ANNUAL REPORT

OF

THE PAPUA NEW GUINEA
OIL PALM RESEARCH ASSOCIATION

1989

NINTH ANNUAL REPORT

of the

PAPUA NEW GUINEA

OIL PALM

RESEARCH ASSOCIATION

1989

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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 = 0.53xfresh bunch, oil/dry bunch = 0.5 and oil energy = 2.1 x carbohydrate energy.)
TDM = Total dry matter = VDM + TDM
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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	J.N. Hansen (from April)
NEW BRITAIN PALM OIL DEVELOP. LTD.	J.P.C. Baskett
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HARGY OIL PALMS PTY. LTD.	J. Wynand
HIGATURU OIL PALMS PTY. LTD.	F.E. McGuire (to July)
	C. Warn (from August)
MILNE BAY ESTATES	J.N. Hansen
KAPIURA PLANTATIONS PTY. LTD.	J. Montgomerie (from Oct)
DIRECTOR OF RESEARCH	Dr. H.L. Foster

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Dr. H.L. Foster	Director of Research

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A.R. McMaster

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	I. Orrell, B.Sc.
ASSISTANT AGRONOMIST	P. Navus, B.Ag., M.Sc.
ASST.AGRONOMIST(Higaturu)	A. Oliver, B.Sc.
RESEARCH ASSISTANT	P. Talopa, B.Ag.
RESEARCH ASSISTANT (Hig)	J. Silu, B.Sc. (from February)
SENIOR ENTOMOLOGIST*	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 RESEARCH RECORDER	BLASIUS LUKARA
FIELD ASSISTANTS	TOPUPUL TEIGA
	PETRUS SOKIP
RECORDERS	JAPSON DAPO
	SIMON MAKAI
	PAUL LUS
	JASON YALIKUA
	HARRY MORAKI
	MARTIN GULAN (from March)
SECRETARY	MONICA MAPE
ACCOUNTS CLERK	CAMILLUS GOLU
TYPIST/CLERK	LUDWINA MARIU
RECORDS CLERK	BERNADINE BUBU
DRIVER/HANDYMAN	JAMES DUKE

HARGY

SENIOR FIELD ASSISTANT	PHILIP SIO

HIGATURU

TECHNICAL ASSISTANT	DANIEL TOMARE
JUNIOR SUPERVISOR	WAWADA KANAMA
RECORDERS	GOLBAN BETARI
	GRAHAM BONGA
	MAX YAURA
	ENOCK TOPENI(to March)
	BEN GIBSON (from Feb.)
	ADRIAN JONAH (from April)
	LEONARD DOMBAKA
	READON ERUGA
DRIVER	JOHN GARIMOPA

MILNE BAY

FIELD ASSISTANT	DANNY STANLEY (to April)
	HILARIAN GORDON (from Dec.)

CHAIRMAN'S STATEMENT

It is with trepidation that one looks at the Crude Palm Oil price record for 1989, and wonders what the future will bring, with prices ranging from $270 to $350 during the year, considerably below that reported in the Chairman's Statement for 1988.

Bearing this reduction in price in mind, it is perhaps understandable that the Government declined the Association's request for an increase in cess from K0.80 to K1.03 per tonne FFB and only agreed a rise to K0.88 per tonne. At the time of these discussions, the Association emphasised the need for improved Government extension service inputs for the Smallholder sector. A marked improvement in these services should ensure that this important sector fully derives the benefits made available by the Association's research work on both Smallholder and Nucleus Estate areas.

The participating companies were asked to contribute towards the ongoing costs of the Association and a sum of K120,000 was realised in this manner. It is heartening to be able to report Government's continuing support in the form of a K150,000 grant. Nevertheless, it has been a period where the Association has been conscious of the monetary constraints laid upon it and has reacted accordingly.

Research into nutritional requirements continues to be the backbone of the Association's programme, and recommendations are being made with sound studied bases. The raison d'être of the Association has always been to direct research to the improvement of the oil palm industry in Papua New Guinea, and improvement in yields must remain the vanguard of our work.

Our thanks go to Dr Foster and his staff for their continuing service. Liaison with other research workers in Papua New Guinea is encouraged and contacts continue to be made with research groups in other countries. Papers have been presented in Malaysia and Nigeria (PORIM & NIFOR) by Dr Foster and A.S. Wilkie.

In conclusion I would like to thank the Managing Agents and in particular Ross McMaster our Secretary, for all his work in holding a diversely situated Association together so well.

J N Hansen
Chairman

March 24, 1990

PART 1. ADMINISTRATION AND DEVELOPMENT

MANAGEMENT BOARD AND SCIENTIFIC ADVISORY BOARD

The Management Board met twice, at the offices of Harrisons and Crosfield (PNG) Ltd.,Lae on 29th March and at the offices of Milne Bay Estates Pty Ltd., on 4th October. The Eighth Annual General Meeting of the Association was held in Lae on 29th March at which Mr. J. N. Hansen was elected as Chairman. Messrs. Harrisons and Crosfield (PNG) Ltd were re-appointed as Managing Agents for the coming year.

The Scientific Advisory Board met at Milne Bay Estates Pty. Ltd., on 4th October. This was preceded by an informal meeting between Scientific Advisors and PNGOPRA staff on 3rd October and a field trip to surrounding estates, attended by most Board members and observers.

FINANCE

The research levy was increased from 80 toea at the start of the year to 88 toea per tonne of fresh fruit bunches with effect from June 1989. The Government grant received from the Department of Agriculture and Livestock was K150,000 for the year. To achieve the budget approved by the Board, each of the five member companies also agreed to contribute a grant of K30,000 for the year.

Expenditure for the year was in fact K94,000 short of estimate, due mainly to delay in the implementation of some projects, whilst income was K50,000 below estimate. Thus the actual surplus for the year of K161,556 exceeded the expected surplus by K44,000. The Association's total funds thus increased considerably during the year from K84,726 to K246,282. The latter included fixed assets valued at K122,290, so the net assets of the Association at the end of the year were K123,994.

Full details of the Association's Accounts for 1989 and the Auditor's Report are presented in Appendix II.

Messrs Price Waterhouse were re-elected as auditors for 1990.

STAFF

In marked contrast to the previous year, there were no changes in executive staff during 1989 except that an additional Assistant Agronomist for the mainland, Mr Jim Silu, a graduate from Unitech, Lae, was recruited in February. At the end of the year PNGOPRA had an establishment of 4 expatriate executive officers, including a Senior Entomologist on attachment from the Department of Agriculture and Livestock, and 4 national executive officers. During the year Mr Ian Orrell, spent three weeks studying at the University of

Newcastle upon Tyne in connection with his proposed Ph.D. project, whilst Mr Pamenda Talopa submitted his thesis for a Post graduate Diploma in Agriculture to Unitech, Lae, at the end of the year.

There were also few changes in non-executive staff during the year, apart from the replacement of the Supervisor at Milne Bay. Junior staff strength at the end of the year was 15 at Dami, 10 at Higaturu and one each at Hargy and Milne Bay. A modest expansion of junior staff is expected next year in line with a planned increase in activities.

MEETINGS

During the year the Director of Research attended research advisory meetings of the PNG Cocoa and Coconut Research Institute and of the NBPOD Oil Palm Research Station at Dami, whilst the Officer-in-Charge PNGOPRA Higaturu and the Senior Entomologist attended similar meeetings at the PNG Coffee Research Institute.

The Director of Research and [illegible] Wilkie both attended the PORIM International Oil Palm Conference in Kuala Lumpur in September 1989, where they presented a joint paper. The Director of Research was also invited as a guest speaker to the NIFOR 50th Anniversary Celebration International Palm Conference at Benin City, Nigeria in November 1989.

BUILDINGS

An additional house is now being rented for the new Assistant Agronomist at Higaturu and security has been improved by the erection of a fence around our office at Higaturu.

The allocation of buildings rented from New Britain Palm Oil Development, Higaturu Oil Palm, Hargy Oil Palm and Milne Bay Estates, at the end of 1989, is shown in Appendix III.

VEHICLES

During the year the Entomology vehicle at Dami was replaced by a new single-cab 4WD Utility, which was the only vehicle purchase planned for 1989. However due to a heavy workload, the 4 year old Utility at Higaturu became unroad-worthy half way through the year and special permission was given to immediately replace this with a small lorry, which is more suited to the transport of field workers. A further two vehicles at Dami are scheduled for replacement in 1990. Details of all vehicles at the end of the year are given in Appendix IV.

EQUIPMENT

At Dami a new desk-top 386 microcomputer with a 110 MB hard disc has been acquired for trial data storage and analysis. The existing XT micro computer is now used largely for word-processing and accounts. At Higaturu an inexpensive portable computer has been purchased, which allows data entry, whilst the main computer is being used for applications.

Other purchases during the year included an electric typewriter for Higaturu and a replacement photocopier for Dami. Purchase of laboratory equipment for the nitrogen project, included in the 1989 estimates, was postponed to 1990.

VISITORS

To Dami:

Antony G., University of New England, Armidale, N.S.W.
Bailey W.E. & 26 Staff members, Hoskins High School.
Barnes A., Dept. of Agric. & Livestock, Kimbe.
Baskett J.P.C., Managing Director, H&C (PNG) Ltd., Lae.
Bassett C., Bassett and Associates, Rabaul.
Bhodthipuks P., Southern Palm Co., Thailand.
Bishop J., Dow Chemicals, Australia.
Boga M., Chards Forwarding Services, Port Moresby.
Boonsukul Prapus, Sagunan Palm Co. Ltd., Thailand.
Boyer M., World Bank, Washington.
Breure C.J., Harrisons & Fleming Advisory Services, London.
Brown G., London Sumatra, Indonesia.
Christensen J., Dept. of Agriculture & Livestock, Konedobu.
Cronin M., Harrisons & Crosfield (PNG) Ltd., Lae.
Cundall E., Cocoa & Coconut Research Institute, Kerevat.
Firnkes F.C., South Eat Asia Fertilizer Co., Singapore.
Fujii Kenju, Nissho Iwai Corporation, Tokyo, Singapore.
Gerritsma W., P.T.P.P. London Sumatra, Indonesia.
Gillbanks R.A., Kina Gillbanks & Co., Rabaul.
Gray H., Agriculture Bank, Boroko.
Greasley W.A., Harrisons & Fleming Advisory Services, London.
Greer H., Harcros Trading (PNG) Ltd., Kimbe.
Hanold D., Waite Agricultural Institute, Australia.
Hextor J.J., Agriculture Bank, Boroko.
Hew Choy Kean, Plantek (M) Sdn. Bhd., Kuala Lumpur
Kam J., Information Specialist, UNDP., Port Moresby.
Kauzi G., Department of Agric. & Livestock, Konedobu.
Kerrigan N., Dow Chemicals, Australia.
King D., Analytical Services Ltd., Cambridge, New Zealand.
Laino M., Minister for Agriculture, N.S. Prov. Govt., Arawa.
Lee Poon Lim, Phumpkin Plantation Co., Thailand.
Lee Song Thai, Southern Palm Co., Thailand.
Lindesay R.H.M., Harrisons & Crosfield PLC, London.
Lockwood G. R., Dr., Commonwealth Development Corp., London.
Lomax L. Ms., Dept. of Home Affairs & Youth, Port Moresby.

Manoa J., National Provident Fund, Port Moresby.
McLeod J., Director, Harrisons and Crosfield PLC, London.
Mesmana E., Harrisons & Crosfield (PNG) Ltd., Kimbe.
Mills G., Price Waterhouse, Lae.
Miyanaga Hiroshi, Nissho Iwai Corporation, Tokyo, Singapore.
Montgomerie J., Director of Plantations, H&C (PNG) Ltd., Mosa.
New M., Agriculture Bank of PNG, Rabaul.
Penning J., National Provident Fund, Port Moresby.
Pidi H., Small Plantation Holder, Hoskins.
Popp T., BASF Fertilizer Extension Service, Kuala Lumpur.
Randles W.J.,Dr., Waite Agricultural Institute, Australia.
Rosenquist E., Harrisons Fleming Advisory Services, London.
Savia K., Minister for Health, N.S. Prov. Govt., Arawa.
Sim K.M. New Britain Palm Oil Development Ltd., Mosa.
Solulu T., University of Technology, Lae.
Tainole P., Dept of Agriculture & Livestock, Nahavio.
Taylor J.G., Harrisons & Fleming Advisory Services, London.
Tepp J., Agriculture Bank, Kimbe.
Toh, Y.P., HMPB Oil Palm Research Station, Banting, Malaysia.
Vava E.,Asst.Secretary,Dept.Agric.& Livestock,West New Britain.
Viner R., Dept. of Agriculture & Livestock, Konedobu.
Vitaharo E., National Provident Fund, Rabaul.
Vugts J.A., Kina Gillbanks & Co., Rabaul.
Warabe R., Dept. of Agric. & Livestock, Nahavio.
Yalikunja J., Dept. of Agric. & Livestock, Nahavio.

To Higaturu:

Atkins R., Dept. of Agric. & Livestock, Popondetta.
Auntar C., Popondetta Agriculture Bank, Popondetta.
Bao F., Dept. of Agric. & Livestock, Alotau.
Birom M., Rabaul Observatory, Rabaul.
Chase L., Commonwealth Development Corporation, London.
Fairhurst T., Solomon Islands Plantations Ltd., Solomon Islands
Fielding B., Higaturu Oil Palms Pty. Ltd., Popondetta.
Gray H., Agriculture Bank, Boroko.
Hansen N., General Manager, Milne Bay Estates Ltd.,Alotau.
Hanzungu, Mr., Dept. of Agriculture, Zimbabwe.
Hare E., Popondetta Agricultural College, Popondetta.
Johnson N., Rabaul Observatory, Rabaul.
Kam J., Ms.,Information Specialist, UNDP., Port Moresby.
Kila K., Physics Dept., U.P.N.G., Port Moresby.
King D., Analytical Services Ltd., New Zealand.
Langton J., Commonwealth Development Corporation, London.
Lewis F., Dept. of Agric. & Livestock, Alotau.
Lockwood G.R. Dr., Commonwealth Development Corporation, London
McFarlane M. Ms., Dept of Agric. & Livestock, Port Moresby.
Memo A., DAL, Quarantine Section, Konedobu.
Monroe D., Manager Warisota Estate, Oro Province.
Ora L., Dept. of Agriculture & Livestock, Popondetta.
Rankine I., Solomon Islands Plantations Ltd., Solomon Islands.
Rosenquist E., Harrisons Fleming Advisory Services, London.
Warn C., Gen.Manager, Higaturu Oil Palms Pty. Ltd., Popondetta.

REVIEW OF RESEARCH

(Dr.H.L.Foster)

I. INTRODUCTION

The Papua New Guinea Oil Palm Research Association has the responsibility of advising oil palm growers throughout the country on the optimum methods of crop management. To obtain and update this information the Association carries out experiments in all oil palm growing areas, on both estate and smallholder blocks.

When the Association was formed in 1980, the main factor limiting yields was poor fruitset due to inadequate pollination. However since the introduction of the pollinating weevil, trials have indicated that nutrition is now the dominant factor influencing yield levels. The fertilizer trial results presented in this report show that it is now possible to obtain FFB yields of 30 tonnes per hectare in most regions with correct nutritional management.

The same fertilizer trials also show that FFB yields may fall below 10 tonnes per hectare with time, if no fertilizer is applied. Once fertility has been lost it is generally a very expensive proposition to restore optimum yields through fertilizer application. On the other hand, only moderate amounts of fertilizer appear to be necessary to prevent yields declining with time. It is concluded that the key to successful oil palm production in most areas of Papua New Guinea, is the regular provision of optimum fertilizers starting from planting.

Average FFB yields in many estates and in particular most smallholdings are below 20 tonnes per hectare, whilst trials indicate that yields close to 30 tonnes per hectare are possible. A major extension effort to persuade growers, particularly smallholders, to improve management inputs is clearly needed. Accordingly the Association, in co-operation with the Department of Agriculture and Livestock, has established a network of demonstrations on oil palm smallholdings throughout the country, which supply readily understood optimum management information and provide an example for other growers to emulate.

In most oil palm development areas in Papua New Guinea, oil palm yields were not seriously limited by pests in 1989, reflecting the success of the pest management policies recommended by the Association. Pest status in oil palm is monitored continuously throughout the country and immediate advice on control measures is given when necessary. Research aimed at improving pest control methods continues, the ultimate objective being to establish biological control where possible. Although oil palms in Papua New Guinea fortunately do not suffer from any serious diseases, the Association continues to investigate all disease reports.

During 1989, six new **Experiments (119, 120, 204, 321, 401 and 506)** were initiated, whilst four **Experiments (102, 313, 705 and 709)** were concluded. At the end of the year a total of 36 projects were in active operation, including 20 fertilizer trials on different estates and 30 demonstration trials on smallholdings.

II. NUTRITION

Nitrogen

1. In every established trial in the Mosa and Popondetta areas, N gave a very appreciable yield response in 1989. N status is clearly the dominant factor controlling yield in all these trials.

2. For the first time, the effect of N was significant in the factorial **Experiment 107** at Bebere, in West New Britain, where it raised the annual FFB yield to a very satisfactory 28 tonnes per hectare. Fertilizer rates in this trial have recently been raised and it is hoped that the optimum combination will successfully prevent any yield decline in future years.

3. Factorial **Experiments 305 and 306** in the Popondetta area have been running for 8 years and moderate applications of N fertilizer have maintained yields and leaf N levels well above control levels. Whilst in **Experiment 305** FFB yields in excess of 30 tonnes per hectare are still being obtained with fertilizer, maximum yields have fallen in **Experiment 306,** where the highest annual N rate of 3 kg ammonium sulphate per palm appears to be inadequate.

4. In the factorial **Experiments 107, 305 and 306** response in 1989 to 1 kg ammonium sulphate per palm per year was at least 2 tonnes FFB per hectare at optimum levels of other treatments. In contrast, in the systematic N fertilizer **Experiments 108, 116 and 117,** average response to this rate of N fertilizer was only approximately 1 tonne FFB per hectare in 1989, and an even lower response was recorded in **Experiment 118.** This emphasises the importance of maintaining adequate levels of other nutrients if the full response to applied N fertilizer is to be obtained, and underlines the shortcomings of systematic trials which generally test only a single nutrient.

5. Variation in the efficiency of response to N fertilizer may also be due to differences in soil and climatic properties or to different management practices (such as method of frond or EFB placement) - factors which are due to be investigated in the proposed Soil N assessment **Experiment 713**, the proposed N and Crop Residue **Experiment 122** and existing **Experiment 115** which is now starting to indicate differences between frond placement methods.

6. Responses also tend to show diminishing returns, declining with yield level. This must partly explain the remarkable response of 9 tonnes FFB per hectare recorded in **Experiment 309b** to only 2 kg ammonium sulphate applied per palm - the control yield level in these experiment was less than 10 tonnes FFB per hectare.

7. Leaf N levels corresponding to optimum yields in the factorial **Experiments 107, 305 and 306,** over the years these trials have been running, have been similar to critical levels reported in other countries. They support the hypothesis that leaf N needs to be in balance with the level of total leaf bases - as the latter decline with palm age, so the minimum recommended level declines from an initial value of 2.8% N to as low as 2.3% N, as currently seen in **Experiments 305 and 306.**

8. Low leaf N levels explain the low average yields in **Experiments 309 and 310,** and a limiting level of N may be the reason for the lack of response to other treatments in these trials.

9. In earlier trials (e.g. **Experiments 109a, 109b, 110 and 309a)** a large part of the benefit of EFB application was attributed to improved N uptake. The initial results of **Experiment 311** at Isavene confirm this conclusion - an FFB yield of 33 tonnes per hectare was obtained with either a substantial application of 6 kg ammonium sulphate per palm, or alternatively with only 2 kg ammonium sulphate plus 32 tonnes per hectare EFB.

10. Growth measurements indicate that N fertilizer invariably increases leaf area, which determines the fraction of radiation intercepted, and also the efficiency of conversion of this energy to carbohydrates. However in no case has N fertilizer improved the bunch index - the proportion of total dry matter diverted to FFB yield.

11. New factorial fertilizer trials, including N as a major treatment, were initiated during 1989 on Navo estate in East Nakanai and on Kautu estate at Kapiura, both in West New Britain. Additional factorial trials including N are due to be established during 1990 on Mamba estate in the Kokoda valley (**Experiments 317 and 318**), on Dobuduru estate in the Popondetta area (Experiment 319) and on Bilomi estate at Kapiura (**Experiment 402**).

Chlorine

1. Chlorine uptake by oil palms is extremely low on the volcanic soils of Papua New Guinea where chloride fertilizers have not been applied, leaflet Cl levels generally being below 0.2%. On the application of chloride fertilizers, as shown in **Experiments 107, 108, 110, 305, 306, 309 and 310,** there is a large and rapid increase in both rachis and leaflet Cl levels. In the trunk and rachis, this large increase in anion level is balanced by an increase in all the major cations: Ca, Mg and K, as shown in **Experiments 305 and 306.** In the leaflets, the increased chlorine level is always accompanied by an increase in Ca, - which inevitably depresses leaflet K as recorded in **Experiments 107, 110, 305, 306, 309 and 310** (even when K is applied together with the Cl). The effect of chlorine treatments on leaflet Mg appears to depend on the leaflet K level, increasing Mg levels when the latter is at least 1% **(Experiments 107, 110 and 310),** but depressing Mg levels when the leaflet K is lower **(Experiments 305, 306 and 309).**

2. Another apparent effect of chlorine treatment on leaflet nutrient levels is the occasional significant increase in leaflet N **(Experiment 110** in 1989 and Experiment 306 in 1987), although this effect could be attributed to the cation simultaneously applied.

3. Single bunch weight was significantly increased by chlorine treatments in **Experiments 107, 110, 305, 306 and 310,** but overall FFB yield was significantly increased only in **Experiments 110, 305 and 306.**

4. Leaf nutrient data suggests (but does not prove) that the yield increment due to chlorine treatments in **Experiments 110, 305 and 306**, was indeed due to the chlorine constituent of the treatments. The KCl treatment in **Experiment 306** significantly increased bunch index, which suggests a chlorine effect, since K does not usually influence partition.

5. All these experiments are being continued, and together with **Experiments 119 and 120** initiated in West New Britain in 1989, which compare N fertilizers containing different anions, should confirm the importance of chlorine in the near future. It is believed that an adequate chlorine status in palms is essential for optimum moisture control. Hence chlorine deficiency may only be revealed when moisture is limiting.

Potassium

1. Potassium fertilizers are currently tested in a large number of factorial trials situated around the country including **Experiments 107, 119, 120, 201, 204, 305, 306, 309, 311, 312, 401 and 501.** Only in **Experiments 305, 306 and 501** have significant responses to the K fertilizer treatments been recorded and in **Experiments 305 and 306** the response appears at least partly due to the chlorine constituent. Thus only in **Experiment 501,** which is sited on alluvial soil at Milne Bay, has a definite requirement for K been identified.

2. Potassium fertilizer is also currently being tested in smallholder demonstration trials in West New Britain **(Experiment 121)** and around Popondetta **(Experiments 314/315** and Milne Bay **(Experiment 506).** These trials have not been running long enough to allow any definite conclusions, but leaf K levels are low at some sites on the mainland, indicating the possibility of K deficiency.

3. Leaf K levels are depressed by chlorine fertilizers and also tend to decline with time (e.g. **Experiments 305 and 306).** Thus K status in trials will continue to be closely monitored to determine if K deficiencies eventually develop.

Magnesium

1. Due to the high Ca content of volcanic soils in Papua New Guinea, kieserite is generally rather ineffective in increasing leaf Mg levels, as indicated in **Experiments 107, 305 and 306.** However the recent results obtained in **Experiment 107** show that although kieserite has little influence on leaf Mg levels in the absence of N fertilizers, it is effective in preventing the decline in leaf Mg levels caused by regular N fertilizer application. Full yield response to N fertilizer in **Experiment 107** is only obtained in the presence of kieserite, which is clearly worthwhile applying in this situation.

2. The systematic N **Experiments 108, 116, 117 and 118** in the Mosa area are currently showing rather disappointing N responses and at least in **Experiment 108,** this appears to be due to a Mg limitation as indicated by a marked decline in leaf Mg level. The above result in **Experiment 107** indicates that this decline can be prevented by kieserite application.

3. In general non-Mg containing fertilizers seem more effective than kieserite in increasing leaf Mg levels. The positive effect of chloride fertilizers on leaf Mg levels, provided leaf K levels are high, has been mentioned above. In addition superphosphate fertilizer may significantly improve leaf Mg as shown in **Experiments 110, 112 and 201** in West New Britain.

4. Several new factorial fertilizer trials testing kieserite have recently been initiated in West New Britain, including **Experiments 119 and 120** in the Hoskins area, **Experiment 204** at Navo and **Experiment 401** at Kapiura. Magnesium may also be deficient in the Kokoda valley in Oro province and will be included as a factorial treatment in fertilizer trials due to be established this year.

Phosphate

1. Similar to the Mg situation, the application of superphosphate fertilizer has very little effect on leaf P levels (**Experiments 107, 305 and 306**).

2. However superphosphate fertilizer has improved yields in the anion trial at Mosa (**Experiment 110**), in the smallholder trials at Buvussi (**Experiment 112**) and on the young volcanic soils at Hargy (**Experiment 201**). In all cases leaf Mg levels were low and were significantly increased by the P treatment. It would appear that at least part of the benefit of superphosphate application at these sites is the stimulation of Mg uptake.

3. A pot test (**Experiment 102c**) using maize as an indicator plant indicated that active rock phosphate, even when mixed with sulphur to increase local acidity, was a much poorer source of P compared with triple superphosphate, on a typical volcanic soil (pH < 6) from West New Britain.

4. Superphosphate fertilizer will be tested next year in a number of new factorial trials recently started or planned, including **Experiment 204** at Navo, **Experiments 401 and 402** at Kapiura and **Experiments 316 and 317** planned for the Kokoda valley.

Oil extraction ratios

1. There is concern about the effect of fertilizers on oil extraction ratios and this is currently being investigated through bunch analysis in fertilizer **Experiments 107 and 108** at Mosa.

2. Initial results from **Experiment 108** confirm earlier work at Dami, that chloride fertilizers increase the moisture content of fruit, whilst any fertilizers which depress Mg levels, tend to depress the dry mesocarp percentage in the fruit. However the effects are relatively small compared with the overall yield increase brought about by the fertilizers.

3. Further results are required before definite conclusions can be made. A slightly higher moisture content in fruit will almost certainly have to be accepted as the normal level in healthy palms having an adequate chlorine status. However a mesocarp decline in the fruit, due to Mg imbalance, should be avoidable with correct fertilization.

III. SMALLHOLDER EXTENSION

1. Information gained in formal trials on estates is transmitted to the smallholder sector through a network of demonstration trials on smallholdings sited throughout the country. These trials are set up in co-operation with the Department of Agriculture and demonstrate improved management practices with emphasis on fertilizer use. These trials not only demonstrate recommended management and fertilizer practice for the area but also test additional treatments so that local recommendations can be improved in the future.

2. At the end of 1989, a total of 29 demonstrations were in operation: 15 in the Hoskins Scheme, 12 in the Popondetta area and 2 at Milne Bay. Further expansion is planned in all these areas next year, when it is also intended to establish demonstrations in the Bialla and Kapiura areas. Thus by the end of 1990 a network of at least 50 demonstrations should be in place covering all the major smallholder areas in the country.

3. The well established smallholder trials at Buvussi in West New Britain, continued to show a marked response to fertilizer in 1989, the plots receiving the recommended N treatment showing an average FFB yield more than 4 tonnes per hectare above the control plots.

4. 7 new demonstration trials were established in the Hoskins Scheme during the year, each one in a different sub-division. By the end of 1990 it is intended to have demonstrations in all sub-divisions in this scheme.

5. In the Popondetta area, complete yi ld data was obtained in 1989 for 12 demonstrations started the previous year. These demonstrations have been divided into three groups according to soil type. An average yield response of 24% to N fertilizer was recorded, the highest responses being on the sandy soils. There was little response to P fertilizer, but some indication of a response to K fertilizer on the heavier soils. Yields on average in the demonstration plots were 40% higher than in the control plots on the sandy and organic soils, but only 20% higher on the clay loam soils. Average FFB yields in the demonstration plots were improved from 11 to 15 t/ha by an average application of 2.5 kg ammonium sulphate plus 1.5 kg potassium chloride per palm. The fertilizers would be expected to have a greater effect next year, when additional demonstrations will also be established.

6. In the Milne Bay area two demonstrations on smallholdings are ongoing. Leaf analysis results indicate that, as on the estates, K is particularly deficient and needs to be applied from planting. Yield recording will commence next year, when additional demonstrations will also be established.

7. All demonstation trials are comprehensively characterised, including the collection of soil and leaf samples, so that results can be extrapolated to other smallholder areas in the future.

IV. OIL PALM MATERIAL

1. It has been agreed to test known material from IRHO and Dami sources in the proposed International Seed Trial, **Experiment 711**, at one site in Oro Province and one site in West New Britain. However the trial has been delayed pending agreement by the seed producers on the planting densities.

2. Two agrogenetic trials, **Experiment 320** at Dobuduru in Oro Province and **Experiment 504** at Sagarai, Milne Bay, which will include Dami known crosses, are planned for establishment next year.

V. ENTOMOLOGY

Pollination

1. Routine recording of fruitset in different environments, which has been carried out for several years as part of **Experiment 603**, was concluded at the end of 1989, and the data will be analysed and reported in 1990. Fruitset was generally satisfactory in all regions in 1989, although still lowest on the mainland.

2. Fruitset recording continued in **Experiment 603**, on selected palms at Ambogo in Oro Province, to investigate whether the relief of yield stress through ablation would improve fruitset.

