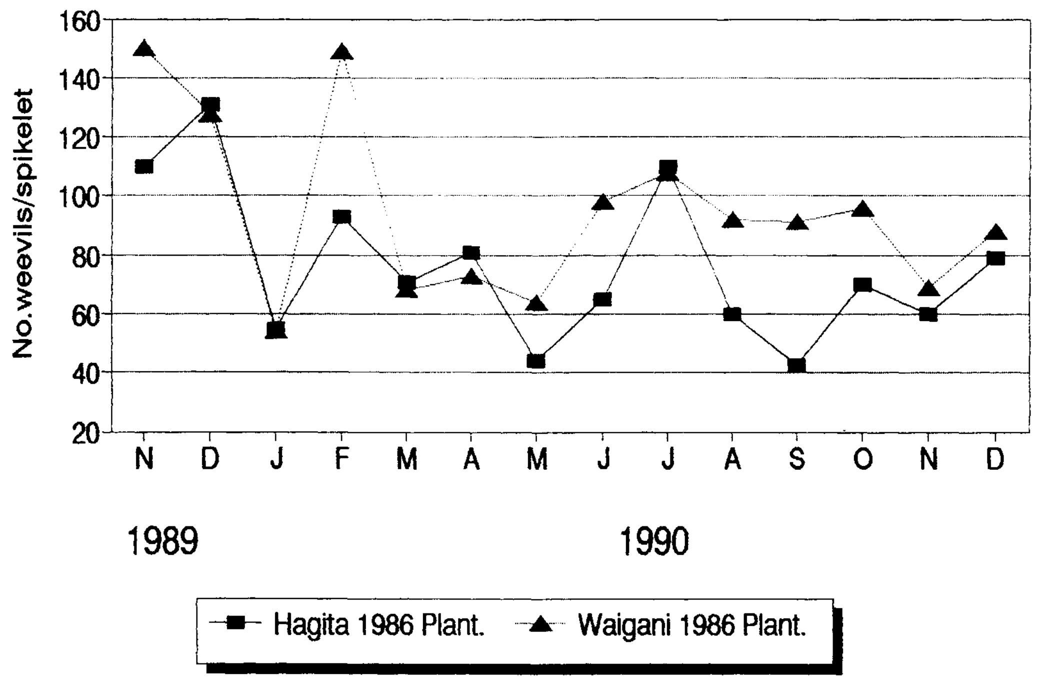


Figure 77: Rainfall, West New Britain Province 1990