3. *Elaedobius kamerunicus* was introduced into the Milne Bay area during the year and its effect on fruitset is now being monitored.

4. Pollination and fruitset will be compared in clonal material from two distinct sources in two contrasting environments, in **Experiment 703** due to be planted in 1990. Ramets for this trial, from Unifield and IRHO, have been received and are now in nurseries in West New Britain and the mainland.

5. It is intended to assess the practical significance of poor fruitset on oil yield in different regions, through selected bunch analyses in 1990.

Pest control

1. Sexava damage, monitored in **Experiment 601**, was widespread in the Bialla area during 1989, indicating the need for vigilance and prompt treatment to keep this pest under control. Elsewhere isolated Sexava outbreaks occurred which were quickly controlled.

2. Release of Sexava egg parasites in **Experiment 607** continued in West New Britain throughout the year. Further recovery of parasites from Sexava eggs collected in parasite release areas, after the success at Navarai in February 1990, has not been achieved.

3. New Hanover was visited in late 1989 to replenish Sexava egg parasite populations. *Leafmansia bicolor*, which was introduced in the 1930's, was still readily found.

4. Experiments to propagate Sexava egg parasites *in vitro* are planned to commence next year.

5. No significant damage by *Scapanes australis*, monitored in **Experiment 608**, was reported during the year - despite an extensive area now underplanted at Mosa, where poisoned palms are left standing. On a visit to New Ireland, large numbers of *Oryctes rhinoceros* larvae were observed in felled coconut logs in oil palm developments - indicating a potential problem, although some larvae were clearly diseased, presumably due to infection by the Oryctes virus.

6. Some damage by bagworms occurred in the Mosa area during 1989, but a high natural mortality helped to keep outbreaks under control.

VI. PATHOLOGY

1. In West New Britain and Oro Provinces, relatively few reports of diseased palms were received during the year.

2. In New Ireland Province, it has been confirmed that an oil palm planted in a trial plot by the DAL in 1968, which recently died, was infected with *Ganoderma*. This raises concern that when oil palm is planted after coconuts in this Province, and the stumps of the old stand are left in the ground, there may be an appreciable risk of infection by *Ganoderma*, as reported in Malaysia.

3. In the Mosa area in West New Britain, underplanting followed by poisoning out the old stand at approximately 9 months, is now standard management practice. As above there is concern that leaving the stumps of the previous planting to rot in the field, may result in *Ganoderma* infection. However in two trials carried out in the Mosa area, no evidence of any *Ganoderma* infection has been detected six years after palms were planted next to buried infected palm wood **(Experiment 803)** or seven years after palms were planted adjacent to the stumps of felled or poisoned oil palms **(Experiment 801)**.

AGRONOMY TRIALS

WEST NEW BRITAIN PROVINCE

(I.Orrell & P.Talopa)

EXPERIMENT 107: FACTORIAL FERTILIZER TRIAL ON REPLANTS, BEBERE

PURPOSE:

To investigate the responses of oil palm to applications of different combinations of ammonium sulphate, triple superphosphate, muriate of potash, kieserite and sodium chloride, in order to obtain guidance on the fertilizer requirements of replants in the area.

SITE DETAILS:

Location: Field D8 and D9, Bebere Plantation, Mosa.

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

Planting date: January 1983

Planting density: 135 palms/hectare

DESIGN AND TREATMENTS

Design: This experiment originally consisted of a mixed series $3^2 x 2^3$ factorial design (N,P,K,Mg and Establishment N). In 1989, a new sodium chloride treatment was introduced, applied orthogonally over the establishment nitrogen treatment. The 72 plots are arranged in 6 blocks of 12 plots each. 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 the treatment "establishment nitrogen". The other treatment applications commenced in February 1985, except for sodium chloride which was introduced in June 1989.

Fertilizers are applied as two equal split doses per year.

Annual fertilizer application rates until the end of 1988 were as follows:

	Kg $palm^{-1}$ $year^{-1}$		
LEVEL	0	1	2
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;

	Kg $palm^{-1}$ $year^{-1}$		
LEVEL	0	1	2
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	-

RESULTS:

FFB Production data are presented in Tables 1 and 2.

Both ammonium sulphate and kieserite applications have significantly increased FFB production ($p=0.027$ and $p=0.002$ respectively for 1987-89 data) .

The sodium chloride treatment has significantly ($p=0.004$) increased single bunch weight.

As the new treatment amendments where only implemented in 1989, their full effects would not be expected until 1990 .

Table 1 Experiment 107, FFB Production and Yield Components Jan-Dec89.

	FFB Yield (t/ha/yr)	No of Bunches (No/ha/yr)	Bunch Wt. (kg/Bunch)
N0	**26.25**	1852	**14.22**
N1	**27.81**	1941	**14.36**
N2	**27.99**	1931	**14.54**
P0	27.48	1902	14.48
P1	27.23	1932	14.10
P2	27.34	1889	14.56
K0	27.63	1934	14.32
K1	27.77	1912	14.43
Mg0	26.93	1904	14.18
Mg1	27.77	1912	14.57
Cl0	27.22	1930	**14.13**
Cl1	27.48	1886	**14.62**
CV%	6.82	8.74	5.07
$LSD_{.05}$ (N&P)	1.08	96.3	0.42
$LSD_{.05}$ (K,Mg&Cl)	0.88	78.6	0.34

Table 2 Experiment 107, FFB Production and Yield Components Jan87-Dec89.

	FFB Yield (t/ha/yr)	No of Bunches (No/ha/yr)	Bunch Wt. (kg/Bunch)
N0	**25.44**	2292	11.40
N1	**26.36**	2344	11.53
N2	**26.37**	2337	11.58
P0	26.14	2315	11.59
P1	26.03	2354	11.33
P2	25.99	2304	11.59
K0	26.21	2345	11.46
K1	25.90	2303	11.55
Mg0	**25.55**	2312	**11.34**
Mg1	**26.56**	2336	**11.67**
CV%	5.10	5.41	4.44
$LSD_{.05}$ (N&P)	0.77	72.5	0.29
$LSD_{.05}$ (K&Mg)	0.63	59.2	0.24

Physiological parameters calculated from vegetative measurements carried out in 1989 are presented in Table 3.

Table 3 Experiment 107, Physiological Measurements 1989.

	Leaf Area Index	Fractional Energy Interception	Efficiency of Energy Conversion (g MJ-1)	Vegetative D.M Production (t ha-1yr-1)	Bunch D.M Production (t ha-1yr-1)	Bunch Index
N0	5.325	0.893	**1.365**	**15.316**	**21.526**	0.583
N1	5.576	0.904	**1.422**	**16.018**	**22.804**	0.587
N2	5.472	0.899	**1.437**	**16.054**	**22.948**	0.588
P0	5.451	0.899	1.409	15.684	22.536	0.589
P1	5.464	0.899	1.405	15.823	22.328	0.584
P2	5.464	0.900	1.410	15.881	22.415	0.584
K0	5.516	0.901	1.415	15.823	22.654	0.588
K1	5.400	0.897	1.402	15.769	22.198	0.584
Mg0	5.377	0.896	1.397	15.691	22.084	0.584
Mg1	5.538	0.902	1.420	15.900	22.768	0.588
Cl0	5.474	0.900	1.400	15.696	22.322	0.587
Cl1	5.441	0.898	1.417	15.896	22.530	0.586
CV%	11.5	3.5	5.0	4.3	7.5	3.3
LSD.05 (N&P)	0.366	0.018	0.041	0.394	0.976	0.011
LSD.05 (K,Mg&Cl)	0.299	0.015	0.034	0.322	0.797	0.009

Only the ammonium sulphate has had a significant effect on the physiological parameters analysed.

Ammonium sulphate application has significantly increased the efficiency of energy conversion ($p=0.003$), the vegetative dry matter production ($p<0.001$) and the bunch dry matter production ($p=0.007$). There is no change in bunch index. The ammonium sulphate treatment has therefore increased total dry matter production without changing the ratio of vegetative and bunch dry matter production. The vegetative dry matter production has increased proportionally to the change in amount of energy intercepted by frond tissue, therefore increasing the efficiency of energy conversion.

Table 4 presents the results of the frond 17 tissue analysis carried out in August.

Table 4 Experiment 107 Tissue Elemental Analysis 1989 (Dry Matter Basis).

	N (%)	P (%)	K (%)	Mg (%)	Ca (%)	S (%)	Cl (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	B (ppm)
N0	2.392	0.157	1.022	0.200	0.905	0.162	0.291	55.0	**35.8**	6.16	21.5	11.6
N1	2.408	0.156	1.043	0.192	0.894	0.164	0.272	54.3	**44.1**	6.33	21.1	11.5
N2	2.421	0.156	1.020	0.186	0.897	0.165	0.271	54.1	**54.8**	6.08	21.3	12.4
P0	2.417	0.157	1.029	0.192	0.900	0.162	0.255	53.9	43.7	6.08	21.6	11.9
P1	2.387	0.157	1.030	0.192	0.895	0.165	0.297	55.1	46.4	6.37	21.0	11.7
P2	2.417	0.155	1.026	0.192	0.901	0.164	0.282	54.5	44.7	6.12	21.4	11.9
K0	2.411	0.156	1.031	0.192	0.900	0.162	0.275	54.4	44.8	6.28	21.0	11.7
K1	2.403	0.157	1.025	0.192	0.897	0.165	0.280	54.6	45.0	6.11	21.6	11.9
Mg0	2.408	0.157	1.032	**0.185**	**0.912**	0.162	0.268	54.8	46.0	6.25	21.3	**11.5**
Mg1	2.407	0.155	1.025	**0.200**	**0.885**	0.165	0.287	54.2	43.8	6.14	21.3	**12.1**
Cl0	2.417	0.158	**1.058**	**0.185**	**0.889**	0.16	**0.206**	53.8	44.6	6.14	21.6	**12.3**
Cl1	2.397	0.155	**0.998**	**0.200**	**0.907**	0.16	**0.349**	55.1	45.2	6.25	21.1	**11.4**
CV%	3.88	4.04	5.00	8.54	4.51	5.11	28.43	10.3	13.5	9.35	8.12	10.57
LSD.05 (N&P)	0.054	0.004	0.030	0.009	0.023	0.00	0.046	3.2	3.4	0.33	1.0	0.7
LSD.05 (ClK&Mg)	0.044	0.003	0.024	0.008	0.019	0.00	0.037	2.6	2.8	0.27	0.8	0.6

The ammonium sulphate treatment has predictably produced significantly ($p<0.001$) increased manganese levels in frond tissue. Although not statistically significant, ammonium sulphate has produced an increase in leaflet nitrogen level and a decrease in leaflet magnesium level.

Kieserite application has produced a significant increase in frond 17 leaflet magnesium level ($p=0.003$) and a decrease in calcium level ($p=0.003$).

The sodium chloride treatment has significantly increased the levels of magnesium ($p=0.010$) and calcium ($p=0.055$) in frond leaflet tissue and decreased the level of potassium ($p<0.001$).

As magnesium is probably the second most important yield limiting nutrient after nitrogen, the depression of leaflet magnesium by ammonium fertilizer is particularly serious. Table 5 presents the plot means for effects of the NxMg interaction on leaflet N and Mg levels and on FFB yield.

Table 5   Experiment 107 NxMg Effects (1989 Data).

	% Leaflet Mg		% Leaflet N		FFB Yield 1989	
Treatment	**Mg*0***	**Mg*1***	**Mg*0***	**Mg*1***	**Mg*0***	**Mg*1***
N*0*	**0.20**	**0.20**	2.40	2.38	**26.03**	**26.47**
N*1*	**0.19**	**0.20**	2.43	2.39	**27.00**	**28.62**
N*2*	**0.17**	**0.20**	2.40	2.44	**27.77**	**28.20**
$LSD_{.05}$	0.01		0.08		1.52	

The application of kieserite does appear to reduce the decline in leaflet magnesium level caused by ammonium sulphate application.

Highest FFB yields are produced with a combined application of ammonium sulphate and kieserite.

EXPERIMENT 108: SYSTEMATIC NITROGEN FERTILIZER TRIAL , KUMBANGO

PURPOSE:

To investigate the response of oil palm to systematically increasing levels of application of ammonium chloride and diammonium phosphate with and without the presence of EFB mulch, in order to obtain guidance on fertilizer requirements in the area.

SITE DETAILS:

Location: Field E7 and F8, Kumbango Plantation, Mosa.

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

Planting date: 1972

Planting density: 120 palms/hectare

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 sources are guarded from each other and the end rows are guarded.

Treatments: The annual fertilizer applications to this experiment are as follows:

	Kg $palm^{-1}$ $year^{-1}$							
LEVEL	0	1	2	3	4	5	6	7
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

RESULTS:

FFB production and yield component data is presented in Tables 6 and 7.

Table 6. Experiment 108, Yield & Yield Components Jan-Dec 1989.

	FFB Yield (t/ha/yr)		No. of Bunches (No./ha/yr)		Single Bunch Weight (kg/bunch)	
	A.C.	D.A.P.	A.C.	D.A.P.	A.C.	D.A.P.
0	16.75	14.75	718	667	23.35	22.06
L 1	16.78	15.85	699	697	24.00	22.73
E 2	17.68	17.62	714	727	24.78	24.31
V 3	18.65	17.53	696	706	26.84	24.58
E 4	18.10	21.22	653	807	27.67	26.40
L 5	21.16	21.46	743	818	28.51	26.27
6	20.69	20.85	779	788	26.53	26.55
7	20.82	18.56	749	700	27.82	26.62

Table 7. Experiment 108, Yield & Yield Components Jan87-Dec89.

	FFB Yield (t/ha/yr)		No. of Bunches (No./ha/yr)		Single Bunch Weight (kg/bunch)	
	A.C.	D.A.P.	A.C.	D.A.P.	A.C.	D.A.P.
0	16.15	14.40	733	715	21.88	20.27
L 1	16.59	15.97	744	749	22.32	21.38
E 2	18.80	17.67	800	808	23.60	22.03
V 3	19.29	18.50	789	814	24.65	22.75
E 4	19.05	20.36	762	851	25.17	24.13
L 5	20.32	20.78	806	891	25.38	23.46
6	20.28	20.78	825	892	24.67	23.45
7	20.53	19.64	796	836	25.88	23.70

The data in Tables 6 and 7 are illustrated in Figs. 1 and 2.

Relative to diammonium phosphate, ammonium chloride application appears to have the effect of increasing bunch weight and decreasing bunch numbers. A possible explanation for this effect is that ammonium chloride is inducing a second yield limiting factor, probably magnesium deficiency.

Figure 3 illustrates the monthly FFB production since the first fertilizer application. The data illustrated represents the combined data of the ammonium chloride and diammonium phosphate treatments. Trend analysis was carried out for the period beginning 12 months after the first fertilizer application.

In the absence of nitrogen fertilizer applications, there is no change in the level of FFB production with time. As the level of nitrogen fertilizer application increases the higher FFB production levels attained by nitrogen application decreases with time, the slope being greater the higher the level of fertilizer application.

This decrease in fertilizer nitrogen response is indicative of a second yield limiting factor affecting yield. Frond 17 leaflet tissue analysis indicates this second yield limiting factor to be magnesium deficiency. Figure 4 illustrates the effects of ammonium fertilizer applications and time on frond 17 leaflet magnesium levels. It is clear that both ammonium fertilizers, particularly ammonium chloride have depressed leaflet magnesium levels to sub-critical levels.

Because of this induced magnesium stress, starting in 1990, half the replicates in this trial will receive annual applications of 4.0 kg kieserite $palm^{-1}$.

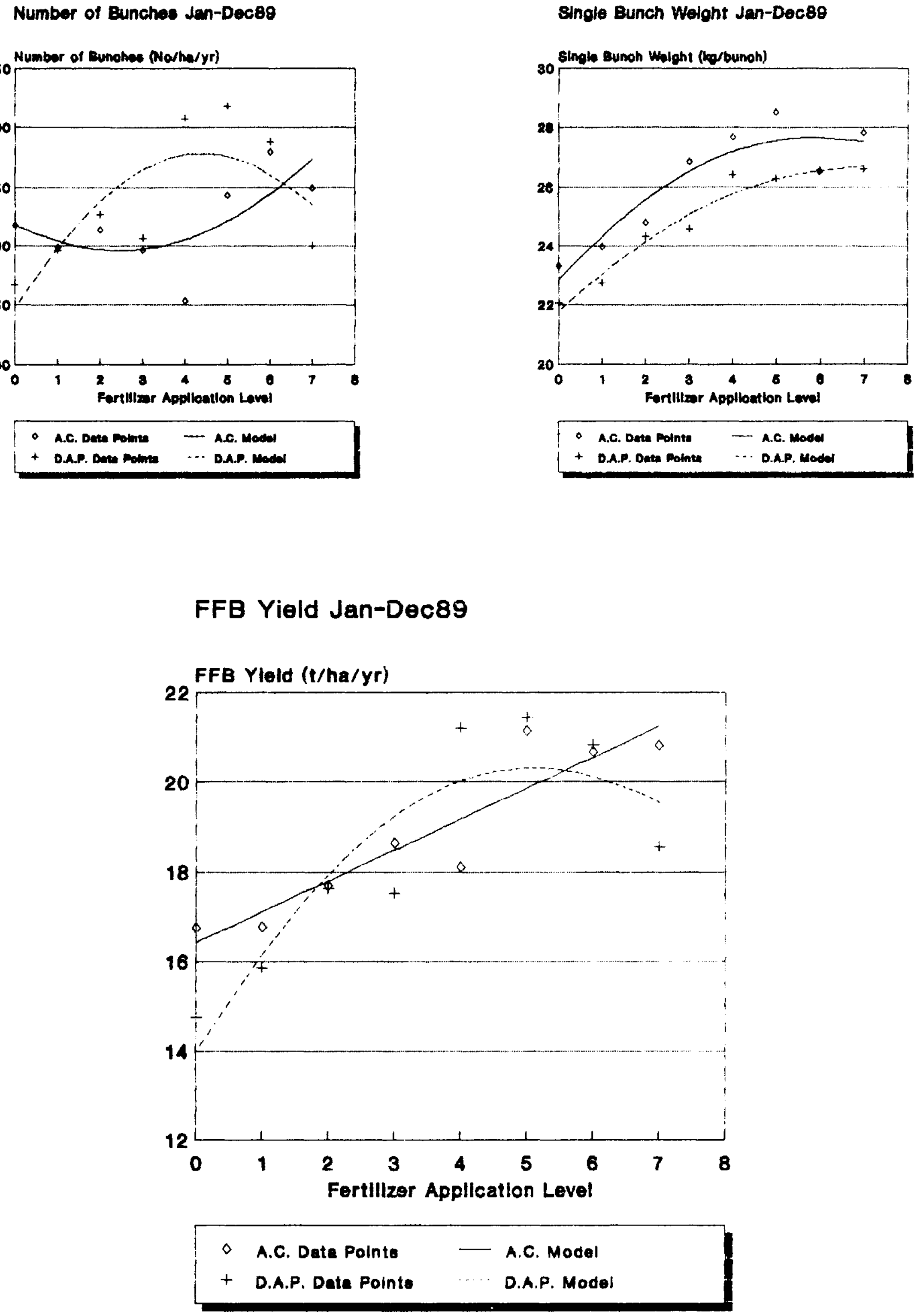


Fig 1. Expt 108. Yield & Yield Components Jan-Dec1989

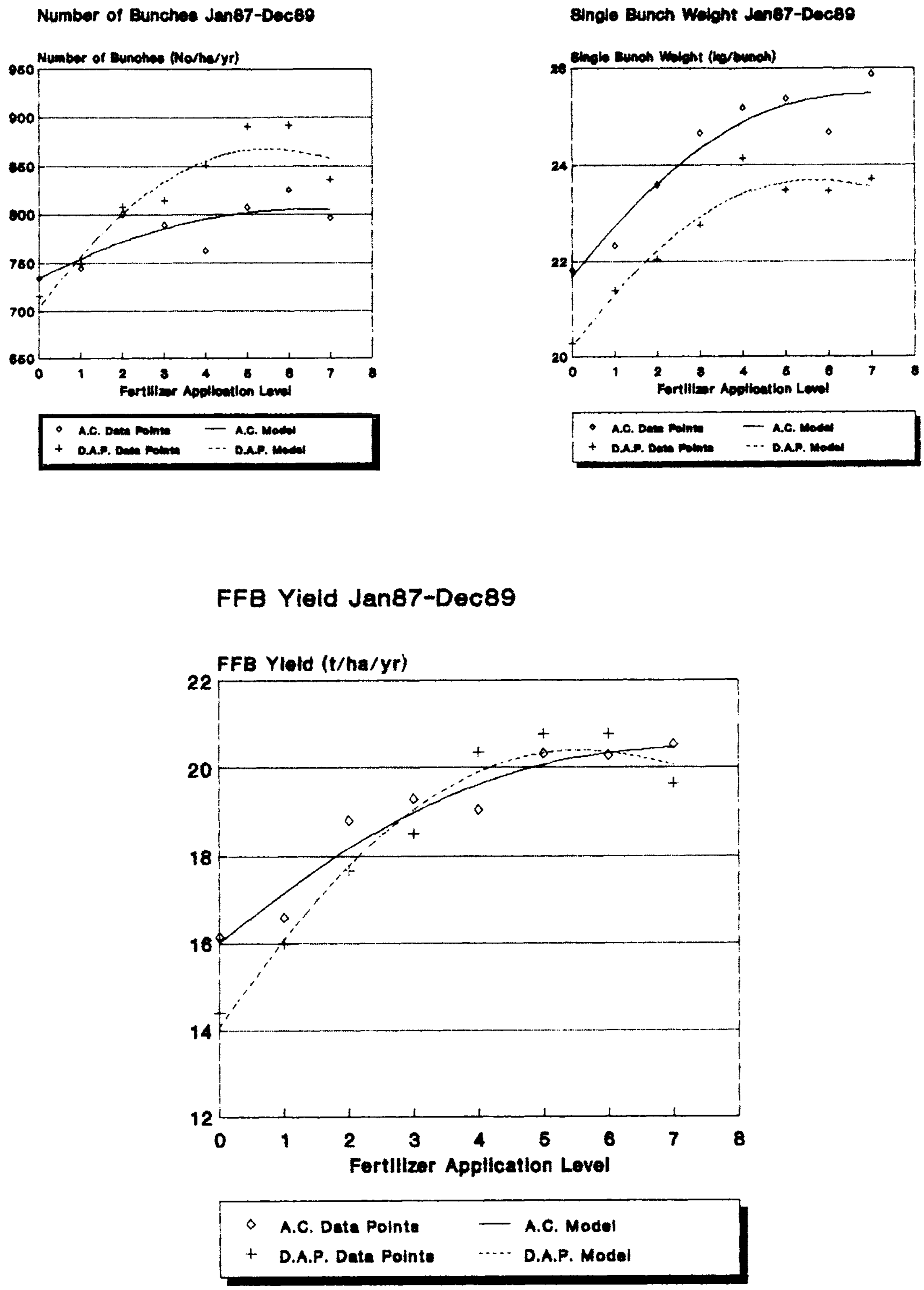
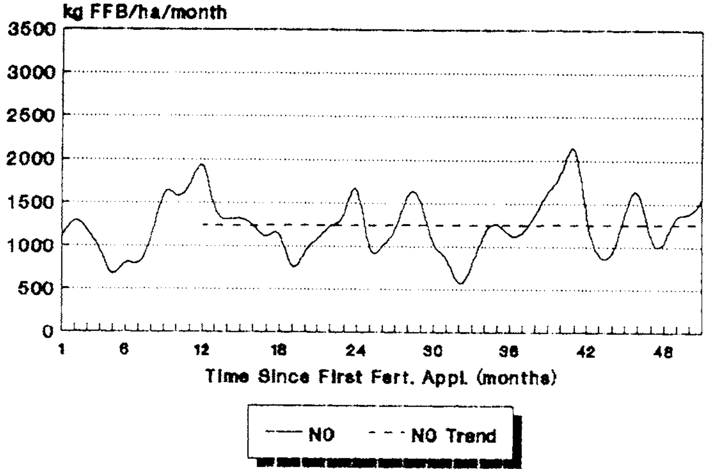


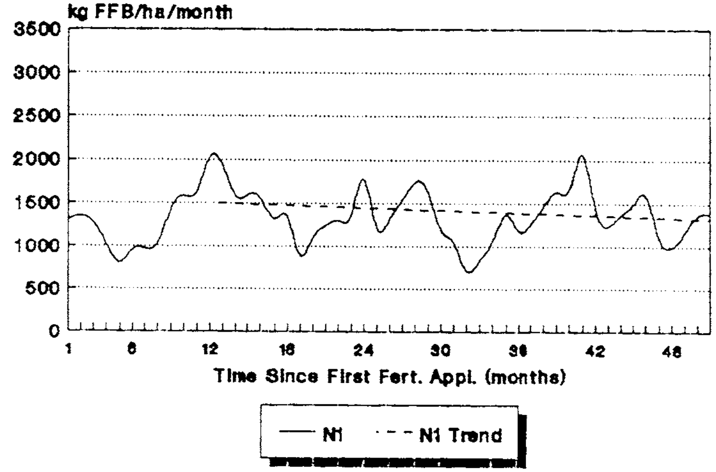
Fig 2. Expt 108. Yield & Yield Components Jan87-Dec89

Fig 3. Experiment 108, Kumbango Plantation.

Nil Nitrogen Treatment

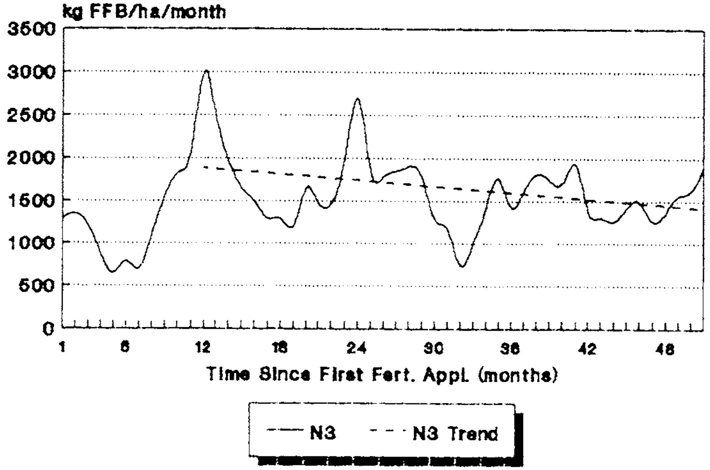


Level 1* Nitrogen Treatment



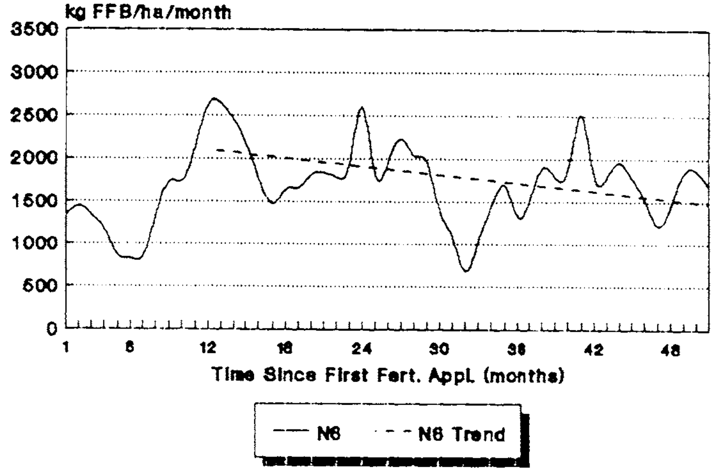
*Equivalent to 0.9 kg Amm Cl/palm/yr

Level 3* Nitrogen Treatment



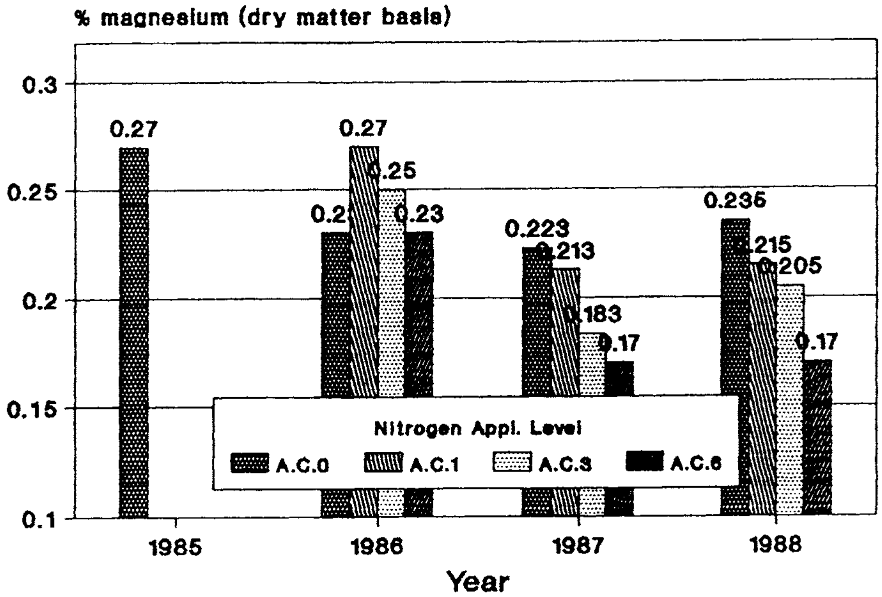
*Equivalent to 2.7 kg Amm Cl/palm/yr

Level 6* Nitrogen Treatment



*Equivalent to 5.4 kg Amm Cl/palm/yr

Frond 17 Leaflet Magnesium Levels
Ammonium chloride treatment



Frond 17 Leaflet Magnesium Levels
Diammonium phosphate treatment

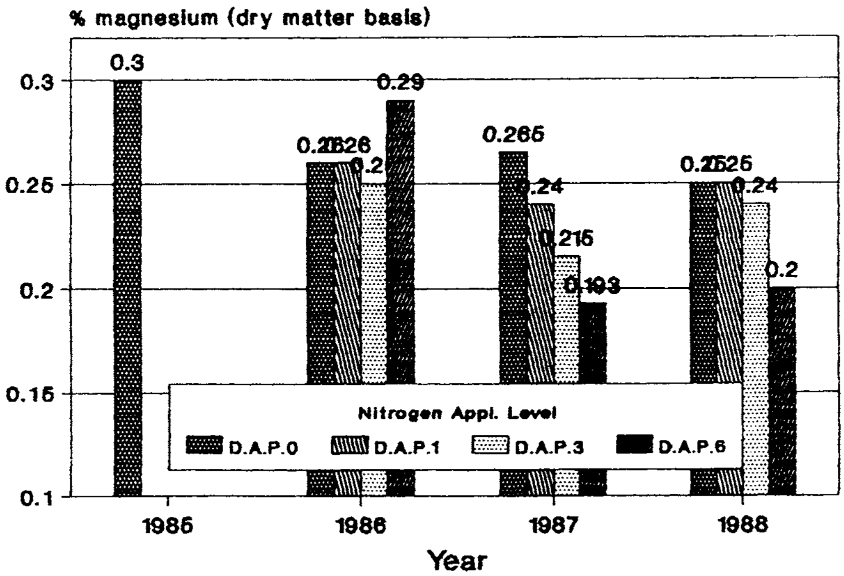


Fig 4. Expt 108.
Effect of Treatment on Leaflet Mg Levels

EXPERIMENT 110: NITROGEN/ANION TRIAL ON YOUNG REPLANTS, BEBERE

PURPOSE:

To investigate the response of oil palm to application of chloride, phosphate and sulphate at a constant level of nitrogen application in the presence and absence of EFB mulch.

SITE DETAILS:

Location: Fields B11 and B12, Bebere Plantation, Mosa.

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

Planting date: February 1984

Planting density: 135 palms/hectare

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 rates are shown in Table 8:

Table 8 Experiment 110, Fertilizer treatment rates

Treatment	Non-N Anion and Level		Non-N anion Source		Additional Ammonium Nitrate	
			Kg $Palm^{-1}$ $Year^{-1}$			
1	Chloride	0	A.C.:	0.0	A.N. :	1.6
2	Chloride	1		0.5		1.2
3	Chloride	2		1.0		0.8
4	Sulphate	0	SOA :	0.0	A.N. :	1.6
5	Sulphate	1		1.25		0.8
6	Sulphate	2		2.50		0.0
7	Phosphate	0	DAP :	0.0	A.N. :	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

(N.B. 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 production and yield component data is presented in Tables 9 and 10. Unfortunately the trial design does not allow a conventional statistical analysis. It appears that in the absence of the EFB mulch applied in 1984, all three non-nitrogenous anion applications resulted in increased FFB production. The magnitude of this response for the three non-nirogenous ions follows the order chloride>phosphate>sulphate. In the presence of the EFB mulch, there is little treatment response.

For the palms receiving nitrogen application, there still appears to be an FFB yield elevation due to the 1984 EFB mulch.

Table 9. Experiment 110, FFB Production Jan-Dec89

Total N Applied (g/palm/yr)	Non-N Anion & Level		FFB Yield (t/ha/yr)		No. of Bunches (No/ha/yr)		S.B.W. (kg/bunch)	
			-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch
580		0	27.78	28.59	2573	2491	10.79	11.48
580	Chloride	1	30.78	31.29	2630	2715	11.71	11.55
580		2	29.57	30.51	2593	2563	11.43	11.89
580		0	27.78	28.59	2573	2491	10.79	11.48
580	Sulphate	1	28.87	28.87	2407	2576	12.01	11.19
580		2	28.65	30.92	2520	2580	11.37	11.98
580		0	27.78	28.59	2573	2491	10.79	11.48
580	Phosphate	1	28.74	29.29	2517	2396	11.42	12.21
580		2	29.35	28.44	2666	2433	11.02	11.71
0.0	No Fert.	-	29.32	28.65	2602	2498	11.27	11.47
	MEAN (+N)		28.81	29.46	2561	2526	11.26	11.66

Table 10. Experiment 110, FFB Production Jan87-Dec89

Total N Applied (g/palm/yr)	Non-N Anion & Level		FFB Yield (t/ha/yr)		No. of Bunches (No/ha/yr)		S.B.W. (kg/bunch)	
			-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch
580		0	22.73	25.27	2704	2982	8.33	8.71
580	Chloride	1	24.94	26.37	2855	3090	8.85	8.72
580		2	25.94	25.98	3020	2906	8.79	9.10
580		0	22.73	25.27	2704	2982	8.33	8.71
580	Sulphate	1	24.26	24.57	2698	2965	9.16	8.46
580		2	23.86	25.77	2794	2930	8.67	8.97
580		0	22.73	25.27	2704	2982	8.33	8.71
580	Phosphate	1	23.66	24.79	2793	2786	8.61	9.11
580		2	25.01	24.72	3008	2836	8.47	8.92
0.0	No Fert.	-	24.25	24.75	2823	2948	8.69	8.62
	MEAN (+N)		23.87	25.34	2809	2940	8.72	8.83

The data in Tables 9 and 10 are illustrated in Figs. 5 and 6.

Table 11 presents the results of frond 17 leaflet tissue analysis carried out in August 1989.

Chloride treatment appears to increase leaflet nitrogen levels particularly in the absence of EFB mulch. Chloride treatment appears to increase divalent cation levels and depress potassium levels. In the absence of EFB mulch, sulphur levels have been raised. Chloride treatment has also raised leaflet chloride and manganese levels.

The sulphate treatment has depressed leaflet calcium levels and increased leaflet chlorine and manganese levels.

Phosphate treatment appears to have increased leaflet nitrogen and phosphorus levels. In the absence of EFB mulch, phosphate application appears to have increased potassium, magnesium, sulphur, chlorine, iron and manganese levels and decreased calcium and copper levels.

All non-nitrogenous anion treatments in the absence of EFB mulch have decreased leaflet boron levels.

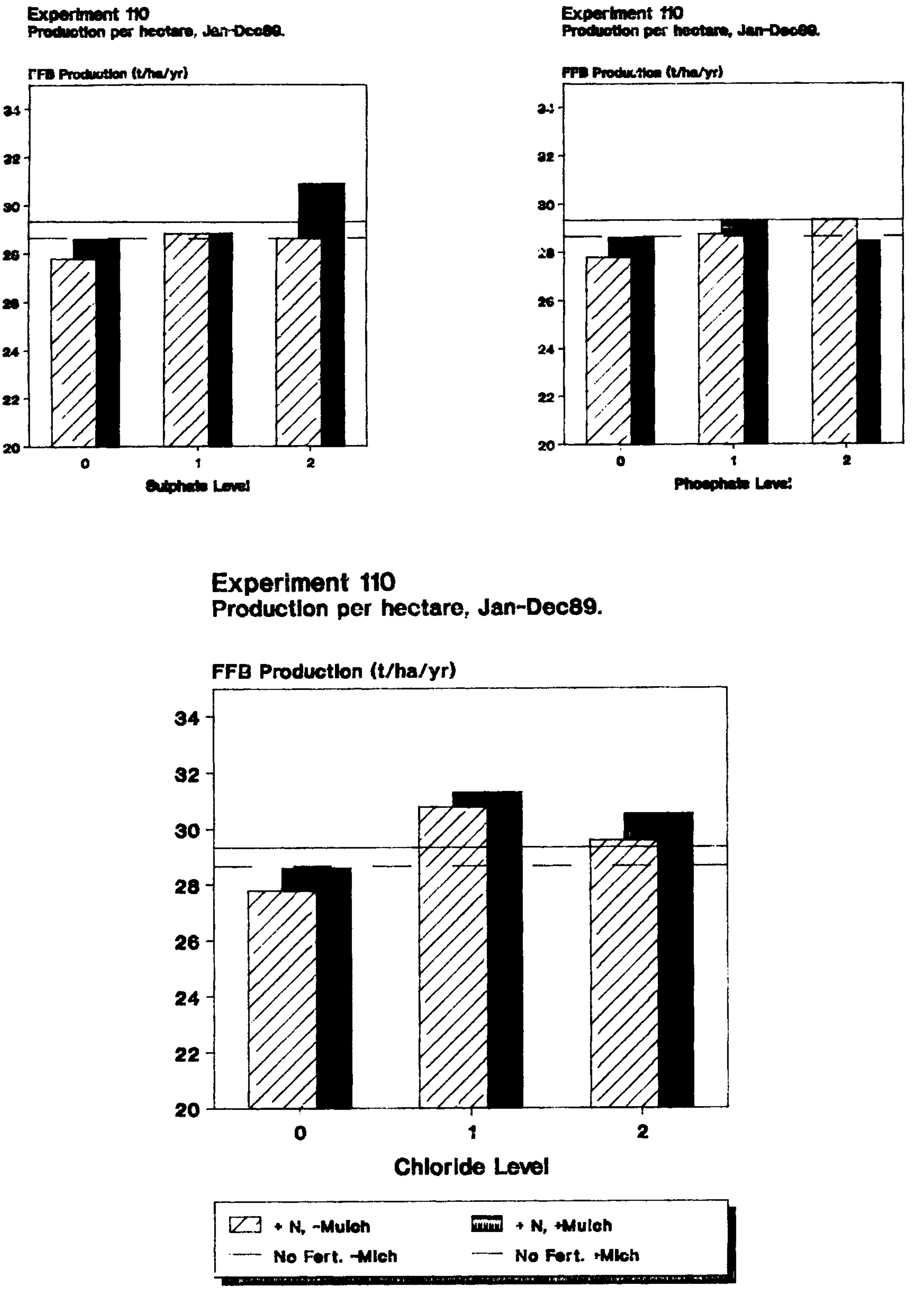


Fig. 5. Experiment 110, Production per hectare, Jan-Dec 1989

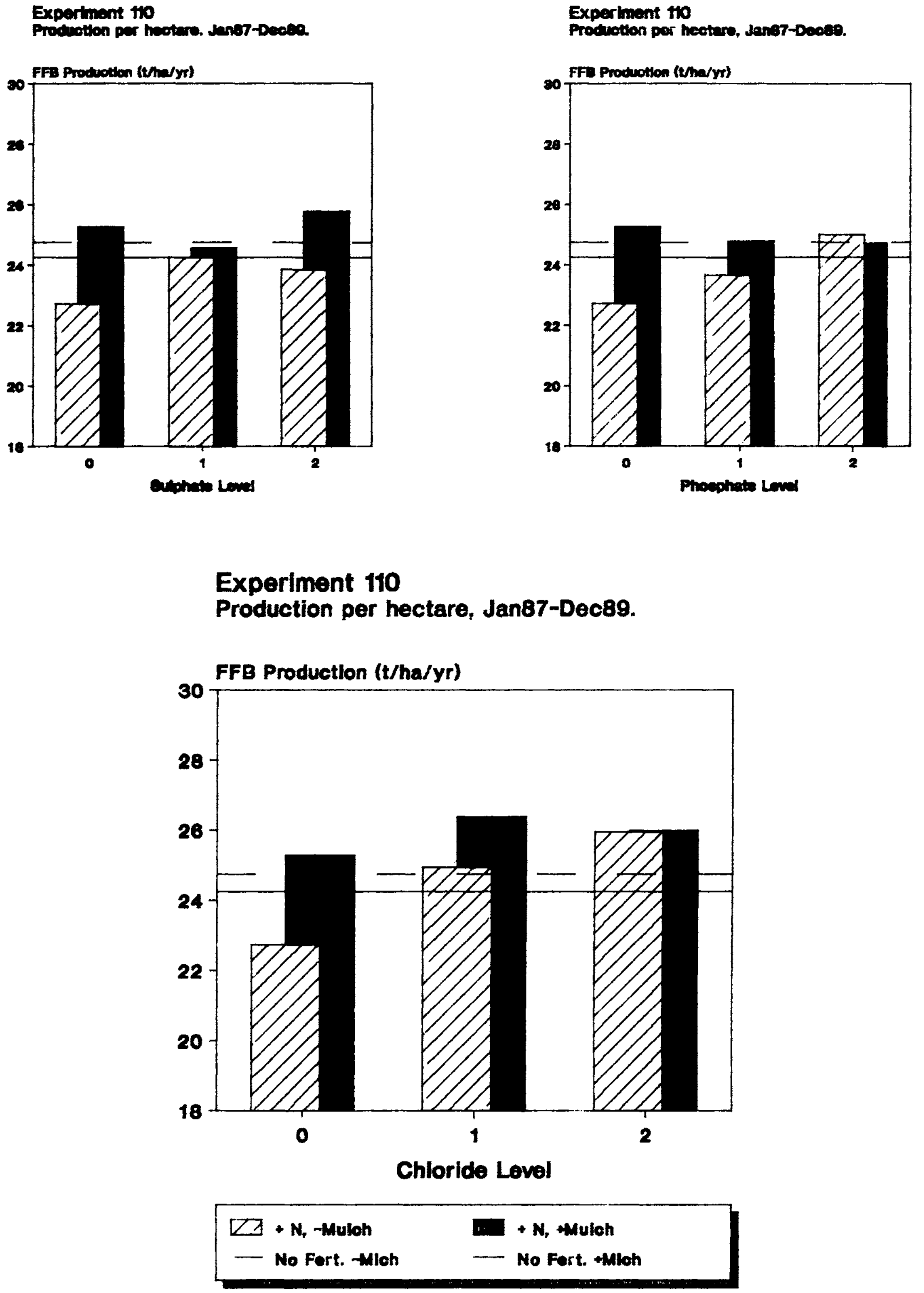


Fig.6. Experiment 110, Production per hectare, Jan 87-Dec 89

Table 11. Expt. 110. Frond 17 Leaflet Tissue Analysis 1989

Total N Applied (g/palm/yr)	Non-N Anion & Level		% Nitrogen		% Phosphorus		% Potassium		% Magnesium		% Calcium		% Sulphur	
			-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch
580		0	2.422	2.411	0.164	0.163	1.117	1.136	0.163	0.173	1.104	1.031	0.164	0.173
580	Chloride	1	2.433	2.500	0.166	0.164	1.127	1.080	0.173	0.200	1.100	1.103	0.167	0.173
580		2	2.567	2.500	0.161	0.168	1.050	1.000	0.183	0.163	1.123	1.193	0.170	0.173
580		0	2.422	2.411	0.164	0.163	1.117	1.136	0.163	0.173	1.104	1.031	0.164	0.173
580	Sulphate	1	2.400	2.500	0.164	0.166	1.100	1.110	0.187	0.177	1.067	1.077	0.170	0.177
580		2	2.500	2.433	0.162	0.166	1.160	1.110	0.160	0.163	1.053	1.060	0.170	0.170
580		0	2.422	2.411	0.164	0.163	1.117	1.136	0.163	0.173	1.104	1.031	0.164	0.173
580	Phosphate	1	2.433	2.467	0.166	0.166	1.153	1.120	0.170	0.160	1.097	1.057	0.170	0.167
580		2	2.433	2.467	0.168	0.166	1.173	1.083	0.183	0.190	1.023	1.053	0.173	0.170
0.0	No Fert.	-	2.489	2.400	0.163	0.164	1.143	1.129	0.179	0.187	1.081	1.042	0.169	0.166
	MEAN		2.448	2.456	0.164	0.165	1.124	1.101	0.172	0.175	1.086	1.071	0.168	0.172

Total N Applied (g/palm/yr)	Non-N Anion & Level		% Chlorine		ppm Iron		ppm Manganese		ppm Zinc		ppm Copper		ppm Boron	
			-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch
580		0	0.238	0.277	48.5	51.1	57.2	60.0	20.3	20.4	5.44	4.78	13.8	12.4
580	Chloride	1	0.383	0.483	48.0	53.3	73.7	70.3	21.3	23.0	5.67	6.00	12.0	9.0
580		2	0.457	0.477	53.7	49.0	90.0	77.3	21.0	22.0	5.33	5.33	9.0	11.7
580		0	0.238	0.277	48.5	51.1	57.2	60.0	20.3	20.4	5.44	4.78	13.8	12.4
580	Sulphate	1	0.280	0.283	47.7	52.0	75.0	78.0	23.0	22.0	5.67	5.33	12.3	12.0
580		2	0.263	0.323	44.0	48.7	74.7	68.3	20.3	19.7	5.00	5.00	11.7	13.7
580		0	0.238	0.277	48.5	51.1	57.2	60.0	20.3	20.4	5.44	4.78	13.8	12.4
580	Phosphate	1	0.273	0.250	50.0	48.3	67.7	59.3	19.7	20.0	5.00	4.33	14.0	14.3
580		2	0.273	0.257	55.3	50.0	79.0	72.7	20.7	20.3	4.00	4.67	10.3	12.0
0.0	No Fert.	-	0.269	0.286	50.3	52.8	51.2	48.3	21.7	20.9	5.22	5.22	11.2	12.3
	MEAN		0.294	0.323	49.4	50.5	70.2	67.3	20.8	20.9	5.22	5.00	12.3	12.2

The results of physiological measurements carried out in August 1989 are presented in Table 12.

Table 12. Experiment 110 Physiological Measurements 1989.

Total N Applied (g/palm/yr)	Non-N Anion & Level		Leaf Area Index		Fract. Energy Intercepted		Efficiency of Energy conver. (g MJ-1)		Vegetative DM Production (t ha-1yr-1)		Bunch D.M. Production (t ha-1yr-1)		Bunch index	
			-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch
580		0	4.209	4.750	0.749	0.790	1.615	1.570	13.751	13.983	22.777	23.448	0.623	0.626
580	Chloride	1	4.277	4.373	0.756	0.760	1.720	1.779	14.019	15.043	25.239	25.656	0.643	0.630
580		2	4.470	4.790	0.770	0.792	1.649	1.677	14.094	14.942	24.248	25.015	0.632	0.626
580		0	4.209	4.750	0.749	0.790	1.615	1.570	13.751	13.983	22.777	23.448	0.623	0.626
580	Sulphate	1	4.020	4.427	0.733	0.761	1.701	1.664	13.927	14.551	23.674	23.675	0.629	0.619
580		2	4.267	4.767	0.751	0.789	1.644	1.669	13.823	14.401	23.490	25.355	0.628	0.638
580		0	4.209	4.750	0.749	0.790	1.615	1.570	13.751	13.983	22.777	23.448	0.623	0.626
580	Phosphate	1	4.557	4.913	0.776	0.798	1.597	1.609	13.858	14.742	23.564	24.021	0.629	0.619
580		2	4.073	4.453	0.739	0.770	1.719	1.630	14.296	14.573	24.066	23.324	0.628	0.616
0.0	No Fert.	-	4.608	4.421	0.779	0.764	1.610	1.626	13.809	13.901	24.046	23.491	0.635	0.628
	MEAN (+N)		4.254	4.664	0.752	0.782	1.653	1.637	13.919	14.467	23.623	24.154	0.629	0.625

Where nitrogen and non-nitrogenous anion treatments have been applied, the EFB mulched plots produce higher leaf area index, fractional energy interception, vegetative dry matter and bunch dry matter production. As the fertilizers are applied in the same place that the EFB mulch was applied, this response is probably due to more effective nitrogen uptake in the mulched soils which will have a higher soil organic matter level.

In the absence of mulch, the chloride treatment increases the leaf area index, fractional energy interception, vegetative dry matter and bunch dry matter production, usually more than the other non-nitrogenous treatments. The phosphate treatment appears to increase vegetative dry matter production more than sulphate or chloride. The sulphate treatment produces a lesser effect that the chloride and phosphate.

Where all three non-nitrogenous anions produce a similar response in yield, yield component, tissue nutrient levels or physiological parameters, it is not possible to determine whether this response is due to the non-nitrogenous anions or whether it is due to the corresponding application of nitrate.

EXPERIMENT 116: SYSTEMATIC NITROGEN FERTILIZER TRIAL, BEBERE.

PURPOSE: To investigate the response of Oil Palm to systematically increasing levels of application of ammonium chloride, duration of applications being i) one years appplication only ii) continuous annual applications.

SITE DETAILS:

Location: Field E3 and E4, Bebere Plantation, Mosa.

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

Planting date: 1971

Planting density: 120 palm/hectare

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 2 year's 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;

	Kg palm^{-1} year^{-1}						
LEVEL	**0**	**0**	**0**	**1**	**2**	**3**	**4**
Ammonium chloride, one year application only	0.0	0.0	0.0	1.5	3.0	4.5	6.0
Ammonium chloride, two years application only	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:

Tables 13 and 14 present the FFB yield and yield component data for 1989 and 1988 to 1989 respectively.

Table 13. Experiment 116. Yield & Yield Components Jan-Dec89

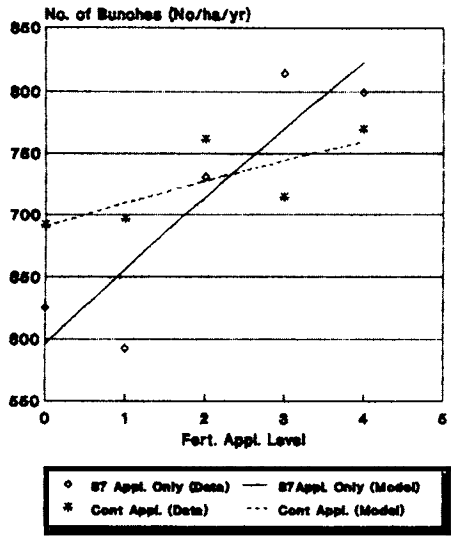
Ammonium Chloride Application Rate (kg/palm/yr)	FFB Yield (t/ha/yr)		No. of Bunches (No/ha/yr)		S.B.W. (kg/bunch)	
	87 app.	Cont App	87 App.	Cont App	87 App.	Cont App
0	15.48	17.77	625	692	24.80	25.78
1.5	15.82	19.35	592	696	26.68	28.09
3.0	19.15	22.54	731	761	25.89	29.62
4.5	21.65	21.56	814	715	26.56	30.16
6.0	21.77	22.77	799	769	27.24	29.59

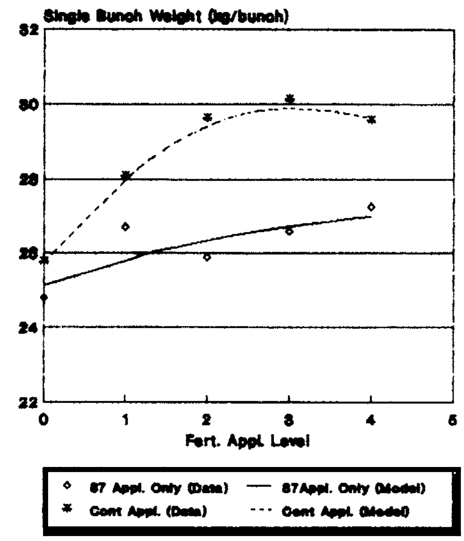
Table 14. Experiment 116. Yield & Yield Components Jan88-Dec89

Ammonium Chloride Application Rate (kg/palm/yr)	FFB Yield (t/ha/yr)		No. of Bunches (No/ha/yr)		S.B.W. (kg/bunch)	
	87 app.	Cont App	87 App.	Cont App	87 App.	Cont App
0	14.20	15.76	614	663	23.18	23.74
1.5	15.30	17.74	618	701	24.81	25.49
3.0	17.68	20.05	737	744	23.77	26.88
4.5	18.49	20.46	759	754	24.17	27.30
6.0	20.69	20.42	806	750	25.69	27.12

The 1987 fertilizer application only treatment has undergone a rapid decrease in single bunch weight relative to the continuous fertilizer application treatment. As yet the numbers of bunches produced in the 1987 application only treatment have not dropped much and so a clear fertilizer application response curve in terms of FFB production is still evident in this treatment.

Figures 7 and 8 illustrate the yield response data and best fit regression models for 1989 and 1988 to 1989 respectively.





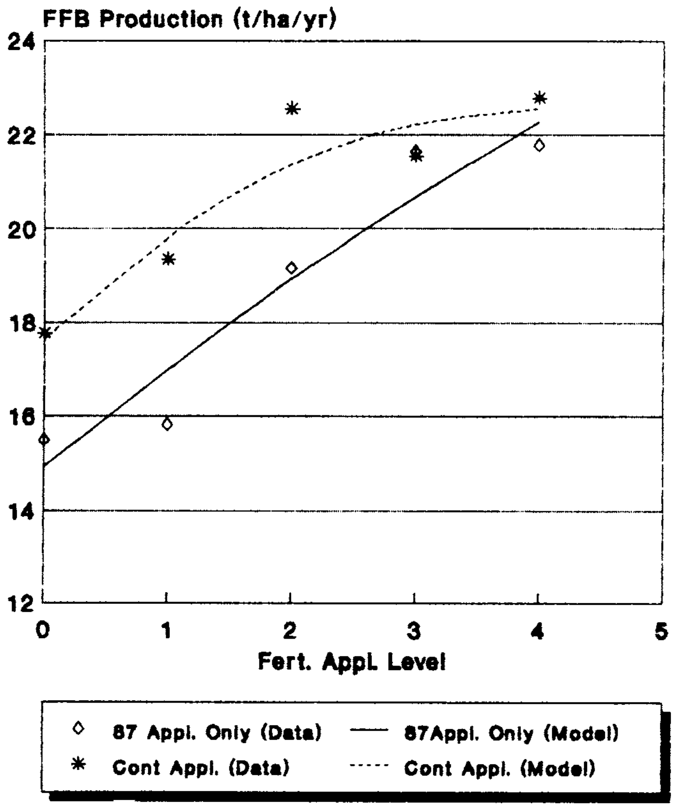


Fig 7. Expt 116 Yield & Yield Components Jan-Dec89

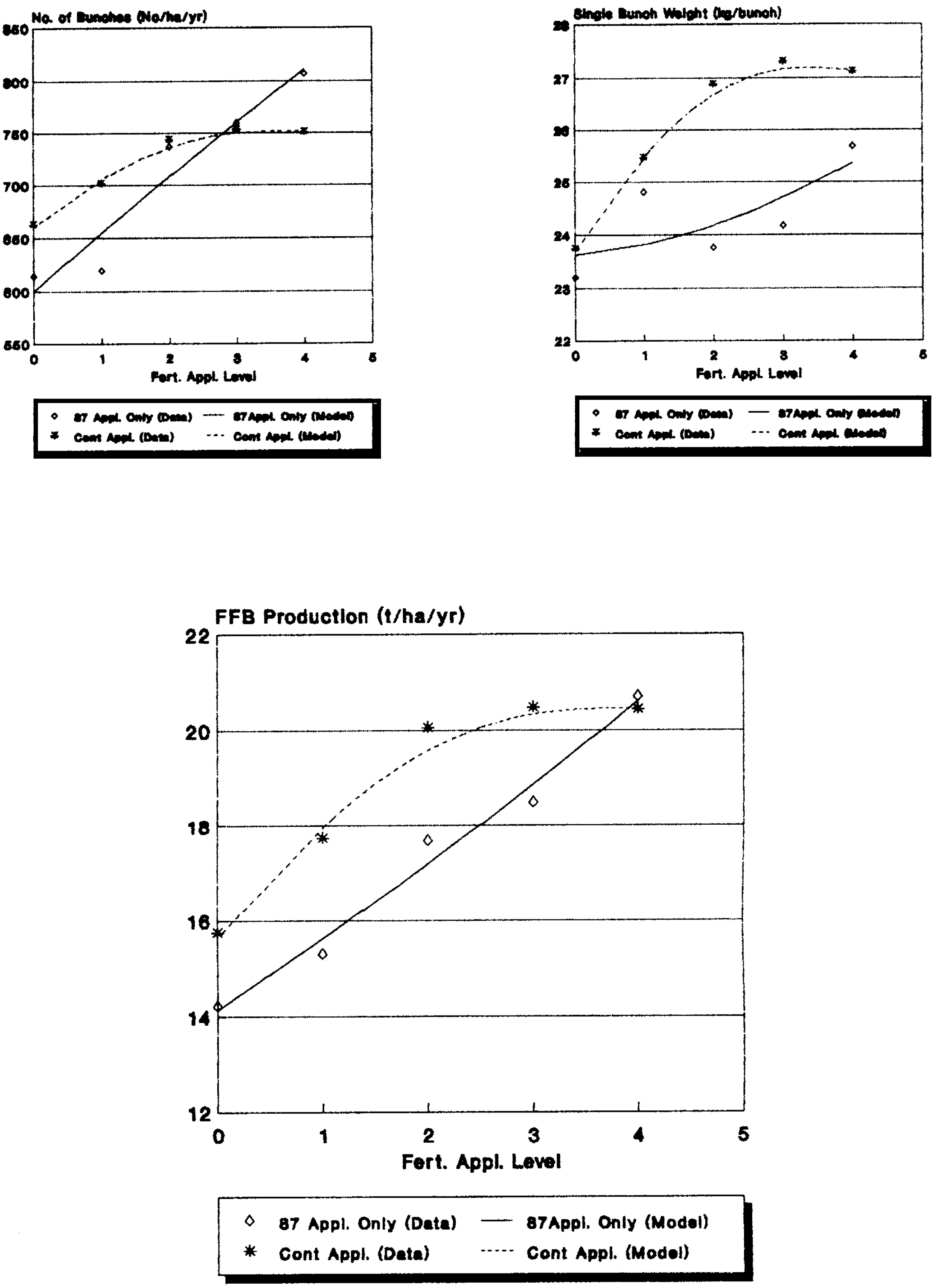


Fig 8. Expt 116 Yield & Yield Components Jan88-Dec89

EXPERIMENT 117 : SYSTEMATIC NITROGEN FERTILIZER TRIAL, KUMBANGO

PURPOSE: To investigate the response of Oil Palm to systematically increasing levels of application of ammonium chloride and urea.