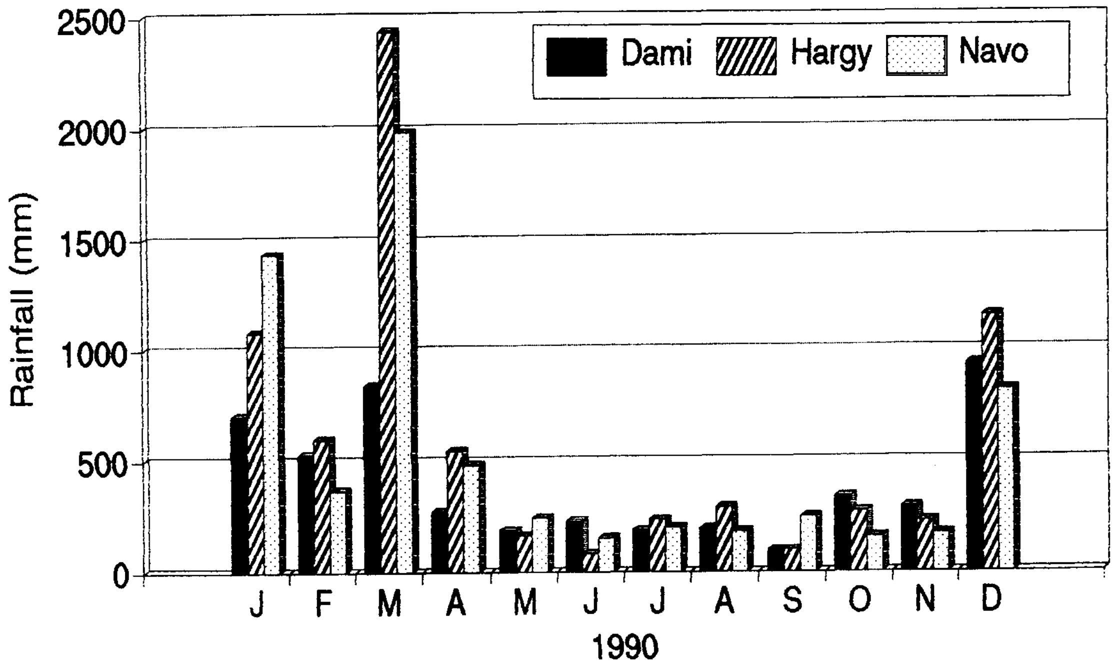


Figure 78: Rainfall, Oro Province 1990

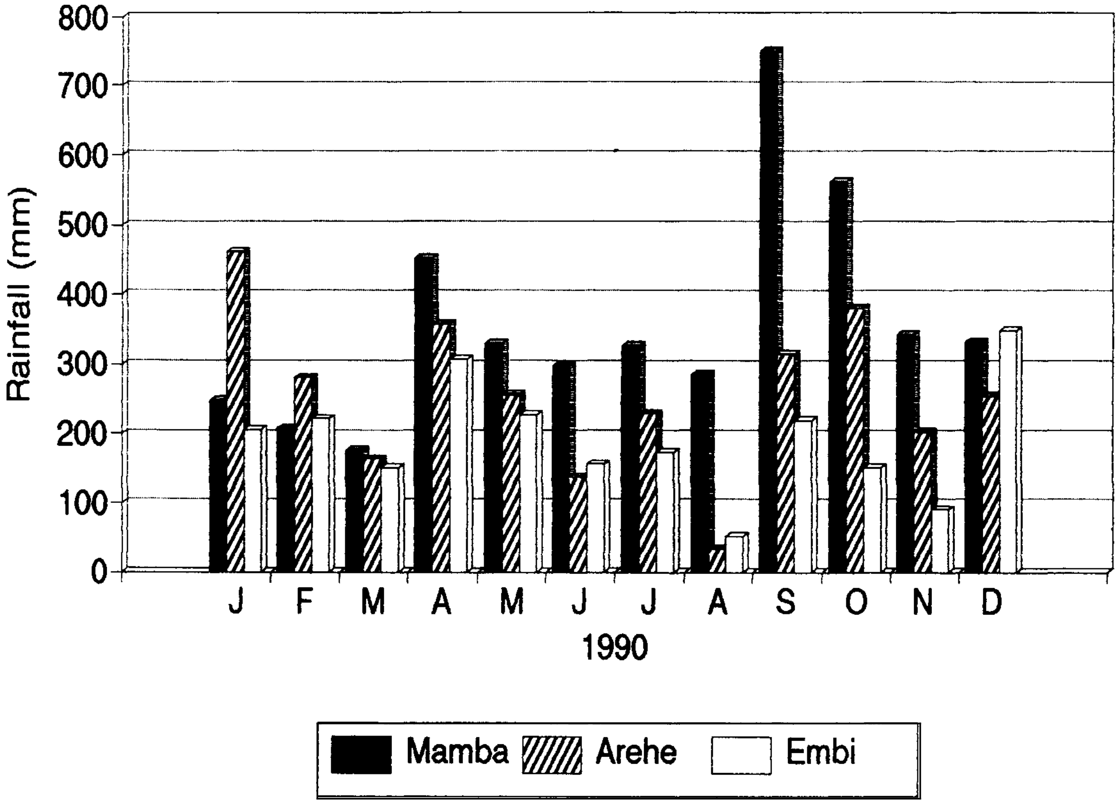