SITE DETAILS:

Location: Fields D8 and D9, Kumbango Plantation, Mosa.

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

Planting date: 1975

Planting density: 120 palm/hectare

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;

Kg palm^{-1} year^{-1}

LEVEL	**0**	**0**	**0**	**1**	**2**	**3**	**4**
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	3.40

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:

Tables 15 and 16 present the FFB yield production and yield component data for 1989 and 1988-1989 respectively.

Table 15. Experiment 117. Yield & Yield Components Jan-Dec89

Ammonium Chloride Application Rate (kg/palm/yr)	FFB Yield (t/ha/yr)		No. of Bunches (No/ha/yr)		S.B.W. (kg/bunch)	
	A.C.	Urea	A.C.	Urea	A.C.	Urea
0	21.15	21.72	864	899	24.59	24.39
1.5	23.17	22.45	906	910	25.57	24.69
3.0	22.94	21.52	875	893	26.49	24.13
4.5	25.84	21.88	967	941	26.83	23.32
6.0	24.52	22.86	923	937	26.63	24.42

Table 16. Experiment 117. Yield & Yield Components Jan88-Dec89

Ammonium Chloride Application Rate (kg/palm/yr)	FFB Yield (t/ha/yr)		No. of Bunches (No/ha/yr)		S.B.W. (kg/bunch)	
	A.C.	Urea	A.C.	Urea	A.C.	Urea
0	18.24	18.53	781	798	23,35	23.32
1.5	19.25	19.73	799	829	24.28	23.74
3.0	19.95	18.62	825	821	24.20	22.60
4.5	22.26	19.43	872	859	25.50	22.60
6.0	20.74	19.05	831	823	24.53	22.98

Because of an apparent decrease in single bunch weight due to urea application, the urea treatment appears poor relative to ammonium chloride application.

It should be pointed out that the urea treatment in this trial is applied in the same way as the ammonium chloride (ring application around the weeded circle). Because this method of application produces a relatively concentrated band of fertilizer the urea applied could possibly undergo significant nitrogen losses due to ammonia volatilization.

Figures 9 and 10 illustrate the FFB yield data and best fit regression models for 1989 and 1988-1989 respectively.

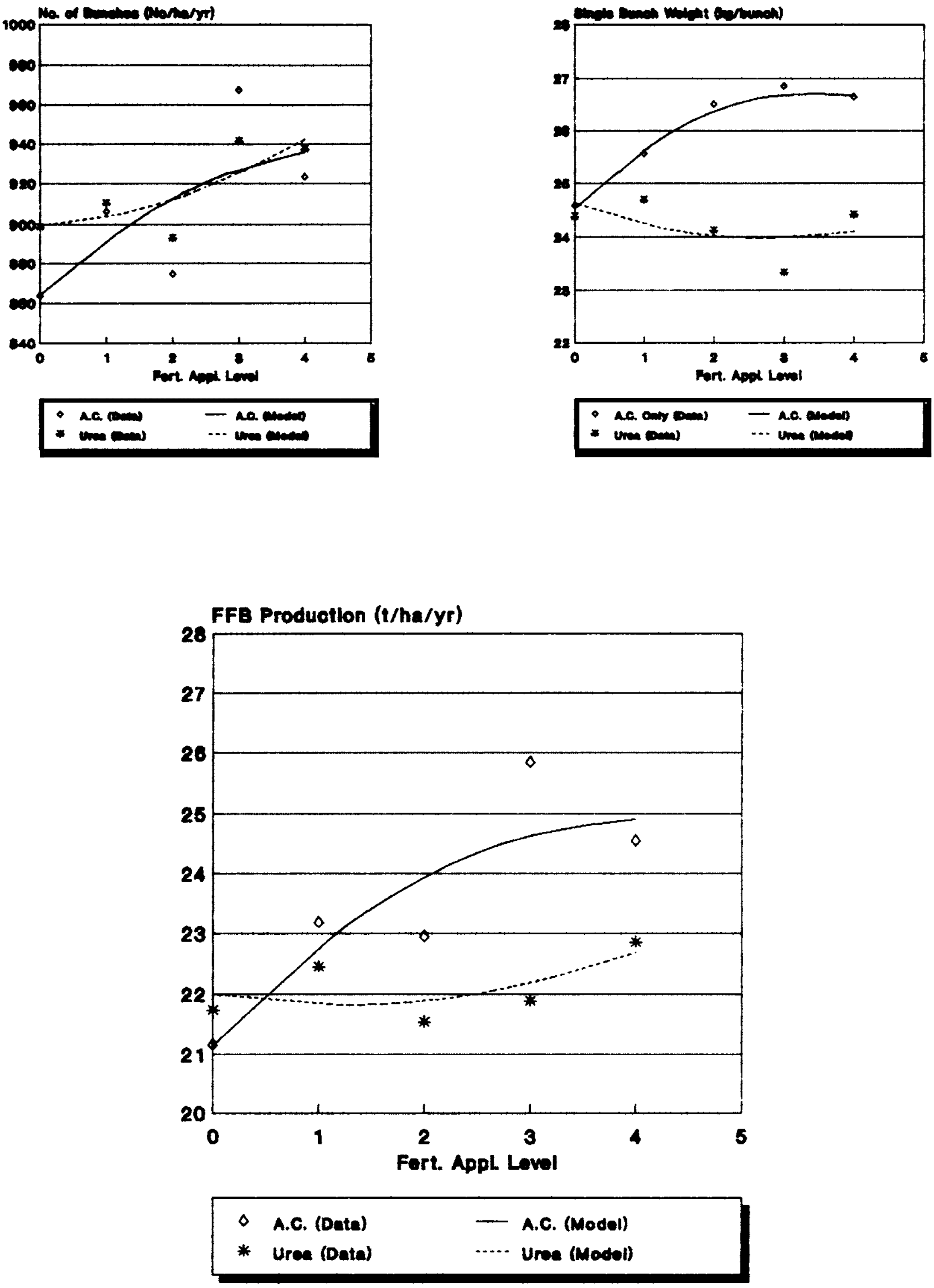


Fig 9. Expt 117 Yield & Yield Components Jan-Dec89

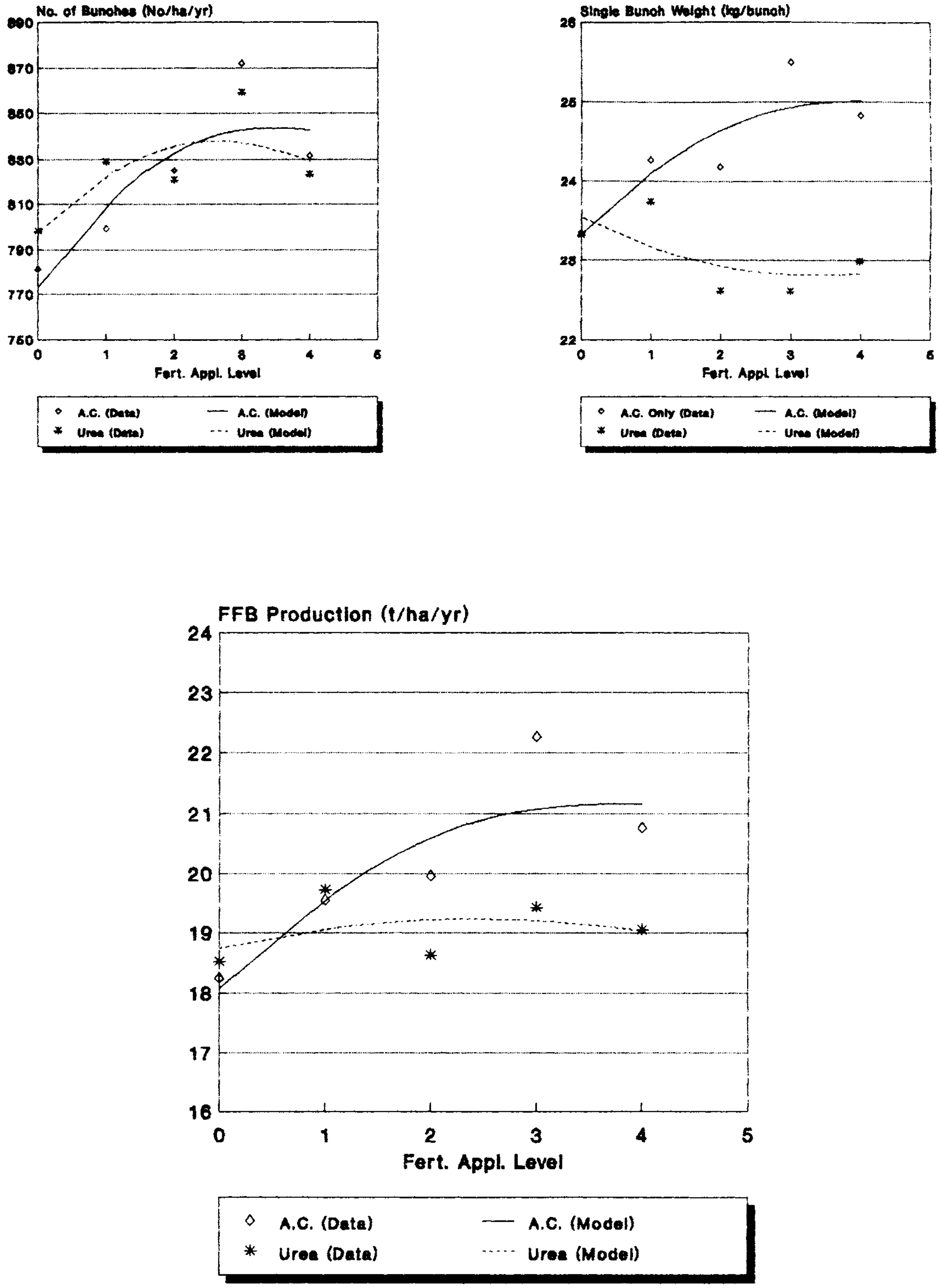


Fig 10. Expt 117 Yield & Yield Components Jan88-Dec89

The results of physiological measurements carried out in December 1989 are presented in Table 17.

Table 17. Experiment 117. Physiological Measurements 1989.

Ammonium Chloride Application Rate (kg/palm/yr)	Leaf Area Index		Fractional Energy Interception		Efficiency of Energy Conversion ($g\ MJ^{-1}$)	
	A.C.	Urea	A.C.	Urea	A.C.	Urea
0	5.943	5.752	0.858	0.848	1.436	1.510
1.5	6.095	5.835	0.865	0.853	1.574	1.538
3.0	6.412	5.570	0.878	0.841	1.590	1.485
4.5	6.392	5.312	0.876	0.825	1.693	1.534
6.0	6.127	6.050	0.866	0.864	1.644	1.563

Ammonium Chloride Application Rate (kg/palm/yr)	Vegetative D.M. Production ($t\ ha^{-1}yr^{-1}$)		Bunch D.M. Production ($t\ ha^{-1}yr^{-1}$)		Bunch Index	
	A.C.	Urea	A.C.	Urea	A.C.	Urea
0	19.90	20.87	17.34	17.81	0.468	0.462
1.5	22.16	21.24	19.00	18.41	0.463	0.464
3.0	23.41	20.08	18.81	17.64	0.451	0.468
4.5	23.52	20.32	21.19	17.94	0.475	0.469
6.0	22.86	22.04	20.11	18.75	0.469	0.460

The urea treatments show little effect on the calculated physiological parameters. The ammonium chloride treatments show increases in leaf area index, fractional energy interception, efficiency of energy conversion, vegetative and bunch dry matter production.

EXPERIMENT 118: SYSTEMATIC NITROGEN FERTILIZER TRIAL, KUMBANGO

PURPOSE:

To investigate the response of Oil Palm to systematically increasing levels of application of ammonium chloride.

SITE DETAILS:

Location: Field B9, Kumbango Plantation, Mosa.

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

Planting date: 1977

Planting density: 120 palms/hectare

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;

Kg palm^{-1} year^{-1}

LEVEL	0	0	0	1	2	3	4
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:

Tables 18 and 19 present the FFB yield and yield component data for 1989 and 1988-1989 respectively.

Table 18. Experiment 118. Yield & Yield Components Jan-Dec89

Ammonium Chloride Application Rate (kg/palm/yr)	FFB Yield (t/ha/yr)	No. of Bunches (No/ha/yr)	Single Bunch Weight (kg/bunch)
0	23.56	1018	23.17
1.5	25.24	1024	24.64
3.0	25.15	1007	24.98
4.5	26.34	1056	24.94
6.0	26.36	1038	25.43

Table 19. Experiment 118. Yield & Yield Components Jan88-Dec89

Ammonium Chloride Application Rate (kg/palm/yr)	FFB Yield (t/ha/yr)	No. of Bunches (No/ha/yr)	Single Bunch Weight (kg/bunch)
0	22.86	1057	21.70
1.5	23.63	1052	22.55
3.0	24.34	1092	22.49
4.5	25.29	1114	22.88
6.0	24.25	1118	21.95

Figures 11 and 12 illustrate the FFB yield response data and best fit regression models for 1989 and 1988-1989 respectively.

Compared to 1988 data, there is a considerable improvement in the response to fertilizer nitrogen application in 1989. There is also an 11% increase in overall FFB yields due to factors other than fertilizer application.

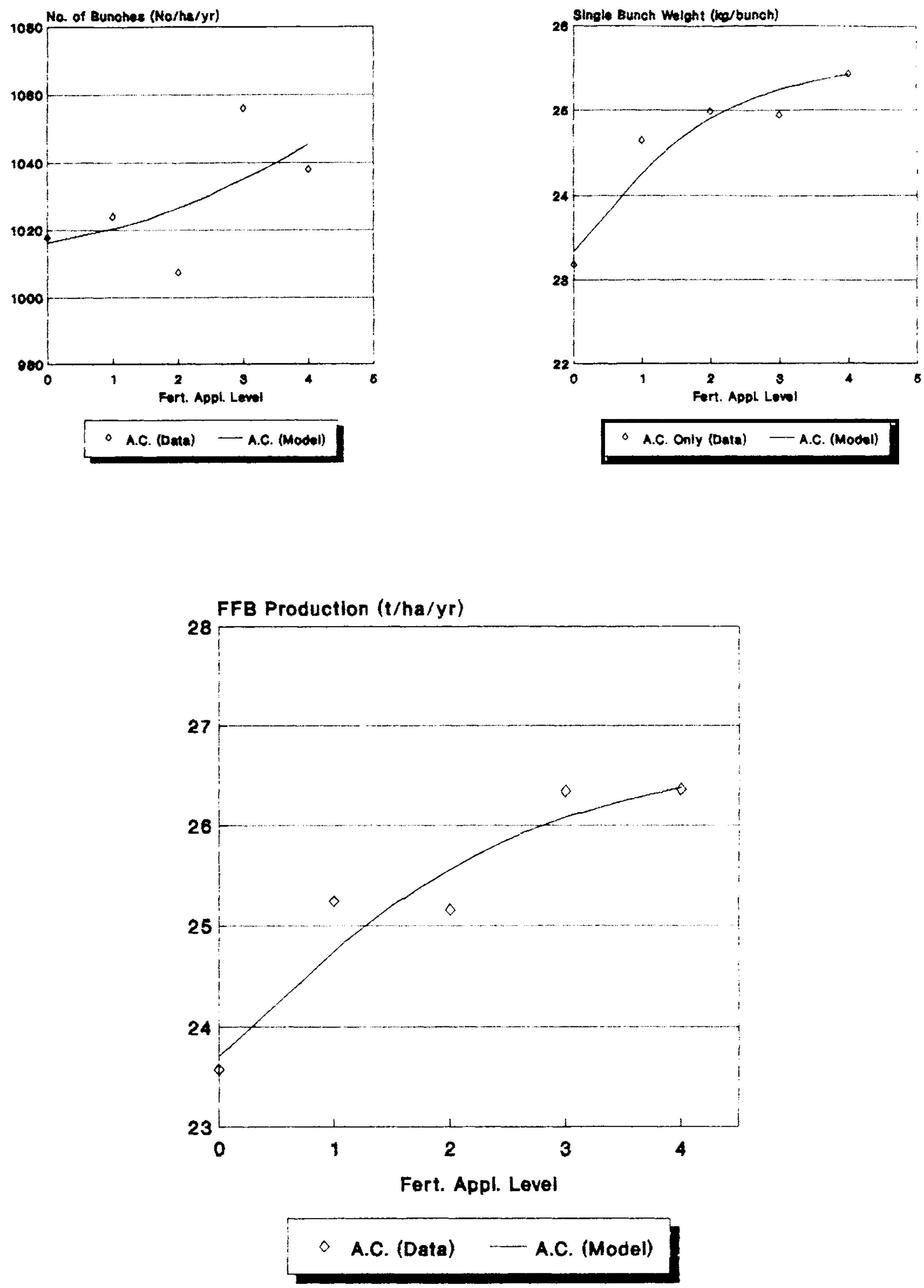


Fig 11. Expt 118 Yield & Yield Components Jan-Dec89

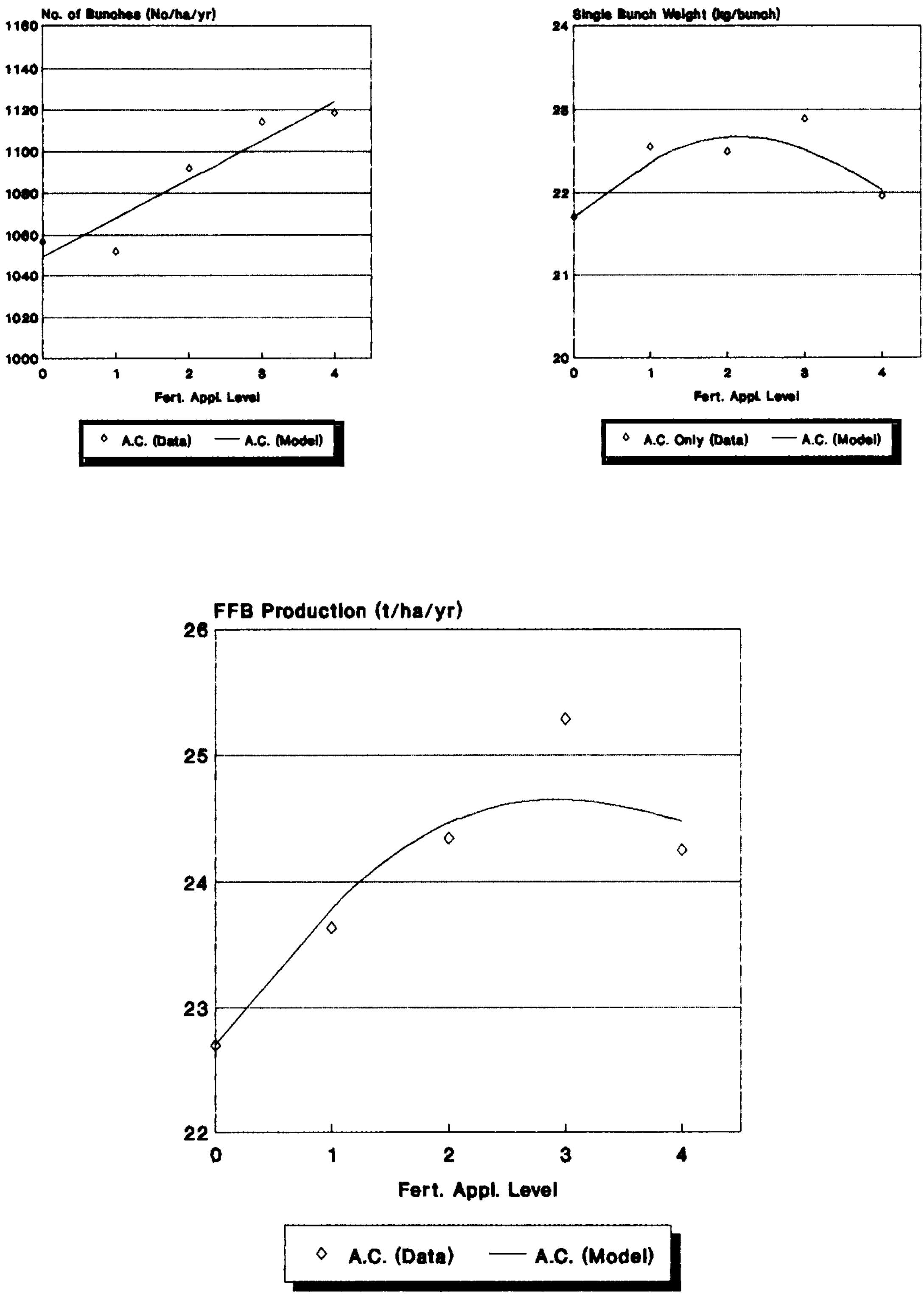


Fig.12. Expt 118 Yield & Yield Components Jan88-Dec89

EXPERIMENT 119: NITROGEN/ANION FERTILIZER TRIAL, MALILIMI

PURPOSE:

To investigate the response of oil palm to application of different types of N fertilizer in the presence and absence of muriate of potash and kieserite, in order to clarify fertilizer requirements in the area including the need for different anions.

SITE DETAILS:

Location: Fields A7 and A8, Malilimi Plantation, Galai.

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

Planting date: October 1985

Planting density: 135 palms/hectare

DESIGN AND TREATMENTS:

Design: 12 treatments replicated in 4 completely randomized blocks. 36 palms per plot, the central 16 being recorded.

Treatments:

	Nil	Muriate of Potash	Kieserite
Nil	---	K+Cl	Mg+S
Diammonium phosphate	N+P	N+P+K+Cl	N+P+Mg+S
Ammonium sulphate	N+S	N+S+K+Cl	N+S+Mg
Ammonium chloride	N+Cl	N+Cl+K	N+Cl+Mg+S

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 $palm^{-1}$ $year^{-1}$

The fertilizers are applied twice a year in two equal doses. The initial treatment application was made in July 1989.

RESULTS:

The results of the frond tissue analysis carried out in November are presented in Table 20.

Other than the treatments containing chlorine, frond 17 leaflet nutrient levels were not significantly ($p<0.05$) affected by the treatments applied.

The treatments containing chlorine significantly ($P<0.001$) increased frond 17 chlorine levels from 0.14% to 0.27% overall.

<u>Table 20. Experiment 119. Frond 17 Leaflet Nutrient Levels December 1989.</u>

Fertilizer Applied		Nutrients Applied	Frond 17 Leaflet Tissue Nutrient Contents (% Dry Matter)					
			Nitrogen	Phosphorus	Potassium	Magnesium	Calcium	Chlorine
Nil	Nil	-	2.652	0.168	0.995	0.190	1.018	**0.148**
	DAP	N+P	2.587	0.167	0.998	0.220	1.045	**0.100**
	AS	N+S	2.618	0.163	1.022	0.193	1.032	**0.120**
	AC	N+Cl	2.640	0.164	0.905	0.200	1.065	**0.233**
MOP	Nil	K+Cl	2.465	0.165	0.933	0.223	1.160	**0.233**
	DAP	N+P+K+Cl	2.603	0.162	0.928	0.195	1.090	**0.283**
	AS	N+S+K+Cl	2.633	0.160	0.940	0.215	1.110	**0.295**
	AC	N+Cl+K	2.625	0.164	0.923	0.210	1.132	**0.340**
Kies	Nil	Mg+S	2.627	0.163	0.962	0.200	1.063	**0.165**
	DAP	N+P+Mg+S	2.670	0.167	0.965	0.195	1.065	**0.150**
	AS	N+S+Mg	2.628	0.165	0.972	0.183	1.038	**0.185**
	AC	N+Cl+Mg+S	2.627	0.161	0.908	0.210	1.078	**0.265**
$LSD_{.05}$			0.178	0.005	0.090	0.031	0.079	0.072
CV%			4.4	2.1	6.6	9.9	4.7	22.2

EXPERIMENT 120: NITROGEN/ANION FERTILIZER TRIAL, DAMI

PURPOSE:

To investigate the response of oil palm to application of different types of N fertilizer in the presence and absence of muriate of potash and kieserite, in order to clarify fertilizer requirements in the area, particularly the need for different anions.

SITE DETAILS:

Location: Field 9, Dami Plantation, Hoskins

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

Planting date: 1983

Planting density: 135 palms/hectare

DESIGN AND TREATMENTS

Design: 12 treatments replicated in 4 completely randomized blocks. 36 palms per plot, the central 16 being recorded.

Treatments:

	Nil	Muriate of Potash	Kieserite
Nil	---	K+Cl	Mg+S
Diammonium phosphate	N+P	N+P+K+Cl	N+P+Mg+S
Ammonium sulphate	N+S	N+S+K+Cl	N+S+Mg
Ammonium chloride	N+Cl	N+Cl+K	N+Cl+Mg+S

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 $palm^{-1}$ $year^{-1}$

The fertilizers are applied twice a year in two equal doses. The initial treatment was applied in June 1989.

RESULTS:

The results of frond tissue analysis carried out in November 1989 are presented in Table 21.

Table 21. Experiment 120. Frond 17 Leaflet Nutrient Levels December 1989.

Fertilizer Applied	Nutrients Applied	Frond 17 Leaflet Tissue Nutrient Contents (% Dry Matter)					
		Nitrogen	Phosphorus	Potassium	Magnesium	Calcium	Chlorine
Nil Nil	-	2.537	0.154	0.943	0.145	0.805	**0.298**
DAP	N+P	2.502	0.154	0.860	0.150	0.845	**0.305**
AS	N+S	2.525	0.152	0.928	0.140	0.810	**0.325**
AC	N+Cl	2.565	0.151	0.865	0.150	0.800	**0.330**
MOP Nil	K+Cl	2.527	0.152	0.830	0.148	0.875	**0.333**
DAP	N+P+K+Cl	2.535	0.153	0.833	0.148	0.865	**0.328**
AS	N+S+K+Cl	2.552	0.150	0.943	0.140	0.785	**0.323**
AC	N+Cl+K	2.538	0.152	0.863	0.158	0.835	**0.353**
Kies Nil	Mg+S	2.550	0.155	0.863	0.148	0.858	**0.300**
DAP	N+P+Mg+S	2.570	0.153	0.900	0.143	0.798	**0.313**
AS	N+S+Mg	2.520	0.151	0.913	0.135	0.768	**0.320**
AC	N+Cl+Mg+S	2.520	0.153	0.890	0.145	0.805	**0.345**
$LSD_{.05}$		0.106	0.005	0.095	0.016	0.088	0.055
CV%		2.7	2.1	6.9	6.9	6.9	10.9

Other than the treatments containing chlorine, frond 17 leaflet nutrient levels were not significantly ($p<0.05$) affected by the treatments applied.

The treatments containing chlorine significantly ($P=0.019$) increased frond 17 chlorine levels from 0.31% to 0.34% overall.

EXPERIMENT 201: FACTORIAL FERTILIZER EXPERIMENT, HARGY

PURPOSE:

To investigate the response of oil palm to applications of different combinations of ammonium sulphate, triple superphosphate, muriate of potash and kieserite, in order to determine the fertilizer requirements of oil palm in this area.

SITE DETAILS:

Location: Blocks 4,6 and 8, Hargy Plantation, Bialla.

Soils: Freely draining andosols formed on intermediate to basic volcanic ash.

Planting date: 1973

Planting density: 115 palms/hectare

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;

Fertilizer	**LEVEL** 0	2	3
	Kg palm^{-1} year^{-1}		
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 are 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}

RESULTS:

Tables 22 and 23 present FFB yield and yield component data for 1989 and 1986-1989 respectively.

Table 22. Expt 201. Yield & Yield Components Jan-Dec89

	FFB Yield (t/ha/yr)	No of Bunches (No/ha/yr)	S.B.W. (kg/bunch)
N0	19.06	845	22.68
N1	18.45	810	22.79
N2	18.95	850	22.34
P0	**17.30**	788	22.10
P1	**19.11**	848	22.60
P2	**20.05**	869	23.12
K0	19.12	849	22.57
K1	18.01	795	22.71
K2	19.34	862	22.54
Mg0	18.66	815	22.94
Mg1	18.59	825	22.58
Mg2	19.22	867	22.29
CV%	17.2	17.9	6.7
LSD.05	1.87	87	0.87

Table 23. Expt 201. Yield & Yield Components Jan86-Dec89

	FFB Yield (t/ha/yr)	No of Bunches (No/ha/yr)	S.B.W. (kg/bunch)
N0	21.43	996	21.66
N1	21.62	999	21.72
N2	22.10	1042	21.34
P0	**20.48**	974	**21.14**
P1	**21.78**	1016	**21.56**
P2	**22.88**	1047	**22.00**
K0	22.13	1043	21.32
K1	21.23	977	21.83
K2	21.79	1017	21.56
Mg0	21.78	998	21.92
Mg1	21.17	988	21.54
Mg2	22.21	1052	21.25
CV%	9.9	10.9	5.2
LSD.05	1.24	64	0.64

Both the 1989 and cumulative data show a significant FFB yield increase due to triple superphosphate application. The 1989 yield data shows a significant ($p=0.02$) yield increase of 15.9% due to application of 1.6 kg TSP $palm^{-1}$ $year^{-1}$, the cumulative 1986-89 data show a significant ($p=0.003$) increase of 11.7%.

The FFB yield increase due to TSP application is due to increases in single bunch weight and numbers of bunches produced.

The lack of response to N fertilizer, despite a very moderate yield level, indicates that either another nutrient (perhaps P) is more limiting, or the applied N fertilizer is not being recovered by the crop (due perhaps to run-off).

EXPERIMENT 204: FACTORIAL FERTILIZER TRIAL, NAVO.