Figure 79: Rainfall, Milne Bay 1990

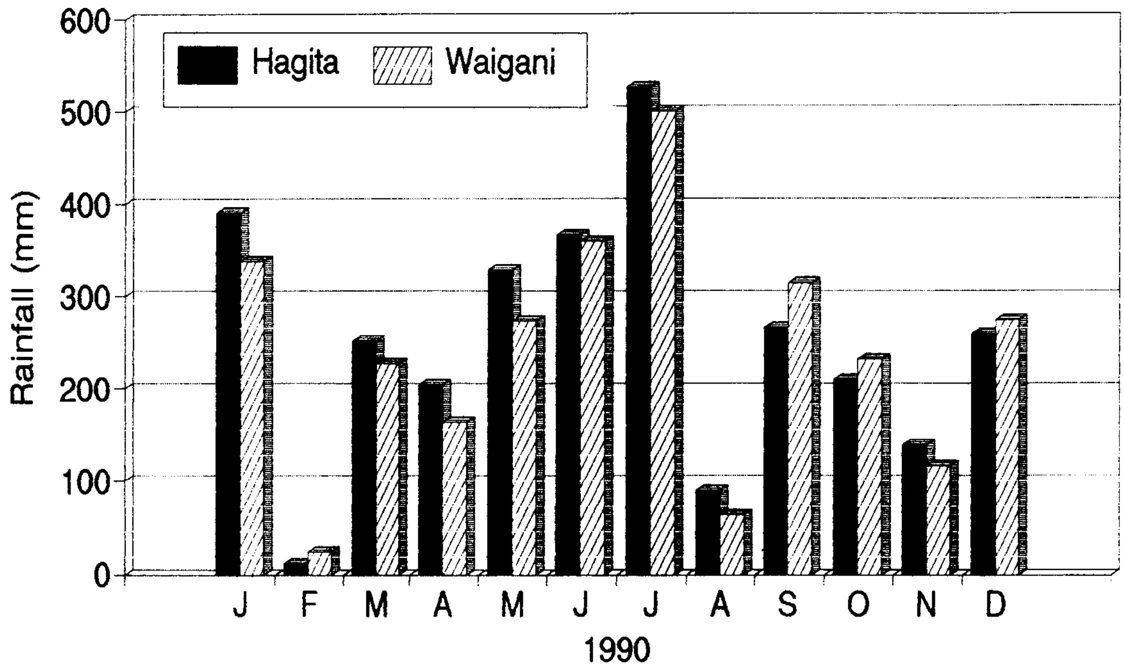
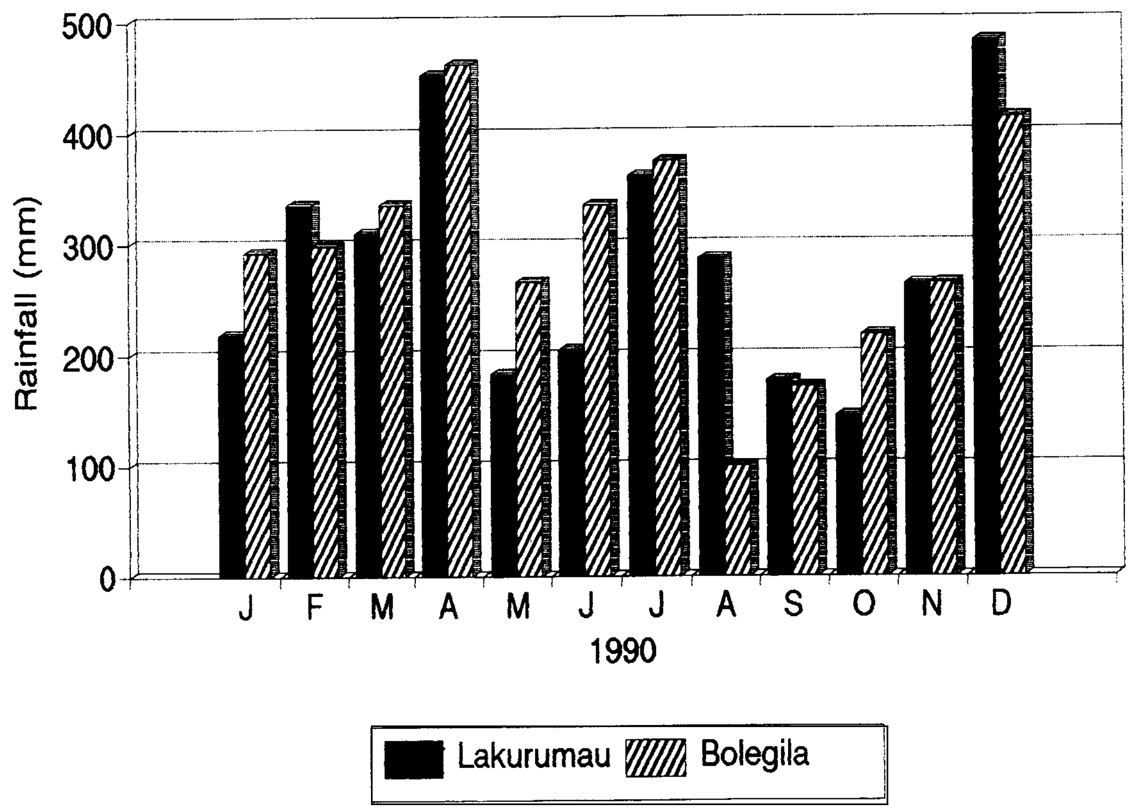