PURPOSE:

To investigate the response of oil palm to different combinations of ammonium chloride, triple superphosphate, muriate of potash and kieserite, in order to determine the fertilizer requirements of oil palm in this area.

SITE DETAILS:

Location: Block 8, Fields 11 and 12, Navo Plantation

Planting date: 1986

Planting density: 115 palms/hectare

DESIGN AND TREATMENTS:

Design: $3^2 x 2^3$ factorial design grouped in 2 block of 36 plots. One "^{x}2" factor is "vacant" and regarded as a replicate for the time being. The 3 factor interaction "$2^x 2^x 2$" is partially confounded with blocks.

Treatments:

Fertilizer Application (kg $palm^{-1}$ $year^{-1}$)

LEVEL	**0**	**1**	**2**
Ammonium chloride	0.0	3.0	6.0
Triple Superphosphate	0.0	2.0	4.0
Muriate of Potash	0.0	3.0	-
Kieserite	0.0	3.0	-

Annual fertilizer applications are carried out as two equal split doses. The first of the split doses and the first fertilizer application to this trial was carried out in July 1989 and the second in November 1989.

Progress in 1989:

The trial area was divided into six areas comprising plots 1-12, 13-24, 25-36, 37-48, 49-60 and 61-72. Representative frond 9 leaflet tissue samples and 0-20cm soil samples were collected from these areas in June and sent for analysis.

Due to severely limited access to Navo Plantation due to unusually bad weather conditions and damage to roads and bridges, no further work was carried out on this trial in 1989.

EXPERIMENT 401: FACTORIAL FERTILIZER TRIAL, KAUTU, KAPIURA

PURPOSE:

To investigate the response of oil palm to factorial combinations of ammonium chloride, triple superphosphate, muriate of potash and kieserite fertilizers

SITE DETAILS:

Location: Blocks 1F and 1G, Kautu Plantation, Kapiura.

Planting date: 1986

Planting density: 135 palms/hectare

DESIGN AND TREATMENTS:

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

Treatments:

Fertilizer Application (kg $palm^{-1}$ $year^{-1}$)

LEVEL	0	1	2
Ammonium chloride	0.0	3.0	6.0
Triple Superphosphate	0.0	2.0	4.0
Muriate of Potash	0.0	3.0	-
Kieserite	0.0	3.0	-

Annual fertilizer applications are carried out as two equal split doses. The first of the split doses and the first fertilizer application to this trial was carried out in July, the second in November.

Progress in 1989:

Standard vegetative measurements were carried out in January 1989 using frond 9.

First frond marking was carried out in June.

The trial area was divided into six areas comprising plots 1-12, 13-24, 25-36, 37-48, 49-60 and 61-72. Representative frond 17 leaflet tissue samples and 0-20cm soil samples were collected from these areas in May 1989 and sent for analysis.

FFB yield recording will begin in 1990.

II. AGRONOMY

ORO AND MILNE BAY PROVINCES

(A.S.Wilkie and A.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: Of volcanic ash origin, consisting of deep sandy clay loam, with good drainage and physical properties.
Planting date: 1978.
Density: 130 palms/hectare.
Size: The trial comprises 72 plots: 2592 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

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.
Trial commencement: September 1981.
Trial progress: Ongoing.

Treatments:

Treatments in Kg/palm/year: Rate:	0	1	2
Ammonium sulphate	0	2.0	4.0
Triple superphosphate	0	2.0	-
Muriate of potash	0	2.0	4.0
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 annum.

RESULTS :

1. Yield

Yield data for 1989, and for the 3 years 1987-1989 is summarised in Table 24.

There has been a continued major response to SOA, and a smaller response to MOP. Responses to TSP or Kieserite alone were absent, although in certain cases they did interact with SOA or MOP applications.

A more detailed indication of fertilizer effects is provided by Tables 25 and 26, which show yields at different levels of SOA and MOP fertilizer. These indicate that SOA alone at 2 kg/palm has raised yields by about 7 t/ha for the minimum fertilizer input. Higher rates of SOA and the addition of MOP provided further benefits of up to 3 tonnes/ha.

The poorer treatments yielded about 22 t/ha in 1989, whilst with high fertilizer inputs yields peaked at over 34 t/ha.

The best single bunch weights were attained with fertilizer rates equal to or exceeding N1K1, with both SOA and MOP raising single bunch weights. Such a combination provided a benefit of approximately 5 kg to single bunch weight in 1989. SOA also increased bunch numbers, whilst they were depressed by MOP.

Table 24: Trial 305, Yield per hectare

TRTMNT	1989 Wt of bunches t/ha	1989 No of bunches /ha	1989 s.b.w. kg	1987/9 Wt of bunches t/ha	1987/9 No of bunches /ha	1987/9 s.b.w. kg
N 0	**22.4**	**1056**	**21.0**	**22.5**	**1128**	**19.9**
N 1	**31.9**	**1349**	**23.7**	**29.8**	**1387**	**21.6**
N 2	**32.7**	**1385**	**23.7**	**31.0**	**1458**	**21.3**
P 0	28.7	1252	22.8	27.3	1335	20.8
P 1	29.3	1275	22.8	26.9	1314	21.1
K 0	**27.9**	**1316**	**21.1**	**25.8**	1358	**19.6**
K 1	**28.5**	**1192**	**23.6**	**27.6**	1284	**21.7**
K 2	**30.6**	**1282**	**23.7**	**27.8**	1332	**21.7**
Mg 0	28.6	1259	22.6	27.5	1341	20.8
Mg 1	29.3	1268	23.0	26.7	1308	21.1
$lsd._{05}$(N&K)	2.18	86	1.1	1.42	68	0.8
$lsd._{05}$(P&Mg	1.78	74	0.9	1.16	55	0.7
c.v.(%)	13	12	8	9	9	7

Table 25: Trial 305 yields in t/ha for different fertilizer combinations, 1989

	K0	K1	K2
N0	22.4	21.3	23.5
N1	29.9	32.0	33.7
N2	31.3	32.1	34.6
$lsd_{.05}$		3.8	

Table 26: Trial 305 yields in t/ha for different fertilizer combinations, 1987-89

	K0	K1	K2
N0	21.4	22.5	23.5
N1	28.7	29.4	31.3
N2	29.6	31.6	31.8
$lsd_{.05}$		2.5	

2. Growth

Introduction of new recording techniques during 1988 has enabled basic data on the various aspects contributing to palm production to be elucidated. This is presented in Table 27.

Table 27: Trial 305, Palm Growth and Conversion Data for 1987-89 (annual basis)

TRTMNT	Annual vert inc cm	Ann.Frond production (n)	Dry Frond weight kg (FW)	Frond DM t/ha (FDM)	*Bunch DM t/ha (BDM)	Vegetative DM t/ha (VDM)	*Total DM t/ha (TDM)	*Bunch Index (BI)	Leaf Area Index (LAI)	*Efficiency energy convert (e) g/MJ
N 0	**68**	**20.6**	**3.74**	**9.8**	**18.4**	**12.9**	**31.4**	0.586	**5.34**	1.16
N 1	**74**	**22.5**	**4.27**	**12.2**	**24.5**	**16.3**	**40.8**	0.600	**5.80**	1.45
N 2	**76**	**23.2**	**4.36**	**12.9**	**25.5**	**17.1**	**42.6**	0.598	**5.92**	1.48
P 0	73	22.2	4.16	11.8	22.8	15.6	38.4	0.593	5.83	1.34
P 1	73	22.1	4.09	11.5	22.8	15.3	38.1	0.596	5.54	1.39
K 0	**71**	22.1	**3.90**	**11.0**	**21.8**	**14.7**	**36.5**	0.597	5.59	**1.28**
K 1	**73**	22.2	**4.21**	**11.9**	**22.9**	**15.8**	**38.6**	0.590	5.61	**1.43**
K 2	**74**	22.0	**4.27**	**12.0**	**23.7**	**15.9**	**39.6**	0.597	5.86	**1.38**
Mg 0	73	22.2	4.07	11.5	22.9	15.3	38.3	0.598	5.54	1.40
Mg 1	73	22.1	4.18	11.8	22.6	15.6	38.2	0.591	5.84	1.33
lsd (N&K)	1.8	0.47	0.15	0.63	1.16	0.72	1.52	0.01	0.47	0.09
lsd (P&Mg)	1.5	0.39	0.12	0.51	0.95	0.59	1.24	0.01	0.39	0.08
c.v.(%)	4	4	6	9	9	8	7	3	14	12

(*Dry matter calculated as carbohydrate equivalent, assuming oil energy = 2.1 x carbohydrate energy)

The vertical increment was increased by approximately 10% by applications of SOA, and also marginally by applications of MOP. Leaf production was similarly increased by SOA.

Frond dry weight, frond dry matter, total dry matter, vegetative dry matter, bunch dry matter, and the efficiency of conversion were all significantly increased by application of SOA, and to a lesser extent also by application of MOP. SOA raised the LAI, both through leaf number and leaf weight. These changes also resulted in a major improvement in efficiency of energy conversion due to SOA applications.

The bunch index at approximately 0.6 was unaffected by any treatments.

3. Nutrient analysis

The latest plant analysis results are presented in Tables 28 and 29.

Table 28: Trial 305, Frond 17 Rachis *Analysis: 1988

		%N	%P	%K	%Mg	%Ca	%Cl	%S
	N0	.23	**.113**	1.54	.083	.468	**.72**	.038
	N1	.25	**.079**	1.45	.076	.485	**.58**	.039
	N2	.26	**.088**	1.51	.074	.480	**.59**	.038
LSD		(.04)	(.024)	(0.15)	(.010)	(.086)	(.12)	(.004)
	P0	.24	**.078**	1.50	**.072**	.468	**.58**	**.041**
	P1	.25	**.109**	1.51	**.083**	.488	**.68**	**.036**
LSD		(.03)	(.020)	(0.12)	(.008)	(.071)	(.08)	(.003)
	K0	.25	**.061**	**1.10**	**.068**	**.398**	**.12**	.041
	K1	.25	**.106**	**1.61**	**.078**	**.496**	**.74**	.038
	K2	.24	**.113**	**1.80**	**.086**	**.540**	**1.03**	.037
LSD		(.04)	(.024)	(0.15)	(.010)	(.086)	(.12)	(.004)
	Mg0	.25	.093	1.51	.074	.483	**.58**	**.042**
	Mg1	.24	.094	1.50	.081	.473	**.68**	**.034**
LSD		(.03)	(.020)	(0.12)	(.008)	(.071)	(.08)	(.003)

(*ASL Laboratory)

Whilst for most nutrients the rachis results conform closely with leaf results, albeit at lower levels, for potassium the results are completely opposed. MOP application lowered K levels in the leaf by about 10%, but rachis levels were substantially raised from an initial rachis level at K0 which was already higher than the leaf level.

Table 29: Trial 305, Leaf Analysis related to fertilizer treatments: 1987

	N0	N1	N2	P0	P1	K0	K1	K2	Mg0	Mg1	LSD.05 N&K	LSD.05 P&MG	C.V.(%)
N%	**2.33**	**2.51**	**2.58**	2.48	2.47	2.46	2.47	2.50	2.48	2.47	.09	.07	6.1
	100	**108**	**111**	100	100	100	100	102	100	100			
P%	**.149**	**.155**	**.154**	.153	.153	.153	.153	.152	**.154**	**.151**	.003	.0025	3.4
	100	**104**	**104**	100	100	100	101	100	**100**	**98**			
K%	.855	.875	.888	.869	.877	**.935**	**.860**	**.824**	.877	.869	.044	.036	8.7
	100	102	104	100	101	**100**	**92**	**88**	100	99			
Cl%	.419	.403	.368	.410	.383	**.203**	**.459**	**.528**	.394	.400	.072	.059	31.5
	100	96	88	100	93	**100**	**226**	**260**	100	102			
S%	**.152**	**.163**	**.163**	.160	.159	.159	.160	.160	.160	.159	.004	.003	4.6
	100	**107**	**107**	100	99	100	100	101	100	99			
Ca%	**.922**	**.859**	**.846**	**.889**	**.863**	**.830**	**.888**	**.910**	.883	.868	.034	.028	6.7
	100	**93**	**92**	**100**	**97**	**100**	**107**	**110**	100	98			
Mg%	**.218**	**.202**	**.195**	.206	.204	.209	.204	.202	.203	.207	.012	.009	9.6
	100	**93**	**90**	100	99	100	98	97	100	102			
Mn ppm	**110**	**132**	**156**	133	133	**121**	**135**	**142**	136	130	17.5	14.2	22.8
	100	**120**	**141**	100	100	**100**	**112**	**118**	100	95			
Zn ppm	**18.8**	**15.8**	**15.0**	16.7	16.4	16.8	16.3	16.6	16.5	16.6	1.41	1.15	14.7
	100	**84**	**80**	100	98	100	97	99	100	100			

(For each nutrient, the second line indicates percentage of control)

The rachis levels indicate that the low leaflet K levels do not indicate a problem in root uptake, but rather that accumulation in the leaflets has been inhibited by MOP applications.

Rachis chloride levels are also affected by MOP to a greater extent than leaf levels, varying from about 33% of the leaf level at K0, up to about 150% of the leaf level at K2. Calcium levels are increased in both rachis and leaflets by MOP. The chloride and cation uptake would therefore appear to be associated with the variation in K levels between the rachis and the leaf, possibly due to increased levels of calcium in the leaflet, due to its inability to be removed.

Responses to P also differ between the rachis and the leaflets. TSP application increased rachis P levels but did not affect leaf levels. SOA application reduced rachis P levels, but increased the leaf P levels.

This data would suggest that application of MOP is not currently necessary for K nutrition, and that at least part of its benefit may be due to the chloride supplied.

4. Soil Analysis

Table 30: Trial 305, Soil Analysis (0 - 30 cm) related to fertilizer treatments: 1986

	N0	N1	N2	P0	P1	K0	K1	K2	Mg0	Mg1	LSD.05 N&K	LSD.05 P&Mg	cv
pH	**6.79**	**6.65**	**6.63**	6.71	6.69	6.71	6.66	6.70	6.70	6.68	0.1	0.08	3
%	100	98	98	100	100	100	99	100	100	100			
P µg/ml	5.1	5.8	5.4	5.4	5.5	5.5	5.1	5.8	5.1	5.8	1.6	1.3	49
%	100	114	106	100	102	100	93	105	100	114			
K me/100g	0.12	0.15	0.13	0.13	0.13	0.11	0.11	0.17	0.12	0.14	0.07	0.05	84
%	100	125	108	100	100	100	100	155	100	117			
Ca me/100g	8.7	8.3	8.4	8.5	8.4	8.7	8.2	8.5	8.4	8.5	0.87	0.71	18
%	100	95	97	100	99	100	94	98	100	101			
Mg me/100g	1.31	1.29	1.23	1.28	1.28	1.28	1.26	1.3	1.29	1.27	0.1	0.08	13
%	100	98	94	100	100	100	98	102	100	98			
Na me/100g	0.027	0.021	0.023	0.023	0.025	0.025	0.023	0.023	0.023	0.025	0.01	0.01	85
%	100	78	85	100	109	100	92	92	100	109			
CEC me/100g	11.9	11.7	11.8	11.8	11.8	12	11.5	11.9	11.7	11.9	0.73	0.6	11
%	100	98	99	100	100	100	96	99	100	102			
K satn %	0.92	0.97	1.07	**1.07**	**0.91**	0.91	0.98	1.07	1.03	0.94	0.21	0.17	37
%	100	105	116	100	85	100	108	118	100	91			
Ca satn %	73	71	72	72	71	72	72	71	72	72	3.6	3	9
%	100	97	99	100	99	100	100	99	100	100			
Mg satn %	11.2	11	10.5	11	10.8	10.7	11.1	10.9	11	10.7	0.92	0.75	15
%	100	98	94	100	98	100	104	102	100	97			
Na satn %	0.22	0.18	0.19	0.19	0.21	0.21	0.2	0.19	0.19	0.21	0.07	0.06	65
%	100	82	86	100	111	100	95	90	100	111			
OM %	2.27	2.28	2.36	2.24	2.36	2.3	2.28	2.32	2.26	2.34	0.24	0.2	18
%	100	100	104	100	105	100	99	101	100	104			
Avl N kg/ha	76	75	78	77	75	79	76	73	73	79	12.5	10.2	28
%	100	99	103	100	97	100	96	92	100	108			
P retn %	23.5	22.8	22.3	22.8	22.9	22.6	22.1	23.8	23	22.8	1.5	1.2	11
%	100	97	95	100	100	100	98	105	100	99			
Ex Al ppm	1.7	2.3	1.9	1.9	2.1	1.9	2	2	1.9	2	0.7	0.5	58
%	100	135	112	100	111	100	105	105	100	105			
Total N %	0.11	0.12	0.12	0.11	0.12	0.12	0.12	0.11	0.12	0.12	0.02	0.01	26
%	100	109	109	100	109	100	100	92	100	100			

Table 31: Trial 305, Soil Analysis (30 - 60 cm) related to fertilizer treatments: 1986

	N0	N1	N2	P0	P1	K0	K1	K2	Mg0	Mg1	LSD.05 N&K	LSD.05 P&Mg	cv
pH	6.53	6.74	6.74	6.62	6.72	6.79	6.45	6.77	6.58	6.76	0.45	0.378	12
%	100	103	103	100	102	100	95	100	100	103			
P µg/ml	4.1	5	4.7	4.6	4.5	4.7	4.3	4.8	4.4	4.8	0.92	0.758	35
%	100	122	115	100	98	100	91	102	100	109			
K me/100g	0.16	0.13	0.14	**0.16**	**0.13**	**0.15**	**0.12**	**0.16**	0.14	0.15	0.03	0.04	42
%	100	81	88	100	81	100	80	107	100	107			
Ca me/100g	7.8	7.9	7.9	7.9	7.8	7.8	7.7	8.1	7.7	8	0.74	0.6	16
%	100	101	101	100	99	100	99	104	100	104			
Mg me/100g	1.54	1.57	1.43	1.52	1.51	1.46	1.48	1.61	**1.6**	**1.43**	0.18	0.15	20
%	100	102	93	100	99	100	101	110	100	89			
Na me/100g	0.038	0.038	0.036	0.036	0.039	0.035	0.035	0.042	0.038	0.037	0.01	0.01	54
%	100	100	95	100	108	100	100	120	100	97			
CEC me/100g	11.8	11.5	11.3	11.4	11.7	11.5	11.3	11.8	11.6	11.5	0.48	0.58	9
%	100	97	96	100	103	100	98	103	100	99			
K satn %	1.32	1.12	1.27	**1.37**	**1.11**	1.26	1.06	1.39	1.22	1.26	0.29	0.24	40
%	100	85	96	100	81	100	84	110	100	103			
Ca satn %	70	68	69	69	69	70	69	69	68	70	2.9	2.4	7
%	100	97	99	100	100	100	99	99	100	103			
Mg satn %	13.2	13.5	12.6	13.3	12.9	12.6	13.1	13.6	**13.8**	**12.4**	1.35	1.1	18
%	100	102	95	100	97	100	104	108	100	90			
Na satn %	0.33	0.33	0.33	0.32	0.33	0.31	0.32	0.35	0.34	0.32	0.1	0.08	52
%	100	100	100	100	103	100	103	113	100	94			
OM %	1.51	1.57	1.58	1.48	1.62	1.58	1.6	1.48	1.56	1.55	0.23	0.18	25
%	100	104	105	100	109	100	101	94	100	99			
Avl N kg/ha	43	41	45	38	47	43	44	40	43	43	10	12	50
%	100	95	105	100	124	100	102	93	100	100			
P retn %	30.7	30.7	28.9	30.2	30	**30**	**28.6**	**31.8**	30.9	29.3	1.94	2.38	14
%	100	100	94	100	99	100	95	106	100	95			
* Ex Al ppm	4.3	4.7	5	4.3	5	4.6	4.9	4.5	5	4.3	1	0.8	37
%	100	109	116	100	116	100	107	98	100	86			
Total N %	0.081	0.093	0.089	0.085	0.091	0.087	0.09	0.085	0.09	0.086	0.01	0.02	34
%	100	115	110	100	107	100	103	98	100	96			

The latest existing soil data have been analysed for inclusion with this report, and are included in Tables 30 and 31. Relatively few fertilizer effects were identified, apart from a minor reduction in pH, due to SOA application.

SUMMARY :

Changes in yield and nutrient status in selected plots over the period of the trial are shown in Table 32.

Table 32: Trial 305, Progressive changes in yield and nutrient status

N0K0

	82	83	84	85	86	87	88	89	AVG
Yield	28.3	28.27	30.44	30.22	23.34	19.96	17.60	22.80	25.12
N%	2.8		2.45	2.6	2.4	2.2	2.0	1.91	2.34
K%	1.2		0.97	1.02	0.95	0.91	0.98	0.63	0.95
P%	0.18		0.17	0.17	0.16	0.15	0.14	0.131	0.16
Cl%	0.21			0.19	0.16	0.13	0.12	0.11	0.15

N1K0

	82	83	84	85	86	87	88	89	AVG
Yield	28.99	33.22	34.02	34.68	29.7	32.22	25.26	31.2	31.16
N%	2.9		2.55	2.65	2.5	2.65		2.27	2.59
K%	1.05		0.94	0.94	0.89	0.96		0.76	0.92
P%	0.16		0.15	0.17	0.16	0.16		0.146	0.16
Cl%	0.17			0.14	0.11	0.07		0.09	0.12

N0K1

	82	83	84	85	86	87	88	89	AVG
Yield	26.95	32.24	36.91	34.68	28.36	25.81	21.85	21.3	28.51
N%	2.95		2.6	2.6	2.45	2.2		2.07	2.48
K%	1.05		0.86	0.93	0.9	0.85		0.68	0.88
P%	0.16		0.16	0.18	0.16	0.15		0.141	0.16
Cl%	0.27			0.46	0.48	0.44		0.36	0.4

N1K1

	82	83	84	85	86	87	88	89	AVG
Yield	28.25	31.94	36.51	38.02	33.7	32.61	29.08	32.2	32.79
N%	2.7		2.65	2.7	2.55	2.55		2.24	2.57
K%	1		0.86	0.94	0.86	0.81		0.7	0.86
P%	0.16		0.16	0.17	0.16	0.15		0.143	0.16
Cl%	0.37			0.5	0.47	0.45		0.34	0.43

N2K2

	82	83	84	85	86	87	88	89	AVG
Yield	26.91	34.58	33.81	36.01	33.9	34.06	27	34.2	32.56
N%	2.65		2.6	2.7	2.5	2.5		2.21	2.53
K%	0.95		0.85	0.94	0.89	0.84		0.72	0.87
P%	0.16		0.155	0.16	0.155	0.15		0.142	0.15
Cl%	0.38			0.52	0.53	0.52		0.4	0.47

General yield levels rose during 1989, and plots receiving SOA averaged 32.3 t/ha. Plots without SOA averaged 22.4 t/ha.

The major response to SOA has continued, with a smaller response to MOP. Responses to TSP or Kieserite alone were absent, although in certain cases they did interact with SOA or MOP applications.

For the period 1987-89, 2 kg/palm per annum of SOA provided yields of over 28 t/ha for the minimum fertilizer input, whilst maximum yields of over 30 t/ha were attained on plots also receiving MOP.

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: Recent alluvial origin, having silty loam topsoil and sandy loam subsoil, with mottling due to seasonally high water tables.
Planting date: 1979.
Density: 143 palms per hectare.
Size: The trial comprises 81 plots: 2916 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

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.
Trial commencement: 1982 (first fertilizer application April 1983).
Trial progress: Ongoing.
Treatments:

Treatments in Kg/palm/year: Rates:	0	1	2
Ammonium sulphate	0	1.5	3.0
Triple superphosphate	0	0.5	1.0
Muriate of potash	0	2.5	5.0
Kieserite	0	0.75	1.5

RESULTS :

1. Yield

Tables 33 and 34 indicate the latest yield figures, and Table 41 the progressive changes in yield on selected plots.

The response to SOA has continued to increase with yields without SOA declining. A smaller response to MOP has also continued. There have also been interactions between TSP and MOP and SOA, whereby a positive response to TSP is lost in the presence of MOP or SOA.

Generally there has been negligible overall response to TSP or kieserite.

Table 33: Trial 306, Yield per hectare

TRTMNT	1989 Wt of bunches t/ha	1989 No of bunches /ha	1989 s.b.w. kg	1987/9 Wt of bunches t/ha	1987/9 No of bunches /ha	1987/9 s.b.w. kg
N 0	**20.0**	**981**	**20.5**	**21.3**	**1322**	**16.2**
N 1	**23.8**	**1060**	**22.6**	**24.5**	**1437**	**17.2**
N 2	**25.5**	**1144**	**22.3**	**25.7**	**1489**	**17.3**
P 0	23.9	1103	21.7	23.9	1423	16.8
P 1	22.3	1028	21.7	23.5	1411	16.7
P 2	23.1	1055	22.0	24.1	1414	17.2
K 0	21.9	1089	**20.1**	**22.2**	**1426**	**15.6**
K 1	23.6	1041	**22.7**	**24.8**	**1410**	**17.7**
K 2	23.8	1056	**22.6**	**24.4**	**1412**	**17.3**
Mg 0	21.9	1020	21.5	23.2	1410	16.5
Mg 1	24.0	1121	21.5	24.6	1444	17.2
Mg 2	23.4	1044	22.4	23.7	1394	17.0
$lsd_{.05}$	2.08	89	0.95	1.23	74	0.75
c.v.(%)	17	15	8	10	10	8

For the period 1987-89 yields in Trial 306 have been lower than in Trial 305, but there has been a rise in bunch weights of nearly 30% in Trial 306 in 1989, with SOA having an increasing effect on bunch weight as well as bunch number.

Table 34 indicates that maximum yields were attained with fertilizer rates of 3kg of SOA and 2.5 kg of MOP per palm.

The response to MOP may either be due to the K component or the Cl component (or both). Indications of the nature of the response are of major importance as a guide to the economic fertilizer practice.

Table 34: Fertilizer interaction tables: annual means

NxK	Yield t/ha		1989
	K0	K1	K2
N0	19.2	20.3	20.4
N1	23.6	23.6	24.3
N2	22.8	26.9	26.8

KxP	Yield t/ha		1989
	K0	K1	K2
P0	21.9	24.8	24.8
P1	20.7	23.3	22.9
P2	22.9	22.7	23.8

NxK	Yield t/ha		87/89
	K0	K1	K2
N0	20.1	22.3	21.5
N1	23.7	24.7	25.1
N2	22.9	27.4	26.7

KxP	Yield t/ha		87/89
	K0	K1	K2
P0	21.0	25.4	25.3
P1	21.9	25.1	23.6
P2	23.9	24.0	24.5

Note:1) LSD at P=.05 is 3.6 for all two way tables
2) N,P & K are coded for the fertilizer rates given at the start of this section.

2. Growth

Table 35 indicates the components of production for 306 for the period 1987 to 1989.

VDM production has been similar for the period in both 305 and 306, but higher bunch indices in 305 have resulted in a higher TDM production and bunch yields, whilst the higher density in 306 has resulted in higher leaf area indices.

The annual vertical increment in 306 at around 80 cm is slightly higher than the 75 cm for 305. Again, the VI was increased by approximately 10% by SOA applications, and to a lesser extent by MOP. Leaf number, bunch number and frond dry weight were also increased by SOA, whilst MOP increased the frond weight, but not frond production or bunch number.

Frond dry matter, vegetative dry matter, total dry matter, bunch dry matter and the efficiency of energy conversion were all significantly increased by the application of SOA, and to a lesser extent also by application of MOP. SOA also raised the LAI through increased leaf numbers and increased frond area.

MOP did not affect the LAI, but achieved a significant improvement in the bunch index, with its major effect being an increase in bunch production rather than vegetative production, improving the partition of assimilates to BDM. However, even after improvement, the bunch index for this period was inferior to that achieved at 305, explaining the poorer yields in spite of similar overall TDM production.

Table 35: Trial 306, Palm growth and conversion data for 1987 to 1989 (annual basis)

TRTMNT	86-89 Ann. Vert Inc. cm	Frond prdn (n)	Dry Frond weight kg (FW)	Frond DM tha (FDM)	Bunch DM tha (BDM)	Vegetative DM tha (VDM)	Total DM tha (TDM)	Bunch Index (BI)	1989 LAI	1989 Fract engy int (f)	1989 Efficiency of conversion (e) g/Mj
N0	**73**	**21.9**	**3.67**	**11.5**	**17.5**	**14.7**	**32.2**	0.542	**6.58**	**0.937**	**1.10**
N1	**78**	**23.2**	**3.96**	**13.1**	**20.1**	**16.8**	**36.9**	0.544	**7.03**	**0.946**	**1.25**
N2	**83**	**23.4**	**4.08**	**13.6**	**21.1**	**17.5**	**38.5**	0.545	**7.19**	**0.952**	**1.29**
P0	78	22.9	3.92	12.9	19.6	16.5	36.1	0.541	6.88	0.944	1.22
P1	78	22.8	3.87	12.7	19.3	16.2	35.5	0.542	7.06	0.949	1.19
P2	78	22.7	3.91	12.7	19.8	16.3	36.1	0.548	6.87	0.942	1.22
K0	75	23.0	3.77	12.4	18.2	15.8	34.0	0.535	6.71	0.941	1.16
K1	79	22.7	3.91	12.7	20.3	16.4	36.7	0.554	7.06	0.949	1.24
K2	79	22.9	4.02	13.2	20.0	16.9	36.9	0.542	6.94	0.945	1.25
Mg 0	76	22.7	3.83	12.5	19.0	16.0	35.0	0.543	6.71	0.938	1.19
Mg 1	80	22.9	3.93	12.9	20.2	16.5	36.7	0.549	7.11	0.950	1.24
Mg 2	78	22.9	3.94	12.9	19.4	16.5	35.9	0.539	6.98	0.947	1.21
lsd	2.96	0.3	0.16	0.56	1.01	0.68	1.51	0.011	0.39	0.01	0.052
c.v.(%)	7	2	7	8	10	8	8	4	10	2	8

3. Nutrient analysis

The most recent plant analyses are given in Tables 36 and 37.

Table 36: Rachis *analysis related to fertilizer treatments: 1988

	N0	N1	N2	P0	P1	P2	K0	K1	K2	Mg0	Mg1	Mg2	LSD.05
N%	0.231	0.249	0.263	0.243	0.251	0.249	0.245	0.248	0.25	0.246	0.246	0.25	0.01
P%	0.182	0.133	0.094	0.132	0.135	0.142	0.103	0.151	0.155	0.129	0.139	0.140	0.016
K%	1.54	1.54	1.54	1.57	1.53	1.51	1.16	1.67	1.78	1.48	1.57	1.57	0.13
Cl%	0.61	0.59	0.67	0.61	0.62	0.61	0.08	0.70	1.05	0.56	0.67	0.60	0.14
S%	0.032	0.033	0.034	0.036	0.033	0.031	0.034	0.034	0.032	0.033	0.034	0.033	0.005
Ca%	0.390	0.396	0.391	0.389	0.407	0.380	0.335	0.418	0.424	0.379	0.400	0.398	0.041
Mg%	0.107	0.100	0.097	0.100	0.107	0.101	0.090	0.107	0.106	0.096	0.099	0.110	0.011
Mn ppm	3	10	18	10	11	13	11	14	17	12	9	13	
Zn ppm	5	5	4	4	5	6	6	6	7	5	5	10	
Na%	0.01	0.01	0.01	0.01	0.01	0.03	0.01	0.01	0.01	0.01	0.01	0.01	
Fe ppm	38	44	66	38	36	51	57	60	58	36	31	45	
B ppm	6	4	5	5	5	7	7	6	8	5	5	7	

(ASL Laboratory)

Table 37: Leaf analysis related to fertilizer treatments: 1989

	N0	N1	N2	P0	P1	P2	K0	K1	K2	Mg0	Mg1	Mg2	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		
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		
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		
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		

Levels of all nutrients in the leaves are declining with age, and N levels are low. Application of SOA has however resulted in a growing leaf response in increased levels of N, P and K, and concomitantly depressed levels of Ca and Mg. Since rachis levels of K are unaffected by SOA and P is actually reduced, the increased leaf levels probably arise as a result of reduction in leaf Ca and Mg, rather than increased uptake by the palm.

Application of MOP resulted in a reduction of K and Mg levels in the leaf, presumably due to the increased level of Ca. In the rachis MOP raised Ca, K, P and Mg. In both the rachis and the leaf Cl was raised by MOP, with the most dramatic increase of 1300% occuring in the rachis.

Rachis K levels even at K0 (1.16%) are well above leaf levels, indicating that potassium nutrition in the trial should be adequate. If this is the case then response to MOP must be largely due to the Cl component rather than K. With an application of 2.5 kg per palm of MOP the leaf level of Cl was approximately 0.4% and the rachis level 0.7%. These levels would be regarded as adequate.

TSP and kieserite had relatively little effect upon plant nutrient levels, except that kieserite increased rachis Mg levels by 10% and TSP depressed rachis S levels by 15%.

4. Soil

The most recent soil data available have been analysed and are summarised in Tables 38 and 39.

Table 38: Soil analysis (0-30 cm) related to fertilizer treatments: 1986

	N0	N1	N2	P0	P1	P2	K0	K1	K2	Mg0	Mg1	Mg2	0.05 lsd	cv
pH	6.68	6.64	6.62	6.65	6.63	6.66	6.65	6.62	6.67	6.66	6.64	6.64	0.08	2
%	100	99	99	100	100	100	100	100	100	100	100	100		
P µg/ml	9.4	11	10.4	9.4	11	10.4	9.4	10.9	10.5	9.9	10	10.9	1.82	33
%	100	117	111	100	117	111	100	116	112	100	101	110		
K me/100g	0.102	0.098	0.089	0.013	0.09	0.096	0.085	0.097	0.107	0.099	0.091	0.099	0.01	26
%	100	96	87	100	692	738	100	114	126	100	92	100		
Ca me/100g	8.6	9.4	8.6	9.1	8.8	8.8	9.1	8.2	9.3	9	8.4	9.2	1.6	33
%	100	109	100	100	97	97	100	90	102	100	93	102		
Mg me/100g	3.96	4.3	3.73	4.26	3.8	3.95	4.31	3.63	4.05	4.18	3.42	4.39	0.83	38
%	100	109	94	100	89	93	100	84	94	100	82	105		
Na me/100g	0.037	0.045	0.038	0.036	0.038	0.046	0.044	0.038	0.038	0.041	0.036	0.043	0.01	57
%	100	122	103	100	106	128	100	86	86	100	88	105		
CEC me/100g	14.6	15.9	14.6	15.4	14.8	14.9	15.5	14.2	15.4	15.2	14	15.9	2.24	27
%	100	109	100	100	96	97	100	92	99	100	92	105		
K satn %	0.74	0.64	0.64	0.71	0.64	0.67	0.56	0.73	0.72	0.68	0.68	0.66	0.1	29
%	100	86	86	100	90	94	100	130	129	100	100	97		
Ca satn %	59	60	60	58	60	60	60	58	61	59	61	59	4.2	13
%	100	102	102	100	103	103	100	97	102	100	103	100		
Mg satn %	27	26	24	27	24	26	27	25	25	27	23	27	3.9	28
%	100	96	89	100	89	96	100	93	93	100	85	100		
OM %	2.13	2.07	2.26	2.27	2.1	2.1	2.06	2.21	2.2	2.07	2.13	2.26	0.3	25
%	100	97	106	100	93	93	100	107	107	100	103	109		
Avl N kg/ha	76	76	80	82	78	83	70	82	80	79	77	76	15.7	37
%	100	100	105	100	95	101	100	117	114	100	97	96		
P retn %	14.9	15.3	15.3	15.2	15.3	15	15.1	15.6	14.8	15.2	14.2	16.1	2.5	30
%	100	103	103	100	101	99	100	103	98	100	93	106		
Ex Al ppm	1.8	1.4	1.6	1.6	1.7	1.6	1.6	1.7	1.6	1.4	1.9	1.5	0.42	47
%	100	78	89	100	106	100	100	106	100	100	136	107		
Ttl N %	0.13	0.13	0.14	0.15	0.13	0.13	0.13	0.15	0.13	0.13	0.14	0.15	0.02	31
%	100	100	108	100	87	87	100	115	100	100	108	115		

Table 39: Soil analysis (30-60 cm) related to fertilizer treatments: 1986

	N0	N1	N2	P0	P1	P2	K0	K1	K2	Mg0	Mg1	Mg2	0.05 lsd	cv
pH	6.82	6.8	6.79	6.81	6.76	6.83	6.81	6.77	6.82	6.77	6.82	6.8	0.09	3
%	100	100	100	100	99	100	100	99	100	100	101	100		
P µg/ml	7.3	8.7	7.4	7.1	8.3	8	7.4	8.3	7.7	8	7.7	7.7	1.45	34
%	100	119	101	100	117	113	100	112	104	100	96	96		
K me/100g	0.08	0.077	0.067	0.075	0.074	0.075	**0.067**	**0.074**	**0.083**	0.076	0.075	0.073	0.01	34
%	100	96	84	100	99	100	100	110	124	100	99	96		
Ca me/100g	6.1	6.6	5.8	6.2	6.2	6.1	6.4	6.1	6	6.1	5.9	6.5	1.3	38
%	100	108	95	100	100	98	100	95	94	100	97	107		
Mg me/100g	3.3	3.5	3.2	3.4	3.3	3.3	3.7	3.1	3.3	3.4	3	3.6	0.77	42
%	100	106	97	100	97	97	100	84	89	100	88	106		
Na me/100g	0.051	0.054	0.041	0.046	0.052	0.048	0.051	0.049	0.046	0.047	0.05	0.049	0.01	60
%	100	106	80	100	113	104	100	96	90	100	106	104		
CEC me/100g	11	11.6	10.6	11.2	11	11.1	11.6	10.9	10.7	11.2	10.4	11.6	2.09	35
%	100	105	96	100	98	99	100	94	92	100	93	104		
K satn %	0.71	0.72	0.67	0.72	0.72	0.66	**0.61**	**0.67**	**0.82**	0.72	0.72	0.67	0.11	29
%	100	101	94	100	100	92	100	110	134	100	100	93		
Ca satn %	57	57	55	57	57	56	56	56	57	56	58	56	2.9	9
%	100	100	96	100	100	98	100	100	102	100	104	100		
Mg satn %	29	30	30	30	29	31	31	29	30	30	28	31	2.8	17
%	100	103	103	100	97	103	100	94	97	100	93	103		
Na satn %	0.43	0.53	0.4	0.42	0.53	0.4	0.44	0.47	0.45	0.43	0.49	0.44	0.17	69
%	100	123	93	100	126	95	100	107	102	100	114	102		
OM %	0.96	1.12	0.92	1.05	0.94	1.01	1.04	1.03	0.93	0.99	0.98	1.03	0.29	52
%	100	117	96	100	90	96	100	99	89	100	99	104		
Avl N kg/ha	30	30	25	29	29	27	27	31	26	30	27	27	7	46
%	100	100	83	100	100	93	100	115	96	100	90	90		
P retn %	10.4	10.5	9.9	10.3	10.3	10.3	10.1	10.9	9.8	10.3	9.7	10.8	1.9	33
%	100	101	95	100	100	100	100	108	97	100	94	105		
Ex Al ppm	2.7	2.7	2.4	2.4	3	2.4	2.8	2.4	2.7	2.3	2.5	3.1	0.79	56
%	100	100	89	100	125	100	100	86	96	100	109	135		
Ttl N %	0.055	0.058	0.055	0.06	0.052	0.057	0.054	0.058	0.057	0.055	0.055	0.058	0.01	49
%	100	105	100	100	87	95	100	107	106	100	100	105		

Trials 305 and 306 had remarkably similar analyses, particularly for the top soil (0 - 30 cm). The main differences were that 306 had higher levels of exchangeable P and Mg, but lower levels of K and a lower P retention. See Table 40.

Table 40: Comparison of mean soil data from trials 305 and 306: 1986

	0 - 30 cm			30 - 60 cm		
	305	306	306/305(%)	305	306	306/305(%)
pH	6.69	6.65	99	6.8	6.8	100
P µg/ml	5.4	10.3	191	4.6	7.8	170
K me/100g	0.13	0.096	74	0.14	0.075	54
Ca me/100g	8.5	8.9	105	7.9	6.2	78
Mg me/100g	1.3	4	308	1.5	3.4	227
Na me/100g	0.024	0.04	167	0.038	0.049	129
CEC me/100g	12	15	125	11.5	11.1	97
K satn %	0.99	0.67	68	1.24	0.7	56
Ca satn %	72	60	83	69	56	81
Mg satn %	11	26	236	13	30	231
Na satn %	0.2	0.26	130	0.33	0.45	136
OM %	2.3	2.2	96	1.6	1	63
Avl N kg/ha	76	77	101	43	28	65
P retn %	23	15	65	30	10	33
Ex Al ppm	2	1.6	80	4.7	2.6	55
Total N %	0.12	0.14	117	0.088	0.056	64

SUMMARY :

For the period 1987 to 89 yield in trial 306 ranged from 20 to 26 t/ha, compared with 22 to 31 t/ha for trial 305.

Vegetative dry matter production in both trials was similar, but the bunch index in trial 306 has been lower, resulting in less fruit being harvested.

There has been an increasing response to SOA, and an ongoing but smaller response to MOP.

There has been negligible response to TSP or Kieserite, particularly when SOA and MOP are also applied.

Of the 9 SOA and MOP combinations, N2K1 (3kg of SOA and 2.5 kg of MOP) has recorded the highest annual yields of 27 t/ha for the period 1987 to 1989.

Study of plant nutrient levels indicates satisfactory levels of K (1.16%) in the rachis even with the K0 treatment. This implies that response to MOP is likely to be due to the Cl component rather than to K.

Table 41: Trial 306, Progressive changes in yield and nutrient status

N0K0		83	84	85	86	87	88	89	AVG
	Yield		26.1	30.3	23.2	14.4	15.7	18.7	21.4
	N%	2.8	2.8	2.6	2.4	2.3		2.01	2.48
	K%	1.2	1.22	1.13	1.01	0.77		0.77	1.02
	Rach K%							1.03	1.03
	P%	0.18	0.18	0.17	0.15	0.14		0.142	0.16
	Cl%	0.23	0.1	0.09	0.05	0.04		0.05	0.09
N1K0		83	84	85	86	87	88	89	AVG
	Yield		23.7	38.0	32.9	27.7	19.4	24.9	27.77
	N%	2.6	2.7	2.9	2.5	1.9		2.33	2.49
	K%	1.2	1.07	1.02	1.06	0.81		0.8	0.99
	Rach K%							1	1.00
	P%	0.16	0.18	0.18	0.16	0.16		0.151	0.17
	Cl%	0.21	0.09	0.1	0.09	0.04		0.06	0.10
N0K1		83	84	85	86	87	88	89	AVG
	Yield		21.4	33.7	31.4	22.5	16.7	21.5	24.53
	N%	2.7	2.8	2.7	2.6	2.2		2.04	2.51
	K%	1.2	1.13	0.98	0.87	0.79		0.79	0.96
	Rach K%							1.2	1.20
	P%	0.16	0.17	0.17	0.14	0.14		0.145	0.15
	Cl%	0.31	0.36	0.56	0.46	0.48		0.38	0.43
N1K1		83	84	85	86	87	88	89	AVG
	Yield		29.9	33.1	33.6	31.3	22.6	28.5	29.83
	N%	2.7	2.8	2.6	2.7	2.5		2.18	2.58
	K%	1.1	1.05	0.97	0.89	0.78		0.85	0.94
	Rach K%							1.1	1.10
	P%	0.16	0.17	0.17	0.15	0.15		0.146	0.16
	Cl%	0.32	0.47	0.47	0.47	0.44		0.36	0.42

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: Recent alluvial 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 palms per hectare.
Size: The trial comprises 25 plots: 900 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

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 was a latin square design, with 5 treatments, each occuring 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.
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

* Note: The exact rate of Bunch Ash is to be adjusted to achieve equivalent K content to the MOP applications.

1. Background

The trial design has enabled analysis of the EFB effect to be continued, although the superimposition of new treatments is raising overall yield levels. The results are reported in 2 separate sections.

2. 309 (a) :

The plots which received EFB in 1984 have continued to display a yield benefit of approximately 20% during 1989, but the difference has not been statistically significant due to the increased variation caused by the superimposition of the new treatments.

3. 309 (b) :

1. **Yield**

The new fertilizer treatments only commenced on 20th January 1988, but as shown in Table 42 achieved a remarkable increase in yield of 200% on plots receiving SOA during 1989. This has comprised improvements of 60% in bunch numbers and 30% in bunch weights.

The yield benefit only occurred where SOA nitrogen fertilizer was applied, at the relatively low rate of 2 kg/palm/year. The response is therefore both very rapid, considering the seriously depleted condition of the palms previously, and very large. In annual cost terms per ha the fertilizer would be K60 (at K 210/tonne) and returns K180 (9 tonnes at K20/tonne).

The trial was set up to compare MOP and bunch ash as K fertilizer sources, and as such does not test the N effect in the absence of K, and it cannot be proven that such a large response would have occurred in the absence of K fertilizers. On the other hand, K fertilizers alone have achieved virtually no response, and leaf and rachis results indicate that even in the absence of any K fertilizer, the K levels are not unduly low (although the overall levels may still be slightly boosted by the earlier application of EFB in 1984). This provides a very strong suggestion that the major part of the response observed should be attributed directly to nitrogen.

The dramatic response to nitrogen in this trial augurs well for the technical prospects of rehabilitating smallholder blocks which have become run down through lack of fertilizer. Trial 309 continues to provide a very valuable demonstration for visiting smallholders of the dangers of inadequate or incorrect fertilization, and the benefits of N fertilizer application.

Table 42: Trial 309 yield data

Treatments	Yield t/ha 1989	Bunches/ha 1989	sbw 1989	Yield t/ha 1988
Individual				
Control	**9.0**	**679**	**12.7**	9.8
MOP	**8.7**	**665**	**12.9**	10.1
BA	**9.4**	**728**	**12.6**	9.1
MOP+N	**18.0**	**1080**	**16.7**	10.4
BA+N	**18.7**	**1165**	**16.2**	9.1
$lsd_{.05}$	5	289	2.9	4.3
Grouped				
+SOA	**18.4)**	**1123)**	**16.5)**	9.8
-SOA	**9.1)**	**696)**	**12.8)**	9.6
MOP	**13.4]**	**872]**	**14.8]**	10.3
BA	**14.0]**	**947]**	**14.4]**	9.1
$lsd_{.05}$	3.5	204	2.1	3.07
cv(%)	28	24	15	32

2. Growth

As shown in Table 43, as with yield, virtually all growth response has been confined to treatments including N. The SOA treatments achieved very significantly increased leaf production and leaf weight, and therefore higher TDM, VDM and BDM production.

In rehabilitating the palms from a severely depleted state N has also achieved a very significant improvement of 20% in the bunch index, returning it closer to the level achieved by palms in a reasonable condition. Without nitrogen the severe stress on the palms not only depressed vegetative production by 30%, but also had a disproportionate effect upon bunch production, which was depressed by 50%. The application of N fertilizer has enabled the palms to commence recovery from their seriously depleted condition, although the 1989 yield and growth figures are still substantially below normal estate levels.

MOP does appear to have had a minor effect in increasing frond weight. Comparison with other treatments would suggest that this is a chloride effect. However, the benefit appears to have been counterbalanced by other factors so that no overall improvement is apparent.

Observation of the results would suggest that use of MOP in place of bunch ash tends to slightly increase vegetative production at the expense of bunch production: possibly as a result of the increased chloride levels. However, apart from the FW, there are no significant differences between MOP and bunch ash, nor indeed between MOP, bunch ash and the control.

Table 43: Trial 309 Palm Growth data for 1989

TRTMNT	Frond prdn (n)	Dry Frond weight kg (FW)	Frond DM tha (FDM)	Bunch DM tha (BDM)	Vegetative DM tha (VDM)	Total DM tha (TDM)	Bunch Index (BI)
Individual							
Control	**21.0**	**2.2**	**6.5**	**7.4**	**8.1**	**15.4**	**0.457**
MOP	**21.4**	**2.4**	**7.4**	**7.1**	**9.0**	**16.1**	**0.434**
BA	**21.7**	**2.2**	**6.8**	**7.7**	**8.4**	**16.1**	**0.464**
MOP+N	**25.0**	**2.7**	**9.8**	**14.8**	**12.6**	**27.3**	**0.540**
BA+N	**25.6**	**2.4**	**8.9**	**15.3**	**11.6**	**27.0**	**0.565**
$lsd_{.05}$	1.2	0.36	1.4	4.1	1.9	5.6	0.083
Grouped							
+SOA	**25.3** |	**2.6** |	**9.4** |	**15.1** |	**12.1** |	**27.2** |	**0.552** |
-SOA	**21.6** |	**2.3** |	**7.1** |	**7.4** |	**8.7** |	**16.1** |	**0.449** |
MOP	**23.2**]	**2.6**]	**8.6**]	**11.0**]	**10.8**]	**21.7**]	**0.487**]
BA	**23.7**]	**2.3**]	**7.9**]	**11.5**]	**10.0**]	**21.6**]	**0.515**]
$lsd_{.05}$	0.86	0.25	1.02	2.9	1.3	3.9	0.058
cv(%)	4	11	13	28	14	20	12

3. Nutrient Analysis

As shown in Table 44, the most marked effect, corresponding to the increased yield is a 15% increase in the leaf N level, from 1.96% to 2.29%. Application of SOA has also markedly affected other nutrient levels, increasing P, K, and Cl in the leaf, whilst depressing Mg and Ca leaf levels.

It is suggested that the depression of Ca and Mg allows increases in the levels of other nutrients in the leaf.

MOP increased plant uptake of Mg and Ca, in comparison with bunch ash. It also increased Cl levels by 160% in the leaf. Leaf levels of Cl were boosted by a further 20% through application of SOA in addition to MOP. The baseline leaf Cl level of 0.172% on the control plots was not unduly low compared with levels below 0.1% recorded in other trials at Higaturu.

Bunch ash application resulted in higher leaf K levels than MOP. Application of SOA reduced the effect of bunch ash to 13% but increased the effect of MOP to 36%.

Table 44: Trial 309 Leaf analysis related to fertilizer treatments: 1989

TREATMENT:	Individual 0	MOP	BA	MOP+N	BA+N	+N	-N	MOP	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	.006	.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			
Mg%	0.24	0.268	0.264	0.21	0.214	0.212	0.266	0.239	0.239	0.035	0.025	11
%	100	112	110	88	89	100	125	113	113			
Ca%	0.762	0.796	0.734	0.724	0.7	0.712	0.765	0.76	0.717	0.057	0.041	6
%	100	104	96	95	92	100	107	107	101			
Cl%	0.172	0.278	0.19	0.334	0.2	(1) 0.267	0.234	0.306	0.195	0.033	0.023	10
%	100	162	110	194	116	100	88	115	72			

Note significant interaction between N and K sources for %Cl:

	MOP	BA
-SOA	0.278	0.190
+SOA	0.334	0.200

SUMMARY :

There has been a major response to N fertilizer at very modest levels: yield was doubled in 1989 by only 2kg of SOA. The rapid recovery being achieved with limited nitrogen fertilizer applications offers encouraging technical prospects for rehabilitation of poor smallholder areas.

Application of MOP or bunch ash in the absence of SOA has not achieved any improvement in yield compared with the unfertilized control.

There is no evidence for any significant difference in response to bunch ash and MOP, even in the presence of SOA. This would imply that no marked Cl effect has developed in this trial.

Both MOP and bunch ash have achieved similar response in terms of boosting K in the plant. In terms of other nutrients there are some interactions, and in particular MOP has also raised Cl, Ca and Mg levels.

The plots which received EFB in 1984 have continued to yield 20% above the no EFB controls in 1989.

Table 45: Trial 309, Progressive changes in yield and nutrient status

		88	89	Avg
Control		88	89	Avg
	Yield	7.70	9.70	8.70
	N%	1.90	2.02	1.96
	P%	0.14	0.14	0.14
	K%	0.69	0.77	0.73
	Rach K%	0.66	1.00	0.83
	Mg%	0.27	0.24	0.26
	Ca%	0.84	0.74	0.79
	Cl%	0.20	0.17	0.19
MOP		88	89	Avg
	Yield	12.70	13.30	13.00
	N%	2.00	1.87	1.94
	P%	0.14	0.13	0.14
	K%	0.63	0.62	0.63
	Rach K%	0.87	1.06	0.97
	Mg%	0.36	0.26	0.31
	Ca%	0.88	0.87	0.88
	Cl%	0.22	0.23	0.23
BA		88	89	Avg
	Yield	14.9	15.1	15.00
	N%	2	1.97	1.98
	P%	0.14	0.146	0.14
	K%	0.71	0.77	0.74
	Rach K%	0.8	1.03	0.92
	Mg%	0.24	0.2	0.22
	Ca%	0.82	0.79	0.81
	Cl%	0.26	0.2	0.23
MOP+N		88	89	Avg
	Yield	10.6	18	14.30
	N%	2	2.24	2.12
	P%	0.14	0.144	0.14
	K%	0.71	0.8	0.76
	Rach K%	0.93	1.18	1.05
	Mg%	0.26	0.18	0.22
	Ca%	0.8	0.69	0.75
	Cl%	0.2	0.25	0.23
BA+N		88	89	Avg
	Yield	8.2	20.9	14.55
	N%	2	2.46	2.23
	P%	0.14	0.151	0.15
	K%	0.64	0.92	0.78
	Rach K%	0.73	1.05	0.89
	Mg%	0.32	0.21	0.27
	Ca%	0.9	0.68	0.79
	Cl%	0.23	0.18	0.21

TRIAL 310, ANION AND FERTILIZER FREQUENCY TRIAL, AMBOGO

PURPOSE:

1. To compare response to the K cation, and S and Cl anions.
2. To compare the benefits of a uniform annual fertilizer dressing applied either every 6 months or every 12 months.

SITE DETAILS :

Location: Ambogo Estate HOPPL, block 80 D.5.
Genetic material: Dami commercial DxP crosses.
Soils: Recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam subsoil, with seasonally high water tables.
Planting date: 1980
Density: 143 palms per hectare.
Size: The trial comprises 1260 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

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.
Trial commencement: November 1986.
Trial progress: Ongoing.
Treatments:

Treatment code	Fertilizer	Kg/palm/yr	Applications/yr
1	None	0.0	0
2	Sulphate source	5.5	2
3	Chloride source	2.0	2
4	K_2SO_4	3.0	2
5	KCl	2.5	2
6	K_2SO_4	3.0	1
7	KCl	2.5	1

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 sodium chloride and sodium sulphate have been 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 application of urea at 600 gm/palm on 22/12/88 and has been continued twice a year.

RESULTS :

1. **Yield:**

With the increased period of recording results are now becoming clearer, and some are actually the reverse of those indicated by the previous single year's data for 1988.

Table 46 indicates the yields. The only significant treatment effect is due to chloride, which increased bunch weight, and reduced bunch numbers. Since these 2 effects cancel out there were no significant differences for weight of bunches/ha.

Table 46: Trial 310 Yield data

TRTMNT	1989 Wt of bunches t/ha	1989 No of bunches /ha	1989 s.b.w. kg	88-89 Wt of bunches t/ha	88-89 No of bunches /ha	88-89 s.b.w. kg
Control	22.1	1158	19.0	22.3	1251	17.8
-K	23.5	1198	19.8	22.7	1245	18.3
+K	22.4	1165	19.3	22.8	1267	18.1
Cl	22.0	**1087**	**20.3**	22.2	**1188**	**18.7**
S	23.9	**1275**	**18.8**	23.3	**1324**	**17.7**
1x	22.8	1191	19.1	23.0	1299	17.8
2x	22.1	1139	19.5	22.7	1235	18.4
lsd K	2.33	115	0.96	2	119	1
lsd Cl,S	2.2	109	0.91	1.9	112	0.9
lsd 1,2	2.7	133	1.1	2.3	137	1.1
c.v.(%)	13	12	6	11	12	7

Interestingly these effects of chloride are identical to those produced by MOP in trials 305 and 306. No direct effect from K was identified, although treatment rachis levels of 1.2% were substantially below those of 1.6% plus on trials 305 and 306. These 2 factors togehter provide a suggestion that the MOP effect on trials 305 and 306 may have been due to chloride.

2. Growth

Palm growth data for 1989 is shown in Table 47 - there were few statistically significant effects during 1989. There were indications that Cl may have boosted frond dm production, and both Cl and K marginally increased dry frond weight in comparison to the untreated control. However, compensation by other elements of production lead to these factors depressing the bunch index for Cl in comparison to S treatments. All these effects are at present minor, so that it would be unwise to draw firm conclusions at this stage.

Table 47: Trial 310 Palm Growth and Conversion data for 1989

TRTMNT	Leaf prdn (n)	Dry Frond weight kg (FW)	Frond DM tha (FDM)	*Bunch DM tha (BDM)	Vegetative DM tha (VDM)	*Total DM tha (TDM)	*Bunch Index (BI)
Control	22	**3.18** (1)	**8.90** (2)	18.1	11.9	30	0.601
-K	22.3	**3.33**	**9.43**	19.2	12.6	31.9	0.601
+K	22	**3.38** (1)	**9.42**	18.4	12.5	30.9	0.592
Cl	22.3	**3.40** (1)	**9.63** (2)	18.1	12.7	30.8	**0.585**
S	21.9	**3.31**	**9.22**	19.6	12.4	32	**0.609**
1x	21.8	3.37	9.33	18.7	12.4	31.1	0.597
2x	22.1	3.39	9.51	18.1	12.6	30.7	0.588
lsd K	0.6	0.14	0.51	1.9	0.6	2.3	0.022
lsd Cl,S	0.6	0.13	0.48	1.8	0.6	2.1	0.021
lsd 1,2	0.7	0.16	0.58	2.2	0.7	2.6	0.026
c.v.(%)	3	5	7	13	6	9	5

(1) Significant treatment effect, and significant differences between +K and +Cl and control.
Also significant difference between control and other treatments as a group.

(2) Significant difference between control and chloride.

(*Dry matter calculated as carbohydrate equivalent, assuming oil energy = 2.1 x carbohydrate energy)

3. Plant Analysis.

At the end of 1988 a detailed programme of leaf and rachis sampling was undertaken. This involved sampling from fronds 1, 9, 17, 25 and 33 for each fertilizer treatment. Samples were then either processed dry, or washed with 12 changes of water, to assess the leaching of different nutrients. Leaf analysis results are shown in Tables 48 and 49.

Leaf age had a major effect on the levels of all nutrients. In most cases the levels of nutrients declined in the leaf with increasing age, except for Ca which increased by 200%.

The effects of leaching were generally losses of less than 15 %. P was the least affected, with losses of only 2% whilst S was the greatest, with losses of 12%. (Zn levels were approximately doubled by washing. This may be attributed to the use of tap water for the washing, since purified water was not available in the quantities required.)

Interpretation of the various interactions between nutrient levels and the fertilizer treatments is complex. The anions affect base levels and balances, and thus interact with many nutrient levels in the plant.

4. Discussion

Whilst the major factorial trials 305 and 306 show a definite MOP effect, the trials which have been set up to investigate this effect in more detail (309 and 310) do not show any K or anion effects significantly influencing production.