Figure 80: Rainfall, Poliamba, New Ireland 1990



INVESTIGATION 606: BAGWORM *(PSYCIDIDAE)* CONTROL.

Purpose:

To monitor the distribution and damage levels to oil palm by bagworms in Papua New Guinea; to identify factors linked with high levels of parasitism of bagworms and to formulate control measures.

Progress:

The worst outbreak seen for over 15 years occurred on Togulo and Kumbango Plantations W.N.B. in July and August resulting in 137.3 hectares requiring treatment. The original report of damage in early June was inspected and considered to be similar to a widespread infestation observed on Togulo in June 1984. However inspite of high natural mortality due to both *Tachinid* parasitism and fungal pathogens, the bagworm *Mahasena corbetti* began to seriously defoliate the palms, particularly along the roadsides and exposed margins of the plantations. Very young larval bagworms are spread by wind travelling on a silken thread similar to the gossamer spiders, and in the high winds experienced in late June, were transported very rapidly throughout the area.

Treatment was effected by trunk injection, concentrating on the road side and marginal affected palms and so preventing further spread. Infected core areas and whole blocks were treated subsequently. It took about 2 months to complete treatment and no resurgence of the pest has occurred subsequently.

It is significant to report that trunk injection was successful against this insect which has a rapid rate of dispersal. The operation was supervised and monitored by the plantation management which assisted in ensuring a thorough job was carried out.

INVESTIGATION 605: RECORD AND OBSERVATION 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:

Stick insects, *Eurycantha calcarata* in Bialla, West New Britain, in association with Sexava caused economic damage requiring treatment on Wilelo subdivision. In Oro province *Eurycantha insularis* caused slight damage to a few blocks which required treatment.

A limocodid, slug caterpillar was found on mature oil palms at Kumbango. This is the first specimen found on oil palm in the Province. Specimens have been sent to C.I.E. for identification

RAT DAMAGE:

No severe rat damage has been recorded outside Ambogo Plantation in Oro Province, where both male flowers and black bunches were attacked. No treatment was considered necessary in the relatively small area involved.

INVESTIGATION 601: SEXAVA CHEMICAL CONTROL.

Purpose:

To monitor the current chemical control programme which is by trunk injection of monocrotophos, or liquid formulation acephate; to assist with surveys of damage and to make treatment recommendations; to test any new chemicals which might be effective against Sexava.

Progress:

This first half of the year has seen the re-appearance of Sexava as a major pest of oil palms in West New Britain, undoubtable encouraged by continuing wet weather. Bialla smallholdings were more seriously affected due entirely to their inaccessability during the period March-June when damaged roads made it impossible to visit and carry out pest surveys. Treatment at Bialla commenced in June and continued to the years end.

A resume of areas treated is as follows:- Smallholder developments: 117 blocks treated from January to April and a further 172 blocks from May to the end of July including both Hoskins and Bialla schemes. From August to December a further 438 blocks from both schemes were treated giving a total for the year of 727 blocks or approximately 2900 hectares treated. Additional outbreaks on Dami, Navarai, Bebere, Kumbango, Walindi and Hargy plantations totalling 1057 hectares required treatment. This sexava damage plus the bagworm damage, to be reported later, made 1990 the worst year for insect damage for nearly thirteen years. The total cost of treatment for smallholdings was approximately 122,000 kina and estates 44,000 kina. The excessively wet period probably assisted in the Sexava's rapid development.

In Oro Province only reports of slight damage in one or two smallholdings has been reported to date. Of material sampled, *Stichotrema* internal parasite was present and no treatment was necessary.

INVESTIGATION 607: SEXAVA BIO-CONTROL

Purpose:

To find and study the most useful biological agents which attack any life stage of Sexava and mass rear by in vitro production if possible the most useful parasites for continuous release into Sexava infested areas.

Progress:

Mass rearing and release of Sexava egg parasites continued throughout the year. Because of the high number of out-breaks nearly every treated area had several batches of parasites released totalling as follows:

Release Site	Parasite	
	Leefmansia bicolor	*Dorania leefmansii*
Galai Subdivision	4,000	25,000
Walindi Plantation		27,500
Kavugara Subdivision	94,425	105,000
Kavui Subdivision	51,575	
Tamba Subdivision	9,675	
Rikau V.O.P	4,500	
Buvussi	77,135	316,870
Kapore	49,970	
Hargy Plantation	52,800	227,500
Bialla/Balima Subdivision	28,050	
Bialla/Wilelo Subdivision	67,045	45,900
Kumbango Plantation	244,285	631,550
Navarai Plantation	23,720	27,300
Mai Mission	14,850	
Kilu V.O.P	10,305	
Namova V.O.P	8,600	
Bebere Plantation	6,800	27,500
Kandori V.O.P	8,800	83,750
Dami Plantation	34,640	
TOTAL	791,175	1,517,870

This is well over two million parasites released into Sexava infested blocks during the year.

Of interest is the apparent recovery of some smallholder blocks at Bialla which were not treated because of lack of chemical but which had parasite releases made in October. Subsequently blocks at Rikau, Hoskins - which were too young to inject, and a very mature block at Mai Mission, have recovered without chemical treatment but with parasite release only.

These are the first recorded occurrences where damage was at a level requiring chemical treatment and which have recovered before total defoliation has occurred. As climatic conditions remained optimum for Sexava development during this time it is difficult to explain the reduction in population other than a result of the introduction of the parasite. Further studies are being planned.

INVESTIGATION 608: SCAPANES AND ORYCTES CONTROL.

Purpose:

To determine if Rhinoceros beetle attacks increase due to underplanting or leaving poisoned palms or felled trunks in the field and hence to recommend changes in plantation practice if necessary.

Progress:

A visit to New Ireland revealed far less damage than expected due to *Oryctes* and few palms have been replaced. Recovery of damaged palms is similar to *Scapanes* damage and no further action is considered necessary. Rapid decay of the coconut logs caused by the *Oryctes* larvae may be beneficial in reducing the tissue mass required to promote *Ganoderma* infection and this will be observed closely. The presence of the *Oryctes* virus has clearly reduced the number of larvae reaching maturity and can be regarded as extremely beneficial in this situation where breeding sites are abundant.