Obviously, response in any trial is only strictly applicable in the exact environment of the trial itself. However, all 3 trials are laid down in very similar conditions, so that the difference in response to MOP is puzzling.

There are certain differences between the 2 groups of trials: 309 and 310 appear to have a generally lower plane of nutrition, and lower NO N levels; possibly also lower soil organic matter and base saturation levels.

Reference to the initial data from trial 311 indicates a possible explanation. With low organic matter levels (in the absence of EFB) there was a minimal response to MOP, whilst with improved organic matter due to EFB application a marked response to MOP was observed.
The low organic matter in trials 309 and 310, possibly in combination with a shortage of N may well be restricting any potential anion or K response.

Table 48: Trial 310 Leaf analysis related to fertilizer treatments, leaf age and washing: October 1988

	Fertilizer treatment: Control	-K	+K	S	Cl	Leaf number: 1	9	17	25	33	Washing: -	+	lsd trts +-K	lsd trts Cl/S	lsd lvs	lsd wash	sd	cv	gm
N%	2.07	2.06	1.89	1.96	1.96	2.22	2.25	2.09	1.81	1.59	2.05	1.94	0.07	0.06	0.08	0.05	0.09	10	1.99
%	100	100	91	95	95	140	142	131	114	100	106	100							
P%	0.146	0.146	0.149	0.147	0.149	0.187	0.163	0.145	0.127	0.115	0.149	0.146	0.004	0.003	0.005	0.003	0.005	3	0.147
%	100	100	102	101	102	163	142	126	110	100	102	100							
K%	1.14	1.14	1.04	1.11	1.06	1.79	1.18	0.97	0.8	0.76	1.12	1.07	0.05	0.04	0.06	0.04	0.06	5	1.1
%	100	100	91	97	93	236	155	128	105	100	105	100							
Ca%	0.766	0.749	0.804	0.769	0.784	0.463	0.67	0.798	0.925	1.017	0.824	0.726	0.029	0.024	0.034	0.021	0.036	5	0.775
%	100	98	105	100	102	46	66	78	91	100	113	100							
Mg%	0.255	0.251	0.252	0.245	0.259	0.275	0.283	0.253	0.24	0.211	0.265	0.24	0.013	0.011	0.016	0.01	0.016	7	0.252
%	100	98	99	96	102	130	134	120	114	100	110	100							
S%	0.132	0.118	0.121	0.122	0.117	0.133	0.138	0.126	0.112	0.101	0.129	0.115	0.008	0.007	0.009	0.006	0.01	8	0.122
%	100	89	92	92	89	132	137	125	111	100	112	100							
Cl%	0.158	0.302	0.302	0.196	0.408	0.46	0.28	0.236	0.206	0.184	0.279	0.267	0.018	0.014	0.02	0.013	0.021	8	0.273
%	100	191	191	124	258	250	152	128	112	100	104	100							
Mn ppm	39	32	36	32	37	29	36	34	39	37	36	34	1.8	1.4	2	1.3	2.14	6	35
%	100	82	92	82	95	78	97	92	105	100	106	100							
Zn ppm	30	30	28	29	28	36	31	29	25	25	21	38	2.4	1.9	2.8	1.8	3	10	29
%	100	100	93	97	93	144	124	116	100	100	55	100							

Table 49: Trial 310 Frond 17 equivalent leaf analysis related to fertilizer treatments, leaf age and washing: October 1988

	Fertilizer treatment: Control	-K	+K	S	Cl	lsd trts +-K	lsd trts Cl/S	sd	cv	gm
N%	**2.23**	**2.22**	**2.04**	2.11	2.11	0.075	0.064	0.097	10	2.145
%	100	100	91	95	95					
P%	0.145	0.145	0.148	0.146	0.148	0.003	0.002	0.004	3	0.146
%	100	100	102	101	102					
K%	**1.03**	**1.03**	**0.94**	**1**	**0.96**	0.045	0.036	0.054	5	0.992
%	100	100	91	97	93					
Ca%	**0.839**	**0.820**	**0.881**	0.842	0.859	0.031	0.026	0.039	5	0.848
%	100	98	105	100	102					
Mg%	**0.268**	**0.264**	**0.265**	**0.258**	**0.273**	0.013	0.011	0.016	7	0.265
%	100	98	99	96	102					
S%	**0.144**	**0.128**	**0.132**	0.133	0.128	0.008	0.007	0.010	8	0.133
%	100	89	92	92	89					
Cl%	**0.139**	**0.266**	**0.237**	**0.1730**	**0.36**	0.015	0.012	0.018	8	0.241
%	100	191	170	124	258					
Mn ppm	**39**	**32**	**36**	**32**	**37**	1.798	1.398	2.138	6	34.97
%	100	82	92	82	95					
Zn ppm	21	21	20	21	20	1.696	1.343	2.120	10	20.50
%	100	100	95	100	95					

Alternatively it is possible that the MOP effect is relatively slow to be expressed, or even that the environmental conditions on the new trials during 1988 and 1989 have not been such as to encourage K or anion effects.

The plant analysis data accumulating from the new trials is useful in comparing K and anion effects. Although little yield response has been achieved to any combination of K, Cl or S, chloride has brought about the greatest changes both in yield and in plant nutrition which are generally similar to those caused by K application. Application of Cl alone has achieved response such as increase in frond weight and bunch weight, which was previously attributed to MOP or K.

However, beneficial effects from both K and Cl application are counterbalanced by an increased Ca uptake, which leads to a reduced leaf K level, and in trial 310 has also concurred with a reduction in leaf N. In all the trials K levels even on the control appear adequate.

This data would tend to suggest that the MOP effect is more likely to be due to Cl than K, and that the main response, particularly on poor areas, is likely to be to N. Under these circumstances the best policy would be to utilise both SOA and AMC to maintain anion levels, and to provide additonal K for areas with poorer leaf and rachis levels as bunch ash, EFB or MOP according to practical and economic considerations.

SUMMARY

The 1989 results show remarkably little yield effect by K or anions. This confirms the priority as a requirement for N in any form.

The lack of response to K or anions in trials 309 and 310 may be due to low organic matter levels, which appear to reduce fertilizer responses.

Chloride has increased bunch weight and frond dry weight: responses which have been attributed to K. Since Cl promotes K uptake, and K increases Cl uptake, the response to both nutrients must be closely linked.

In the leaf Cl has similar effects to K: both increase base levels, particularly Ca, and thus depress leaf K.

These factors indicate that at least part of the benefit of MOP is likely to be due to the Cl anion content.

S also appears beneficial, in that it counterbalances the increases in Ca in the plant.
Practical implications are that the priority requirement is for N, and that periodic alternation between SOA and AMC would be likely to supply the necessary balance of anions.

Table 50: Trial 310 Progressive changes in yield and nutrient status

		87	88	AVG
Control				
Plot 6	Yield	32.05	25.19	28.62
	N%	2.4	2.4	2.4
	P%	0.16	0.15	0.16
	K%	0.95	0.82	0.89
	Ca%	0.81	0.85	0.83
	Mg%	0.19	0.23	0.21
	S%	0.16	0.17	0.17
	Cl%	0.17	0.16	0.17
Cl		87	88	AVG
Plot 1	Yield	31.11	21.56	26.34
	N%	2.4	2.2	2.3
	P%	0.17	0.16	0.17
	K%	1	0.83	0.92
	Ca%	0.72	0.76	0.74
	Mg%	0.24	0.25	0.25
	S%	0.16	0.16	0.16
	Cl%	0.2	0.31	0.26
KCl		87	88	AVG
Plot 7	Yield	32.35	26.71	29.53
	N%	2.6	2.4	2.5
	P%	0.16	0.15	0.16
	K%	0.96	0.74	0.85
	Ca%	0.8	0.91	0.86
	Mg%	0.23	0.25	0.24
	S%	0.15	0.16	0.16
	Cl%	0.2	0.37	0.29
SO4		87	88	AVG
Plot 5	Yield	34.72	27.36	31.04
	N%	2.4	2.4	2.4
	P%	0.17	0.15	0.16
	K%	0.93	0.76	0.85
	Ca%	0.86	0.87	0.87
	Mg%	0.23	0.2	0.22
	S%	0.16	0.17	0.17
	Cl%	0.17	0.16	0.17
K2SO4		87	88	AVG
Plot 2	Yield	34.41	28.35	31.38
	N%	2.3	2.2	2.25
	P%	0.17	0.16	0.17
	K%	0.91	0.79	0.85
	Ca%	0.76	0.79	0.78
	Mg%	0.24	0.25	0.25
	S%	0.16	0.19	0.18
	Cl%	0.16	0.17	0.17

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

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: Isavene Estate HOPPL, block 78A.
Genetic material: Dami commercial DxP crosses.
Soils: Of volcanic ash origin, consisting of deep sandy clay loam, with good drainage and physical conditions.
Planting date: 1978.
Density: 130 palms per hectare.
Size: The trial comprises 32 plots: 1150 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

DESIGN AND TREATMENT DETAILS :

Statistical background: Trial 311 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.
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 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. The next application will be due in March 1990, when it is intended to apply 500 kg per palm, to last for 2 years.

RESULTS :

1. Yield

Table 51 indicates the summarised yields for 1989, and Table 52 the production for particular fertilizer combinations.

Table 51: Trial 311 Yield data 1989

TRTMNT	1989 Wt of bunches t/ha	1989 No of bunches /ha	1989 s.b.w. kg
N 0	**27.8**	1209	23.0
N 1	**30.6**	1301	23.5
N 2	**33.0**	1383	23.9
N 3	**33.2**	1402	23.7
K 0	30.6	1335	23.0
K 1	30.8	1280	23.9
K 2	30.0	1279	23.6
K 3	33.2	1400	23.8
EFB 0	**29.8**	1290	23.1
EFB 1	**32.5**	1356	24.0
lsd (EFB)	2	103	1
lsd(FBNK)	2.4	126	1.2
lsd (NK)	2.8	146	1.4
c.v.(%)	8	10	5

(K x EFB interaction was significant at P = .05)

Overall during 1989 SOA boosted yields by over 5 tonnes at rates of 4 kg plus per palm, and EFB boosted yields by 2.7 tonnes/ha. There was no significant response to MOP, although it did interact significantly with EFB.

Yields during 1989 have been high, and responses have developed very rapidly, particularly to EFB. The rapid response in this trial is probably associated with the high production, during which suitable fertilizers can attain a rapid response by reducing abortion of bunches. In addition, single bunch weights have also been boosted by the fertilizer applications, although not presently to a statistically significant extent.

Table 52 indicates that in 1989 the overall maximum yield of 36.4 tonnes/ha was attained with application of 2kg of MOP and 6 kg of SOA.

Table 52: Trial 311 production figures for different fertilizer combinations 1989

Yield in t/ha 1989	K0	K1	K2	K3
N0	28.3	24.1	27.8	31
N1	30	29.6	30.4	32.6
N2	32.7	33.1	30.7	35.5
N3	31.5	36.4	31.2	33.7

Yield in t/ha 1989	K0	K1	K2	K3
EFB0	29.1	27.1	30.4	32.7
EFB1	32.2	34.5	29.7	33.8

Yield in t/ha 1989	N0	N1	N2	N3
EFB0	26.3	28	32	32.9
EFB1	29.3	33.3	34	33.5

FDM prodn t/ha 1989	K0	K1	K2	K3
EFB0	10	9.7	10.5	9.8
EFB1	10.3	11.6	10.3	10.3

FDM prodn t/ha 1989	N0	N1	N2	N3
EFB0	9.4	10.2	9.8	10.6
EFB1	10.8	10.2	11	10.7

VDM prodn t/ha 1989	K0	K1	K2	K3
EFB0	13.7	13.2	14.4	13.9
EFB1	14.4	16.1	14.2	14.5

The effect of EFB is particularly interesting, since it appears to boost production at all levels of SOA and MOP, and additionally increased fertilizer response, enabling higher yields to be attained with lower fertilizer inputs.

For MOP, in the absence of EFB the maximum yield of 32.7 tonnes was attained at K3 (6 kg of MOP). With EFB a maximum yield of 34.5 tonnes was attained with only 2 kg of MOP. This represented a 27% (7.4 tonnes) increase in yield due to EFB at the K1 level, which yielded 6% more than the highest yield in the absence of EFB.

For SOA, in the absence of EFB the maximum yield of 32.9 tonnes was attained at N3 (6 kg of SOA). With EFB a maximum yield of 34 tonnes was attained with 4 kg of SOA, and a comparable yield of 33.3 tonnes with only 2 kg of SOA. This represented a 18% (5.3 tonnes) increase in yield due to EFB at the N1 level, which was higher than any yields in the absence of EFB.

With EFB, yields approached the maximum at the N1 and K1 levels. In the absence of EFB yields were maximum at the N3 and K3 levels.

For reliable recommendations to be based upon the data from this trial, it will be preferable to have at least 1 more years yield recording. Calculation of the response surface will enable realistic recommendations to be made for fertilizer application both with and without EFB.

2. Growth

Table 53 indicates the 1989 palm growth data. SOA and EFB achieved marked responses in terms of increased production, SOA particularly boosting leaf production, and EFB raising the frond weight. There were a number of significant interactions between EFB and MOP, although MOP alone did not achieve any significant response. The general nature of the interactions was to increase response to low levels of MOP in the presence of EFB.

For the important index of VDM, which generally relates directly to bunch yield, EFB in the absence of MOP produced values equal to any level of MOP without EFB. The highest value was attained with the EFB K1 treatment which was 22% greater than the EFB0 K1 value, and 12% greater than VDM production attained under any level of MOP application.

3. Leaf and Soil Analyses

Table 54 indicates the initial soil and leaf data collected prior to commencement of the trial.

Table 53: Trial 311 Growth and conversion data 1989

TRTMNT	1989 Leaf prodn (n)	1989 Frond wt (FW)	1989 Frond dm (FDM)	Bunch dm (BDM)	Vegetative dm (VDM)	Total dm (TDM)	Bunch index (BI)
N 0	**22.1**	3.56	**10.1**	**22.8**	**13.7**	**36.5**	**0.621**
N 1	**23.2**	3.45	**10.2**	**25.1**	**14.1**	**39.2**	**0.64**
N 2	**23.8**	3.45	**10.4**	**27.1**	**14.6**	**41.7**	**0.65**
N 3	**23.7**	3.53	**10.6**	**27.2**	**14.8**	**42.0**	**0.647**
K 0	23.0	3.48	10.2	25.1	14.1	19.2	0.64
K 1	23.1	3.63	10.7	25.2	14.7	39.9	0.628
K 2	23.3	3.51	10.4	24.6	14.3	38.9	0.633
K 3	23.3	3.40	10.1	27.2	14.2	41.4	0.657
EFB 0	22.9	**3.43**	**10.0**	**24.4**	**13.8**	**38.2**	0.637
EFB 1	23.5	**3.57**	**10.7**	**26.7**	**14.8**	**41.5**	0.643
lsd (EFB)	0.65	0.13	0.4	1.6	0.5	1.8	0.018
lsd(FBNK)	0.8	0.16	0.5	2	0.6	2.2	0.023
lsd (NK)	0.92	0.19	0.6	2.3	0.7	2.5	0.026
c.v.(%)	3	5	5	8	4	6	4
			KxEFB * NxEFB *	KxEFB *	KxEFB **	KxEFB *	

Table 54: Trial 311 Initial 0-20 cm soil and leaf data, 1988

Block	SOIL Bulk density g/ml	pH	P p.p.m	Extractable cations m.e./100g K	Ca	Mg	Na	CEC	Percentage saturation K%	Ca%	Mg%	Na%	OM %	P retn %	Total N %
Block 1	1.035	6.525	5.125	0.141	7.337	1.143	0.077	11.06	1.262	66.06	10.29	0.7	2.112	17.18	0.136
Block 2	1.028	6.65	4.5	0.129	8.187	1.345	0.066	12.12	1.056	67.37	10.85	0.537	2.837	20.81	0.131
Mean:	1.03	6.59	4.81	0.14	7.76	1.24	0.07	11.59	1.16	66.72	10.57	0.62	2.48	19.00	0.130

	LEAF N%	P%	K%	S%	Ca%	Mg%	Cl%	RACHIS April 88 K%	Ca%	Mg%
Block 1	2.269	0.148	0.795	0.16	0.959	0.246	0.327	0.996	0.423	.076
Block 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

There has been an apparent response to MOP, but only in the absence of EFB. This indicates that the benefit of EFB is due to its supply of either K or Cl.

The application of EFB has not raised the N requirement: initial evidence indicates that the contrary is the case. that

SUMMARY

Responses in trial 311 have developed very rapidly, particularly to EFB.

There have been significant overall responses to both SOA (5.4 tonnes/ha) and EFB (2.7 tonnes/ha).

The effects of EFB in the trial are interesting:
1. EFB increased yield at any level of fertilizer.
2. EFB reduced inorganic fertilizer requirement. Thus in the presence of EFB much lower fertilizer applications achieved similar or greater responses than high fertilizer applications in the absence of EFB.

As an example, for maximum yield without EFB levels of N3 and K3 were required, whilst with EFB higher yields were attained with only N1 and K1 levels of fertilizer application.

No significant response was obtained to MOP, although a significant negative interaction with EFB was identified. This suggests that the benefit of EFB is due to increased uptake of K or Cl.

The initial data indicates that the contribution of organic matter in the Higaturu soils is crucial, and that measures to maintain organic matter will boost yield and improve fertilizer response.

Table 55: Trial 311, Progressive changes in yield and nutrient status

N K EFB				
0 0 0		88	89	AVG
Plot	Yield		26.4	26.4
31	N%	2.5	2.08	2.29
	P%	0.15	0.137	0.14
	K%	0.79	0.68	0.74
	RK%	0.82	1.05	0.94
	Ca%	0.89	0.73	0.81
	Cl%	0.32	0.16	0.24

(Table 55 continued)

N K EFB				
0 2 0		88	89	AVG
Plot	Yield		30.2	30.2
7	N%	2.2	2.11	2.16
	P%	0.15	0.143	0.15
	K%	0.79	0.68	0.74
	RK%	0.87	1.28	1.08
	Ca%	1.01	0.87	0.94
	Cl%	0.31	0.32	0.32
N K EFB				
0 0 1		88	89	AVG
Plot	Yield		30.3	30.3
8	N%	2.3	2.11	2.21
	P%	0.14	0.144	0.14
	K%	0.75	0.73	0.74
	RK%	1.03	1.23	1.13
	Ca%	0.98	0.7	0.84
	Cl%	0.37	0.24	0.31
N K EFB				
2 0 0		88	89	AVG
Plot	Yield		30.4	30.4
13	N%	2.4	2.23	2.32
	P%	0.15	0.152	0.15
	K%	0.79	0.82	0.81
	RK%	0.85	0.88	0.87
	Ca%	0.97	0.7	0.84
	Cl%	0.27	0.21	0.24
N K EFB				
2 0 1		88	89	AVG
Plot	Yield		35	35
26	N%	2.2	2.16	2.18
	P%	0.14	0.145	0.14
	K%	0.82	0.71	0.76
	RK%	0.97	1.16	1.07
	Ca%	0.93	0.69	0.81
	Cl%	0.32	0.23	0.28
N K EFB				
3 3 0		88	89	AVG
Plot	Yield		31.7	31.7
25	N%	2	2.12	2.06
	P%	0.14	0.143	0.14
	K%	0.68	0.68	0.68
	RK%	0.79	1.2	1
	Ca%	0.9	0.76	0.83
	Cl%	0.32	0.35	0.34
N K EFB				
3 3 1		88	89	AVG
Plot	Yield		35.8	35.8
12	N%	2.3	2.3	2.3
	P%	0.15	0.152	0.15
	K%	0.8	0.8	0.8
	RK%	0.99	1.4	1.19
	Ca%	0.89	0.73	0.81
	Cl%	0.25	0.38	0.32

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: Of recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam subsoil, with seasonally high water tables.
Planting date: 1980.
Density: 143 palms per hectare.
Size: The trial comprises 32 plots: 1150 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

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.
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. The next application will be due in April 1990, when it is intended to apply 500 kg per palm, to last for 2 years.

RESULTS :

1. **Production**

Yield results obtained in 1989 are summarised in Table 56. A very high level of variability has occurred within the trial in 1989 with respect to yield. This renders it difficult to correctly identify genuine responses. However there are definite indications that SOA application has been beneficial, with rates of 2kg upwards having yields at least 4 tonnes greater than the N0 treatment.

No significant MOP or EFB effects were recorded in 1989.

Table 56: Trial 312 yield data

TRTMNT	1989 Wt of bunches t/ha	1989 No of bunches /ha	1989 s.b.w. kg
N 0	25.3	1536	16.5
N 1	29.6	1587	18.7
N 2	31.8	1768	18.1
N 3	30.0	1644	18.2
K 0	30.6	1697	18.0
K 1	27.5	1579	17.4
K 2	29.7	1647	18.1
K 3	28.8	1612	17.9
EFB 0	30.0	1690	17.7
EFB 1	28.3	1577	18.0
$lsd_{.05}$ (EFB)	4.4	270	1.1
$lsd_{.05}$ (N&K)	6.2	382	1.6
c.v.(%)	18	20	8

Palm growth results for 1989 are show in Table 57. For growth the variation is substantially less than for yield, but statistically significant responses were only recorded for SOA. In particular SOA significantly increased vegetative dm production, which is usually closely related to bunch production.

Examination of the data also indicates a trend towards raised frond weights with application of MOP, which is similar to response in other trials, but the effects of SOA appear substantially greater even in this respect.

This trial is still at a very early stage, and it is expected that responses will become clearer as the trial progresses.

Table 57: Trial 312 Growth and conversion data 1989

TRTMNT	1989 Leaf prodn (n)	1989 Frond wt (FW)	1989 Frond dm (FDM)	1989 Bunch dm (BDM)	1989 Vegetative dm (VDM)	1989 Total dm (TDM)	1989 Bunch index (BI)
N 0	20.4	3.57	9.2	20.8	12.6	33.3	0.617
N 1	21.2	3.56	9.6	24.3	13.3	37.6	0.639
N 2	21.3	3.68	9.9	26.4	13.9	40	0.65
N 3	21.6	3.81	10.4	24.6	14.3	38.9	0.629
K 0	20.8	3.58	9.4	25.1	13.3	38.4	0.648
K 1	21.1	3.68	9.8	22.6	13.4	36.0	0.624
K 2	21.1	3.73	10.0	24.4	13.9	38.2	0.635
K 3	21.4	3.63	9.8	23.6	13.6	37.2	0.629
EFB 0	21.3	3.64	9.8	24.6	13.7	38.3	0.64
EFB 1	21.0	3.67	9.8	23.2	13.4	36.6	0.628
$lsd_{.05}$ (EFB)	0.6	0.23	0.4	3.6	0.6	4.0	0.034
$lsd_{.05}$ (N&K)	0.9	0.32	0.6	5.1	0.9	5.7	0.048
c.v.(%)	4	8	5	18	6	13	7

2. Plant Analyses

Table 58 indicates the initial leaf and rachis data compiled prior to commencement of the trial.

Table 58: Trial 312 Initial leaf and rachis data 1988

	LEAF N%	P%	K%	S%	Ca%	Mg%	Cl%	RACHIS April 88 K%	Ca%	%Mg
Block 1	2.475	0.174	0.844	0.184	0.893	0.279	0.362	1.169	0.352	.080
Block 2	2.513	0.174	0.837	0.188	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

Table 59: Trial 312, Progressive changes in yield and nutrient status

N K EFB		88	89	AVG
0 0 0				
Plot	Yield		34.4	34.4
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	1.41
	Ca%	0.88	0.63	0.76
	Cl%	0.36	0.25	0.31

N K EFB		88	89	AVG
0 2 0				
Plot	Yield		22.9	22.9
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	1.36
	Ca%	0.86	0.62	0.74
	Cl%	0.35	0.37	0.36

N K EFB		88	89	AVG
0 0 1				
Plot	Yield		16.5	16.5
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	1.17
	Ca%	0.89	0.61	0.75
	Cl%	0.43	0.32	0.38

N K EFB		88	89	AVG
2 0 0				
Plot	Yield		35.5	35.5
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	88	89	AVG
2 0 1			
Plot		33.1	33.1
29	2.5	2.37	2.44
	0.17	0.158	0.16
	0.85	0.87	0.86
	1.34	1.35	1.35
	0.98	0.73	0.86
	0.32	0.29	0.31

N K EFB	88	89	AVG
3 3 0			
Plot		37.6	37.6
31	2.5	2.37	2.44
	0.17	0.154	0.16
	0.78	0.92	0.85
	1.14	1.38	1.26
	0.97	0.65	0.81
	0.4	0.49	0.45

N K EFB	88	89	AVG
3 3 1			
Plot		31.5	31.5
	2.4	2.34	2.37
	0.17	0.159	0.16
	0.88	0.92	0.9
	1.16	1.66	1.41
	0.9	0.69	0.8
	0.33	0.41	0.37

SUMMARY

In general responses have developed less rapidly than in Trial 311, and the higher level of error variation has tended to obscure treatment effects.

A clear response to SOA at rates of N1 and above was identified, but no significant response to MOP or EFB was recorded in the first full year of recording.

TRIAL 313, MISSING NUTRIENT SOIL POT TRIAL SERIES

PURPOSE:

To assess potential major and minor nutrient deficiencies on soils from estates, either currently planted to oil palm, or with future planting potential.

INTRODUCTION

David Coomes, an undergraduate student from Cambridge UK, assisted in setting up the trials during an 8 week visit. His contribution is gratefully acknowledged.

The series currently consists of 5 separate trials, using maize, oil palm and cocoa as the indicator plants. Maize was used to provide rapid results, oil palm as a benchmark, and cocoa as an additional indicator plant for the Mamba soils.

Soil details are presented in Table 60, and details for each individual trial are reported separately.

Table 60: Soil Characteristics

Soil origin:								
Number	1	2	3	4	5	6	7	8
Location	Sagarai	Gili-Gili	Gili-Gili	Waigani	Waigani	Mamba	Mamba	Mamba
Detail	Nursery	Corran-ous	Corran-ous	Ex-forest	Ex-coconut	LT	UT	RT
Depth (cms)	0-15	0-15	15-30	0-15	0-15	0-15	0-15	0-15
Texture:	Clay loam	Clay	Clay	Clay loam	Loam	Sandy loam	Sandy loam	Sandy loam
Particle distribution:								
Coarse sand %	3	17	14	6	36	23	24	21
Fine sand %	32	7	9	16	8	39	39	43
Silt %	37	35	33	47	31	29	27	26
Clay %	28	41	44	31	25	9	10	10
Chemical analysis:								
Bulk density g/ml	0.96	1.04	1.06	0.96	0.99	0.93	0.85	1.05
pH	6.9	7.4	7.8	6.8	6.5	5.3	5.4	5.1
Phosphorus p.p.m.		4	4	6	2	4	4	9
Extractable cations me/100g								
Potassium	0.36	0.24	0.23	0.3	0.17	0.22	0.22	0.19
Calcium	19.7	58.6	29.5	33.4	11.3	1.2	3	1.3
Magnesium	6.11	2.09	1.34	13.99	5.45	0.28	0.36	0.32
Sodium	0.07	0.07	0.08	0.37	0.2	0.05	0.05	0.04
CEC me/100g	29	61	61	52	21	11	15	8
Percentage saturation								
Potassium	1.3	0.4	0.4	0.6	0.8	2	1.4	2.3
Calcium	69	96	97	64	52	11	20	15
Magnesium	21.3	3.4	2.2	26.9	25.4	2.5	2.4	3.8
Sodium	0.2	0.1	0.1	0.7	0.9	0.4	0.3	0.4
Other								
Organic Matter %	4	4.2	3.1	3.5	3	6.5	9.3	2.7
Total N %	0.25	0.22	0.21	0.35	0.2	0.62	0.88	0.19
Phosphate retn %	31	43	74	36	52	91	96	35

Trial 313 (a) Maize Trace Element Trial

TRIAL DETAILS :

Location: Adjacent to OPRA premises at HOPPL.
Genetic material: Commercial corn seed.
Soils: 8 soils as described above.
Planting date: August 1988
Size: The trial comprised 392 experimental plants plus guard rows around the trial.

DESIGN AND TREATMENTS

DESIGN :

Statistical background: Trial 313(a) is a randomised block split plot trial, consisting of 7 replicates, each divided into 8 main plots (soils). The main plots are split into 7 for nutrients.

Layout: The split plots are unguarded single pots.

TREATMENT DETAILS :

Trial commencement: August 1988
First fertilizer application: 18/8/88
Trial progress: Completed 25/10/88.
Treatments:

Compound fertilizer of analysis 15:15:6:4 was applied as the source of major nutrients. Trace elements were applied at the commencement of the trial and fortnightly, with treatment structure as follows:

Treatments for trial 313(a)

Treatment:	Mixed TE	Fe	Chelated Cu	Zn	Mn	Comment
A	+	0	0	0	0	Commercial mixed TE
B	0	+	+	+	+	Full treatment
C	0	0	+	+	+	No Fe
D	0	+	0	+	+	No Cu
E	0	+	+	0	+	No Zn
F	0	+	+	+	0	No Mn
G	0	0	0	0	0	No TE

RESULTS :

Table 61: Harvested dry matter for Maize with TE Application

TABLE OF MEANS: g/plant

FERTILIZER TREATMENTS

		A	B	C	D	E	F	G	Average
SOILS	1	37.9	40.0	39.9	30.7	30.7	32.7	39.0	**35.8**
	2	19.4	33.7	22.3	18.1	29.0	21.3	20.0	**23.4**
	3	8.0	22.3	11.6	20.1	21.0	17.6	15.3	**16.6**
	4	47.1	51.0	54.3	46.0	39.9	36.3	46.9	**45.9**
	5	36.9	37.9	21.4	29.7	37.1	18.6	16.1	**28.2**
	6	26.4	24.0	23.7	27.7	17.1	30.9	24.6	**24.9**
	7	30.7	34.9	25.4	43.4	24.7	37.9	34.4	**33.1**
	8	8.3	14.0	15.1	6.9	6.9	14.6	23.6	**12.8**
Average		26.8	32.2	26.7	27.8	25.8	26.2	27.5	27.6

COMPARISONS

	sd	cv	lsd
Soil<>Soil	19.43	70	7.85
Fert <> Fert	14.75	53	5.58
Fert <> Fert (1 soil)			15.77
Fert <> Fert (2 soils)			16.58
Soil<>Soil (1 or 2 ferts)			16.58

In extrapolating results to oil palm it must be borne in mind that maize is a more sensitive plant than oil palm, and that indications of deficiencies in a pot trial are not always corroborated in the field. Also in comparisons between soils, growth in pots is not the same as growth in the field, and maize has different soil requirements from oil palm. Thus whilst the indications particularly for nutrients give a valid guide to possible problems and requirements in the field, it is only a guide, which requires subsequent confirmation by further work in the field.