No significant *Scapanes* attack to underplanted oil palms in West New Britain nor in the new development areas of Milne Bay or New Ireland has been recorded. It remains an insignificant pest of oil palm.

PATHOLOGY

There were several palms reported collapsing both in estate and smallholder blocks in Oro Province. In Arehe estate seven diseased palms were observed of which two had collapsed, whilst in Ambogo estate it was reported that two palms had collapsed. Also in Ambogo several palms were observed to be suffering from basal stem rot. Some of the palms fallen in the past have developed *Armillaria mellea* fruiting bodies. Two smallholder blocks at Isavene were reported suffering from root and basal stem rot, and specimens have been confirmed as *Ganoderma species*.

EXPERIMENT 801: INCIDENCE OF *GANODERMA* DISEASE

(H.L. Foster)

Purpose:

To monitor the incidence of *Ganoderma* disease after replanting.

Trial Details:

This experiment was set up in 1982 in Section 9 of Bebere. There are three replicates of six treatments comparing different methods of felling the old stand. After felling, three seedlings were planted within one metre of each stump. The six felling methods were:

1. Palm poisoned and left standing
2. Palm poisoned and subsequently felled at 1 metre
3. Palm poisoned and subsequently felled at 30cm
4. Palm not poisoned and felled at 1 metre
5. Palm not poisoned and felled at 30cm
6. Palm excavated

RESULTS:

Every year since 1985, a selection of the seedlings, have been cut down, split and inspected for *Ganoderma* . By the start of 1990 the majority of seedlings had been cut down for *Ganoderma* inspection, but with no positive results.

In June 1990 all remaining seedlings were visually inspected but none showed any obvious signs of disease (e.g. multiple unfolded spears). In each replicate the 15 poorest seedlings were then identified, cut down and split open. Out of the total of approximately 100 seedlings, none showed any sign of internal fungal infection.

CONCLUSION:

Since the area is now due for replanting the trial was closed at the end of June 1990. After eight years, absolutely no sign of any *Ganoderma* infection has been observed, despite the close proximity of the seedlings to oil palm stumps. It is concluded that underplanting in the Mosa area does not entail a serious risk of *Ganoderma* infection, at least for the first 8 years after replanting.

PUBLICATIONS

Antony, G., Kauzi, G.Y. and Prior, R.N.B. (1990). Returns to research on insect pollination of oil palm in Papua New Guinea. Quarterly Journal of International Agriculture, **29**, 119-131.

Breure, C.J. and Menendez, T.M. (1990). The determination of bunch yield components in the development of inflorescences in oil palm (*Elaeis guineensis* Jacq.). Experimental Agriculture, **26**, 99-115.

Breure, C.J., Menendez, T.M. and Powell, M.S. (1990). The effect of planting density on the yield components of oil palm (*Elaeis guineensis*). Experimental Agriculture, **26**, 117-124.

Foster, H.L. and Barr, J. (1990). Oil palm production in Papua New Guinea. Proceedings of ISOPB International Workshop on Yield Potential of the Oil Palm, Phuket 1990.

APPENDIX I

METEOROLOGICAL DATA

Table 122 : Rainfall (mm) all sites 1990

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
W.N.B. PROVINCE													
Dami	696	524	835	268	186	224	181	190	91	334	287	928	4744
Bebere	732	447	1070	263	244	91	181	137	98	253	115	840	4471
Kumbango	811	536	1060	256	158	113	137	115	98	138	159	916	4497
Malilimi	447	332	873	260	197	141	215	162	190	387	196	951	4351
Hargy	1077	595	2429	539	159	74	229	285	92	270	226	1150	7125
Navo	1431	367	1981	479	237	149	194	180	245	151	167	809	6390
ORO PROVINCE													
Arehe	404	386	201	274	257	136	253	35	204	429	211	272	3062
Ambogo	259	283	237	300	236	115	202	58	287	287	189	405	2858
Isavene	390	334	245	248	304	126	236	54	312	428	274	306	3257
Mamba	248	207	176	4521	331	297	326	286	750	561	342	333	4309
MILNE BAY PROVINCE													
Hagita	391	11	253	204	329	367	526	91	267	210	140	260	3049
NEW IRELAND													
Lakurumau	217	335	309	451	182	205	361	286	177	144	263	483	3413

Table 123 : Meteorological Data, Dami, 1970-90

	Rainfall (mm)		Rainy days (/mth)		Sunshine (hr/mth)	
	1970-90	1990	1970-90	1990	1970-90	1990
January	631.0	695.6	24.7	26	114.8	80.2
February	630.7	524.2	23.7	16	111.2	160.5
March	522.3	835.4	24.3	20	123.3	100.4
April	352.8	268.2	21.3	20	147.3	126.6
May	228.7	186.0	17.7	19	166.8	162.0
June	161.5	224.2	15.6	13	160.7	148.4
July	187.1	180.8	15.8	16	151.8	112.1
August	158.2	189.6	14.9	12	179.0	147.8
September	175.3	91.0	13.9	14	177.3	118.0
October	184.9	334.4	15.6	22	176.3	146.1
November	245.8	287.2	17.7	14	173.5	165.5
December	440.4	928.3	22.5	21	125.5	90.0
Total	3918.7	4744.9	227.7	213	1807.5	1557.6

Table 124 : Meteorological Data, Higaturu 1981-90

	Rainfall (mm)		Rainy days (/mth)		Sunshine (hr/mth)	
	1981-90	1990	1981-90	1990	1981-90	1990
January	284	460.8	19	23	153	141
February	269	279.5	19	13	127	179
March	317	161.7	20	15	159	135
April	278	358.3	19	18	162	133
May	187	254.5	16	22	171	122
June	172	134.7	16	16	145	163
July	115	227.8	11	15	165	119
August	107	32.0	13	7	177	134
September	178	315.0	14	19	168	100
October	243	381.3	19	21	180	143
November	224	201.6	16	10	185	180
December	311	253.5	20	18	147	130
Total	2685	3061	202	197	1939	1679

APPENDIX II

SOIL ANALYSIS DATA

National Agricultural Chemistry Laboratory
Department of Agriculture and Livestock
Kila Kila

Table 125 : Island Trials

Table 126 : Mainland Trials

Table 125: Soil Chemical Analysis Summary - Island 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	4.7	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	7.9	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	5.0	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	5.1	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	3.5	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	5.9	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	3.5	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	5.8	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	4.9	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	5.5	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	3.9	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	3.4	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	7.9	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	3.1	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	10.5	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	4.3	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	18.5	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	16.4	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 : 126 Soil Chemical Analysis Summary - Mainland 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 1990

Auditor's Report to the members of Papua New Guinea Oil Palm Research Association Inc.

We have audited the balance sheet and income and expenditure statement in accordance with International Auditing Guidelines.

In our opinion the attached balance sheet and income and expenditure statement give a true and fair view of the state of affairs of the Association as at 31 December 1990 and of its income and expenditure for the year ended on that date.

Price Waterhouse
Lae, 20 March 1991

BALANCE SHEET AT 31ST DECEMBER, 1990

	1990 Kina	1989 Kina
Accumulated funds	186,527	246,282
Fixed Assets	147,553	122,288
CURRENT ASSETS		
Cash at bank and on hand	9,240	106,995
Debtors and prepayment net of provision for doubtful debts of K10,000	167,512	106,698
	176,752	213,693
CURRENT LIABILITIES		
Trade creditors	120,483	56,350
Other creditors and accruals	17,295	33,349
	137,778	89,699
Net current assets/(liabilities)	38,974	123,994
	186,527	246,282

STATEMENTS OF INCOME AND EXPENDITURE FOR THE YEARS ENDED 31st DECEMBER

	1990 Kina	1989 Kina
INCOME		
FFB Levy	582,315	506,976
Profit on disposal of fixed assets	2,700	3,979
Interest received	7,215	5,324
Government Grant received	100,000	150,000
Member Grants received	60,000	120,000
Sundry income	844	7,535
	753,074	793,814
EXPENDITURE		
Agency, audit, legal and professional fees	28,895	15,038
Bank charges	633	378
Depreciation	56,082	34,257
Direct experiment costs	323,361	260,855
Doubtful debts expense	10,000	-
Electricity, water and gas	28,261	15,743
Insurance	8,127	10,128
Laboratory	2,185	82
Medical	4,227	4,187
Motor Vehicle	10,271	10,271
Office expenses	19,487	17,836
Rentals and other accommodation costs	91,486	90,082
Repairs and maintenance - buildings	21,982	16,890
Salaries, wages and allowances	192,549	139,177
Staff recruitment	3,220	2,671
Staff training	20	1,870
Travel and entertainment	12,043	12,793
	812,829	632,258
SURPLUS/(DEFICIT) FOR THE YEAR	(59,755)	161,556
ACCUMULATED FUNDS BROUGHT FORWARD	246,282	84,726
ACCUMULATED FUNDS CARRIED FORWARD	186,527	246,282

NOTES TO AND FORMING PART OF THE ACCOUNTS AT 31st DECEMBER 1990 AND 1989

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 ASSETS

	1990 Kina	1989 Kina
Household, office and laboratory furniture		
and equipment at cost	141,136	80,224
Less accumulated depreciation	38,168	24,327
	102,968	55,897
Motor vehicles at cost	119,965	114,149
Less accumulated depreciation	75,380	47,758
	44,585	66,391
Total written down value	147,553	122,288

3. CAPITAL COMMITMENTS

Capital expenditure authorised and contracted for at 31 December 1990 totalled K Nil (1989) K Nil).

4. COMPARATIVE BALANCES

Certain comparative balances have been revised to conform with the disclosure format in the 1990 accounts.

MANAGEMENT BOARD'S STATEMENT AT 31 DECEMBER 1990

We, J.P.C. Baskett and J. Montgomerie, 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 statement of income and expenditure are drawn up so as to exhibit a true and fair view of the state of affairs of the Association at 31 December 1990 and of the results of the business of the Association for the year ended on that date.

For and on behalf of the Board

J.P.C. BASKETT

J. MONTGOMERIE

Lae,
19 March, 1991.

SECRETARY'S STATEMENT

I, Alfred Ross McMaster, Secretary of the Papua New Guinea Oil Palm Research Association Inc., do hereby state that the accompanying balance sheet and statement of income and expenditure 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 1990 and of the results for the year ended on that date.

A.R. McMASTER
SECRETARY

Lae,
19 March, 1991

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
"IB" houses	5
"JG" houses	7
"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	2
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	Purchased	Km run
Toyota Hilux 4WD (twin)	AFL 659	DOR	3/88	62,628
Toyota Hilux 4WD (single)	AFH 562	OiC, Higaturu	5/88	84,291
Toyota Hilux 4WD (single)	AFF 235	Ext.Agronomist	8/87	154,446
Toyota Hilux 4WD (single)	AHA 967	Entomologist	6/89	70,922
Suzuki Samurai	AGC 752	Soil Agronomist	10/89	23,448
Toyota Dyna	AGG 068	Driver (Dami)	1/90	52,332
Toyota Dyna	AGC 505	Driver (Hig.)	8/89	30,272
Honda 125 M/C	AP 201	Assistant (Hig.)	5/90	9,419

APPENDIX VI

LIST OF INVESTIGATIONS

Number	Location	Title	Initiated	Concluded
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	
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	
401	Kautu	NPKMg Fertilizer Trial	1989	
402	Bilomi	NPKMg Fertilizer Trial	1990	
403	Kapiura	Smallholder demonstration trials	1990	

Number	Location	Title	Initiated	Concluded
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	Concluded
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	1986
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
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