Under the trial conditions, with generous applications of commercial major nutrient fertilizer, there was no overall significant difference between omission of the trial trace elements. This confirms a major influence of the main nutrients on these soils in the short term, but does not rule out trace element responses in the longer term. Major and highly significant differences did arise between the soils within the trial.

For soils, the Waigani ex forest soil proved the best, followed by Sagarai and the Mamba UT. The worst growth was on the Mamba RT and the Corranous sub soil. In fact it is surprising that growth on the Corranous sub-soil was not even poorer, bearing in mind that this was the only sub-soil included in the trial.

Examination of the detailed results between individual plots does indicate a number of trends developing, which provide a basis for careful consideration of trace element requirements in the field.

Overall treatment b (including high levels of Fe, Cu, Zn and Mn) gave clearly higher yield than any of the other treatments. Of more interest is the effect of nutrients on individual soils.

For Milne Bay on the Waigani ex-coconut soil both treatments omitting Mn gave poor results. On the GiliGili corranous sub-soil, all treatments including Fe gave clearly higher yields.

At Mamba on the UT soil treatments without Cu yielded well. For both UT and LT omission of Zn decreased yield, but omission of Mn improved yield. The RT soil gave best results in the absence of any TEs, but combinations including both Cu and Zn also yielded better than others.

CONCLUSIONS

The major aim of the trial is to identify possible nutrient problems. Differences between comparative soil performance may not reflect field performance with oil palm, but further investigation would be justified for any soils giving particularly poor performance.

Only soils had an overall statistically significant difference. The best growth was on the Waigani ex-forest soil, and better than average growth was found on the Sagarai and Mamba UT soils.

Poor growth occurred on the Mamba RT soil, and on the Gili-Gili corranous sub-soil. On the other hand oil palms are presently growing satisfactorily in both these locations.

For TE nutrients, supplementation of Fe, Cu, Zn and Mn provided the highest yields overall.

For individual soils, the problem areas at Milne Bay appear to be ex-plantation soils and the corranous soils. At Waigani the ex-coconut soil benefitted from Mn application, and at GiliGili the corranous soil benefitted from Fe application.

The Mamba soils exhibited various trace element problems. Mn appeared potentially toxic, and on the UT soil additional Cu appeared harmful. Zn however was beneficial on all Mamba soils, and Cu possibly also beneficial on the RT soil.

Trial 313 (b)   Maize Major Nutrient Trial

TRIAL DETAILS :

Location: Adjacent to OPRA premises at HOPPL.
Genetic material: Commercial corn seed.
Soils: 3 Mamba soils.
Planting date: August 1988
Size: The trial comprised 126 experimental plants plus guard rows around the trial.

EXPERIMENTAL DESIGN :

Statistical background: Trial 313(b) is a randomised block split plot trial, consisting of 7 replicates, each divided into 3 main plots (soils). The main plots are split into 6 for nutrients.

Layout: The split plots are unguarded single pots.

TREATMENT DETAILS :

Trial commencement: August 1988
First fertilizer application: 18/8/88
Trial progress: Completed 25/10/88
Treatments:

SOA, TSP, MOP, Kieserite and commercial TE mix were applied in various combinations at fortnightly intervals, with treatment structure as follows:

Treatments for trial 313(b)

Treatment:	Mixed TE	SOA	TSP	MOP	Kies	Comment
A	+	+	+	+	+	Full
B	+	0	+	+	+	No SOA
C	+	+	0	+	+	No TSP
D	+	+	+	0	+	No MOP
E	+	+	+	+	0	No Kieserite
G	0	0	0	0	0	Control

RESULTS :

Table 62: Harvested dry matter for Maize with Major Nutrient Applications

TABLE OF MEANS: g/plant

FERTILIZER TREATMENTS

		A	B	C	D	F	G	Average
SOILS	6	31.7	16.5	2.3	11.3	16.7	2.7	13.5
	7	26.0	14.5	0.0	6.8	3.0	2.2	8.8
	8	31.5	17.3	0.0	4.8	21.8	3.8	13.2
Average:		**29.7**	**16.1**	**0.8**	**7.7**	**13.8**	**2.9**	11.8

COMPARISONS

	sd	cv	lsd
Soil<>Soil	11.72	99	5.80
Fert <> Fert	10.46	88	6.97
Fert <> Fert (1 soil)			12.08
Fert <> Fert (2 soils)			12.33
Soil<>Soil (1 or 2 ferts)			12.33

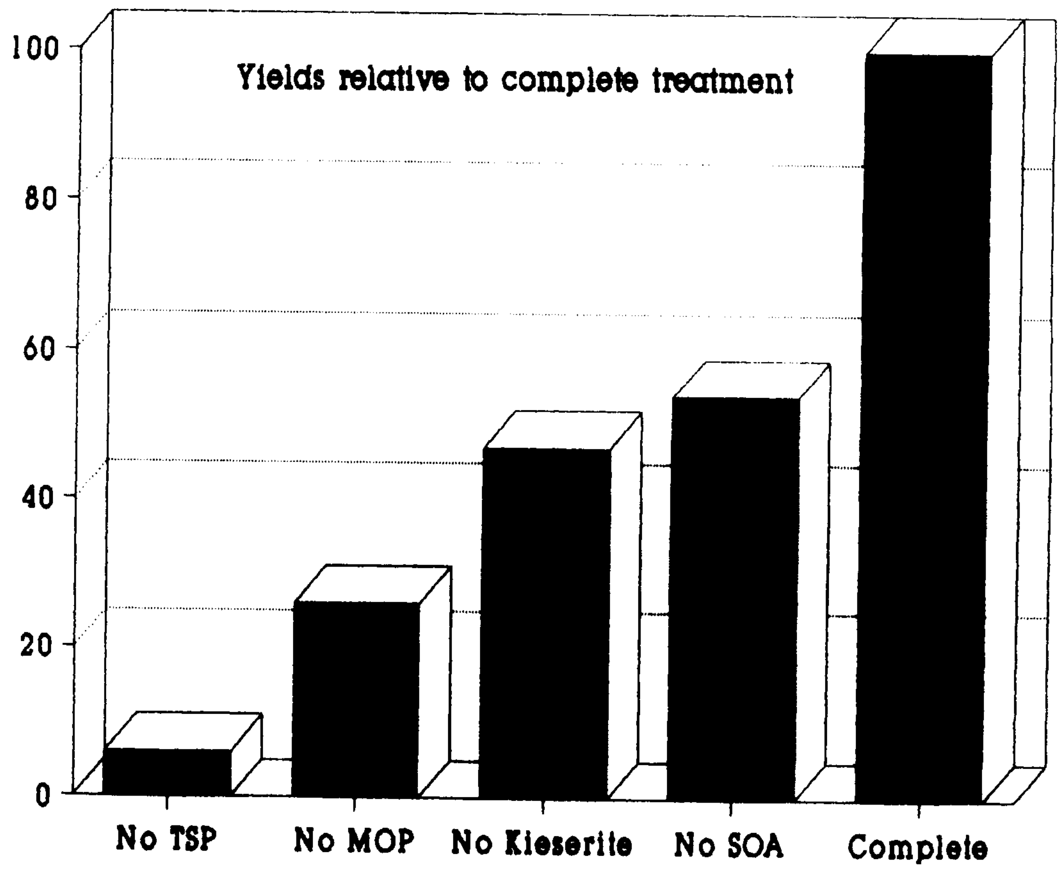


Figure 13: Relative Yields for Trial 313(b)

In extrapolating results to field practice for oil palms the provisos indicated in section 313(a) should be borne in mind.

Differences between soils were not significant. Differences between nutrients were highly significant.

For nutrients the complete treatment (a) was significantly superior. The omission of TSP virtually prevented growth (6% of the full treatment). Very poor growth also occurred with omission of MOP (26%). Omission of SOA or Kieserite was the least harmful, but even these treatments only attained 50% of the yield of the full treatment.

Although not identified by these results, soil analysis indicates that the RT soil has a substantially lower phosphate fixation capacity than the other 2 Mamba soils.

CONCLUSIONS

The results indicate potential requirement for fertilizing with all 4 major nutrients on the 3 Mamba soils. In order of response, application of phosphate was essential, MOP application was the next requirement, and major benefit was also obtained by inclusion of SOA and Kieserite.

Trial 313 (c) Oil Palm Trace Element Trial

TRIAL DETAILS :

Location: Adjacent to OPRA premises at HOPPL.
Genetic material: Commercial Dami DxP seed.
Soils: 3 Mamba soils.
Planting date: August 1988
Size: The trial comprises 147 experimental plants plus guard rows around the trial.

EXPERIMENTAL DESIGN :

Statistical design: Trial 313(c) is a randomised block split plot trial, consisting of 7 replicates, each divided into 3 main plots (soils). The main plots are split into 7 for nutrients.

Layout: The split plots are unguarded single pots.

TREATMENT DETAILS :

Trial commencement: August 1988
First fertilizer application: 22/8/88
Trial progress: Ongoing
Treatments:

Compound fertilizer of analysis 15:15:6:4 is applied as the source of major nutrients. Trace elements were applied at the commencement of the trial and monthly, with treatment structure as shown (Table 63).

Table 63: Treatments for Trial 313(c)

Treatment:	Mixed TE	Fe	Chelated Cu	Zn	Mn	Comment
A	+	0	0	0	0	Commercial mixed TE
B	0	+	+	+	+	Full treatment
C	0	0	+	+	+	No Fe
D	0	+	0	+	+	No Cu
E	0	+	+	0	+	No Zn
F	0	+	+	+	0	No Mn
G	0	0	0	0	0	No TE

RESULTS:

Assessment was made of the final health index, and final fresh and dry weights. Since all results were similar only the final dry weight is presented in Table 64.

Overall the differences between the 3 Mamba soils and between treatments were not statistically significant. This is not surprising, since young oil palm seldom exhibit serious trace element deficiencies. In the nursery trace elements are available both from seed reserves, and also possibly through watering.

Certain trends could be observed, generally confirming the results obtained with the maize trace element trial 313(a). The LT soil benefitted from Fe and Cu, whilst Zn and Mn were detrimental.

The UT soil benefitted from Zn and Fe applications. Cu was detrimental.

The RT soil did not show any benefit from TE applications.

In extrapolating these results it must be borne in mind that indications of deficiencies in a pot trial are not alwayscorroborated in the field. Also in comparisons between soils, growth in pots is not the same as growth in the field . Thus whilst the indications particularly for nutrients give a valid guide to possible problems and requirements in the field, it is only a guide, which requires subsequent confirmation by further work in the field.

Table 64: Harvested dry weight for Oil Palm with TE Applications

TABLE OF MEANS: grams/plant

		FERTILIZER TREATMENTS							
		A	B	C	D	E	F	G	Average
SOILS	6	48.6	53.1	46.3	49.7	58.8	56.2	60.4	53.3
	7	47.6	53.1	51.3	58.8	44.4	52.8	53.1	51.6
	8	53.9	54.1	53.1	57.4	56.5	58.7	64.2	56.8
Average:		50.0	53.4	50.3	55.3	53.2	55.9	59.2	53.9

COMPARISONS	sd	cv	lsd
Soil<>Soil	13.7	25	6.1
Fert <> Fert	13.9	26	8.6
Fert <> Fert (1 soil)			14.9
Fert <> Fert (2 soils)			14.9
Soil<>Soil (1 or 2 ferts)			14.9

CONCLUSIONS

Trace element response in the nursery stage is relatively limited, and differences did not develop to a statistically significant level.

The results with oil palm generally confirm that maize was a suitable 'indicator' plant for identification of potential trace element deficiencies. In comparing the two, the oil palm is a more "robust" plant.

Examination of individual plot yields indicated the development of trace element effects as follows:

a) The LT soil benefitted from Fe and Cu supplementation, whilst Zn and Mn were detrimental.

b) The UT soil benefitted from Zn and Fe applications. Cu was detrimental.

c) The RT soil did not show any benefit from TE applications.

Trial 313 (d) Oil Palm Major Nutrient Trial

TRIAL DETAILS :

Location: Adjacent to OPRA premises at HOPPL.
Genetic material: Commercial Dami DxP seed.
Soils: 8 soils: for details see introductory section.
Planting date: August 1988
Size: The trial comprised 392 experimental plants plus guard rows around the trial.

EXPERIMENTAL DETAILS :

Statistical design : Trial 313(d) was a randomised block split plot trial, consisting of 7 replicates, each divided into 8 main plots (soils). The main plots were split into 7 for nutrients.

Layout: The split plots were unguarded single pots.

TREATMENT DETAILS :

Trial commencement: August 1988
First fertilizer application: 22/8/88
Trial progress: Completed May 1989
Treatments:

SOA, TSP, MOP, Kieserite and commercial TE mix were applied in various combinations at fortnightly intervals, with treatment structure as shown (Table 65).

Table 65: Treatments for Trial 313(d)

Treatment:	Mixed TE	SOA	TSP	MOP	Kies	Comment
A	+	+	+	+	+	Full
B	+	0	+	+	+	No SOA
C	+	+	0	+	+	No TSP
D	+	+	+	0	+	No MOP
E	+	+	+	+	0	No Kieserite
F	0	+	+	+	+	No TE
G	0	0	0	0	0	Control

RESULTS :

All palms have been harvested, and fresh and dry weights and health index recorded. Since all 3 measurements are in close agreement, only Table 66, showing final dry weights is presented.

Table 66: Harvested dry weight of Oil Palm with Major Nutrient Application

TABLE OF MEANS: grams/plant

		FERTILIZER TREATMENTS							
		A	B	C	D	E	F	G	Average
SOILS	1	52.3	17.3	50.8	51.3	45.8	40.7	15.4	**39.7**
	2	18.3	11.1	15.5	23.2	28.6	21.0	10.4	**18.3**
	3	15.4	7.3	12.7	17.3	25.8	19.4	7.3	**15.0**
	4	42.1	16.7	23.2	33.1	34.9	44.5	19.7	**30.6**
	5	37.2	8.0	22.8	17.3	33.2	43.2	9.7	**24.5**
	6	35.3	15.5	16.3	28.1	34.5	36.7	12.9	**25.6**
	7	26.4	16.2	12.3	13.7	24.3	33.5	9.1	**19.4**
	8	38.8	10.4	16.5	26.2	30.0	33.5	9.6	**23.6**
Average		**33.2**	**12.8**	**21.3**	**26.3**	**32.2**	**34.1**	**11.8**	24.5

COMPARISONS

	F	sd	cv	lsd
Soil<>Soil	***	10.7	43	4.3
Fert <> Fert	***	11.1	45	4.2
Fert <> Fert (1 soil)				11.8
Fert <> Fert (2 soils)				11.8
Soil<>Soil (1 or 2 ferts)				11.8
Interaction Soil <> Fertilizer	***			

Caution is obviously necessary in extrapolating pot trial results to field application: they are rather a guide to further research in the field, than complete in themselves.

The oil palm major nutrient trial identified highly significant differences ($p < 0.001$) between soils, fertilizers and also for interactions between soils and fertilizers.

Table 67 indicates the ranking between soils.

Table 67: Soil Performance Ranking: Harvested Dry Weights

Soils	Percentage
Sagarai	100
Waigani Ex-forest	78
Waigani Ex-coconut; Mamba LT; Mamba RT	60 - 66
Mamba UT; Gili Gili corranous	38 - 50

The differences in performance in pots do not necessarily correctly reflect field performance. For example, the limited soil volumes, and unusual growth conditions mean that free draining soils may be particularly prone to leaching and moisture stress. However there is likely to be some correlation, and there is a possibility that the Mamba UT and Gili Gili corranous soils may have some limitations for oil palms. On the other hand the data confirms the likely potential for oil palm growth particularly at Sagarai, and also at Waigani and on the Mamba LT and RT soils.

For fertilizers, treatments omitting nitrogen generally performed very poorly, apart from the Mamba UT soil, which had very high OM and total N levels. Omisssion of kieserite generally had only a minor depression on yield.

Under pot trial conditions one would normally expect N deficiency. However, in the field the soil may meet the crop's N requirement for a number of years before supplementation is necessary. For TSP the seedling stage has particularly high P sensitivity, which again may not be reflected by older palms in the field. For MOP the seedling stage has a relatively minor requirement, and field needs could be under-estimated by a pot trial. For trace elements this trial has not given any clear indications. With mixed trace elements as used in this trial effects were generally minor. Interpretation of any effects is difficult, since certain components of the mixture may bebeneficial, and others toxic.

For specific soils, the Sagarai soil indicated only a requirement for N: reasonable growth was obtained in the absence of TSP, MOP and kieserite. The Gili Gili soils benefitted from the omission of kieserite, and one of the Waigani soils indicated a possible benefit from TSP application.

The Mamba UT and LT soils required TSP. The UT soil also benefitted from MOP application. Kieserite was not beneficial on the LT soil. The RT soil differed, showing mainly a response to SOA applicaiton.

CONCLUSIONS :

Overall differences between the soils, differences between fertilizers, and fertilizer x soil interactions were all significantly different ($p < 0.001$).

The major response was to SOA (except on the Mamba UT soil) indicating a requirement of N on all these soils in the long term.

Kieserite depressed performance on the Gili Gili soils, in keeping with the general Mg/K imbalance at Milne Bay.

The Mamba UT and LT soils benefitted from TSP, and also MOP on the UT, confirming the requirement for generous fertilizing at Mamba. Poorest growth overall was on the Gili Gili corranous soils and on the Mamba UT soil.

Trial 313 (e) Cocoa Major Nutrient Trial

TRIAL DETAILS :

Location: Lejo cocoa nursery, HOPPL.
Genetic material: A single selected HOPPL cross.
Soils: 3 Mamba soils.
Planting date: 7th August 1988
Size: The trial comprised 147 experimental plants plus guard plants at the edge of the trial.

EXPERIMENTAL DESIGN :

Statistical background: Trial 313(e) was a randomised block split plot trial, consisting of 7 replicates, each divided into 3 main plots (soils). The main plots were split into 7 for nutrients.

Layout: The split plots were unguarded single pots.

TREATMENT DETAILS :

Trial commencement: August 1988
First fertilizer application: 26/10/88
Trial progress: Completed March 1989
Treatments:

SOA, TSP, MOP, Kieserite and commercial TE mix were applied in various combinations at fortnightly intervals, with treatment structure as shown (Table 68).

Table 68: Treatments for Trial 313(e)

Treatment:	Mixed TE	SOA	TSP	MOP	Kies	Comment
A	+	+	+	+	+	Full
B	+	0	+	+	+	No SOA
C	+	+	0	+	+	No TSP
D	+	+	+	0	+	No MOP
E	+	+	+	+	0	No Kieserite
F	0	+	+	+	+	No TE
G	0	0	0	0	0	Control

RESULTS :

All plants have been harvested, and fresh and dry weights and health indices recorded. Growth was rather variable, and generally unhealthy, but this did not obscure treatment differences.

The final health index has been selected as the most discriminating assessment of performance, which is also corroborated by final height and harvest measurements.

Table 69: Final health index for Cocoa with major nutrients

TABLE OF MEANS:

		FERTILIZER TREATMENTS							
		A	B	C	D	E	F	G	Average
SOILS	6	1.7	0.7	1.7	1.6	1.7	1.7	1.0	**1.4**
	7	1.3	0.7	1.4	1.6	1.0	1.6	1.1	**1.2**
	8	1.6	0.6	0.7	1.0	1.4	0.9	0.4	**0.9**
Average:		**1.5**	**0.7**	**1.3**	**1.4**	**1.4**	**1.4**	**0.9**	1.2

COMPARISONS

	F	sd	cv	lsd
Soil<>Soil	*	0.87	73	0.39
Fert <> Fert	***	0.59	49	0.36
Fert <> Fert (1 soil)				0.63
Fert <> Fert (2 soils)				0.68
Soil<>Soil (1 or 2 ferts)				0.68

Health Index Scoring:

0	Dead
1	Dying
2	Small - unhealthy
3	Normal - healthy
4	Large with good appearance

Overall the results indicate a significant difference between the 3 Mamba soils ($p < 0.05$) and also between fertilizers ($p < 0.001$) but caution is needed in extrapolation of the results to the field.

For soils the RT soil had the poorest overall performance for cocoa.

For fertilizers omission of SOA depressed performance on all 3 soils. The RT soil also benefitted from inclusion of TSP and TE mixture. This may reflect rooting problems for the seedlings in this medium.

CONCLUSIONS :

There were significant differences between the 3 Mamba soils ($p < 0.05$) amd also between fertilizers ($p < 0.001$).

The performance of the RT soil with cocoa was inferior to that of the other 2 soils.

The major fertilizer response identified was to SOA

Overall conclusions :

1. Interpretation:
The major aim of the trial was to identify possible nutrient problems. Differences in a pot trial may not accurately reflect field performance, but can provide initial guidlines.

Particular limitations were as follows:

a) Under pot trial conditions one would normally expect N deficiency. However, in the field the soil may meet the crop's N requirement for a number of years before supplementation is necessary.

b) For TSP the seedling stage has particularly high P sensitivity, which again may not be reflected by older palms in the field.

c) For MOP the seedling stage has a relatively minor requirement, and field needs may be under-estimated by a pot trial. This was confirmed for Milne Bay, where the major field requirement was not reflected by the pot trial results.

d) The use of trace element mixtures has not given any clear results. Effects were generally minor and interpretation was difficult, since certain components of the mixture may have been beneficial and others toxic.

e) Pot results may not accurately indicate field growth, since conditions are not identical, and anomalous responses to soil physical conditions can arise: for instance poor performance could have arisen from poor water retention in the polybags with free draining soils, rather than as a genuine indication of field performance.

2. Indicator plants:

The results with oil palm generally confirm that maize to be a suitable 'indicator' plant for identification of potential deficiencies. In comparing the two, the oil palm is a more "robust" plant, being less affected by deficiencies.

Cocoa did not prove to be a good "indicator" plant for oil palm, and again oil palm was more robust.

3. Soils:

There were considerable differences identified between growth on the various soils in the trial:

a) The Sagarai soil was particularly good.

b) Growth was poorest on the Mamba UT and also on the Gili Gili corranous soils. Whilst this would indicate possible limitations for oil palm on the latter soils, careful interpretation is necessary, since conditions in the field may not be identical to those in a pot trial.

4. Trace Elements:

The influence of TE's was minor compared with the role of the major nutrients, and often differences were not statistically significant.

At Milne Bay the Waigani ex-coconut soil benefitted from applications of Mn but analyses have not indicated any deficiency of this element in the field. The Gili Gili corranous soils benefited from Fe applications.

The Mamba soils had relatively complex trace element relationships, which appeared to be as follows:

a) On all 3 soils Mn was toxic.
b) On the UT and LT soils Fe was beneficial.
c) The UT soil benefitted from Zn, whilst Cu was harmful.
d) The LT soil benefitted from Cu, whilst Zn was harmful.
e) The RT soil may have benefitted marginally from Cu.

5. Major Nutrients:

Highly significant differences emerged, mainly due to a major effect from SOA on all soils except the Mamba UT. Kieserite effects were generally minor.

At Mamba there was a potential requirement for all nutrients, particularly P, but also with identified requirements for N on the RT and K on the UT. However Kieserite on the LT soil and SOA on the UT soil were not beneficial.

At Milne Bay Kieserite was harmful on the Gili Gili corranous soils, confirming the general Mg/K imbalance shown by trial 501

TRIALS 314 & 315, SMALLHOLDER DEMONSTRATION SITES, ORO 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 (eg 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 17 sites up to 60km apart and throughout the major smallholder oil palm areas of Oro Province. Locations are marked on the map in Fig. 14.

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 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.
The remainder of the soils are less easily characterised as a group, and generally posess 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.

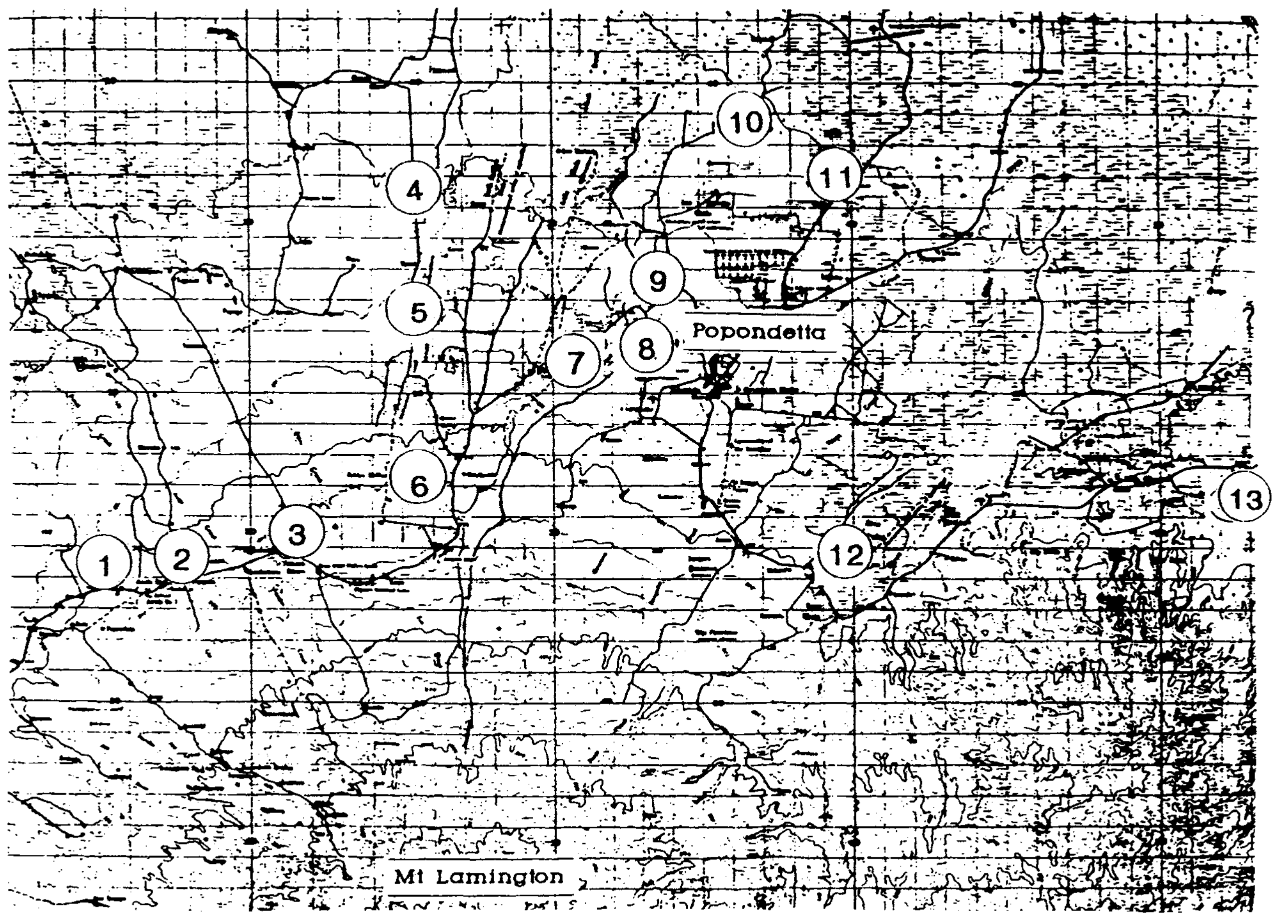
Planting dates: Various.

Density: 120 palms per hectare.

Size: The trial presently comprises 17 sites: 16 of 4 ha and 1 of 2 ha - total 66 ha. At each site the entire block is fertilized. On the 4 ha holdings there are 6 experimental plots (150 experimental points, 294 points with guards). On the 2 ha holding there are only 4 plots.

Fig. 14. 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
260002	Dobuduru	8
300029	Waseta	1
320012	Saiho	2
390001	Agenahambo	3
520003	Waru	4
881111	Embi	13



Trial naming: The trials have been divided into 2 groups:
1) Trial 314 being "Smallholder Demonstration Blocks" ie those in good condition, which it is hoped that fertilizer application will maintain as exemplary blocks.
2) Trial 315 being "Smallholder Rehabilitation Blocks" for blocks with low production, which it is hoped that fertilizer application may rehabilitate.

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. 2 of the 4 plots also receive TSP, and 2 do not.
Layout: To clarify details of the layout please refer to the map of a typical smallholder demonstration block in Figure 15, and Table 71 indicating the arrangement of the systematic treatments.

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 receeives 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 1989 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 application of 1kg/palm/year.

Table 70: Fertilizer rates

Demonstration plots: kg/palm in 1988
Location (W or E of the Ambogo river)

	Fertilizer	West	East
N	SOA	2.5	2.5
K	MOP	1	2

Systematic component rates in kg/palm/year

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

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

Figure 15: Trial 314: Example of trial block layout (Waru)

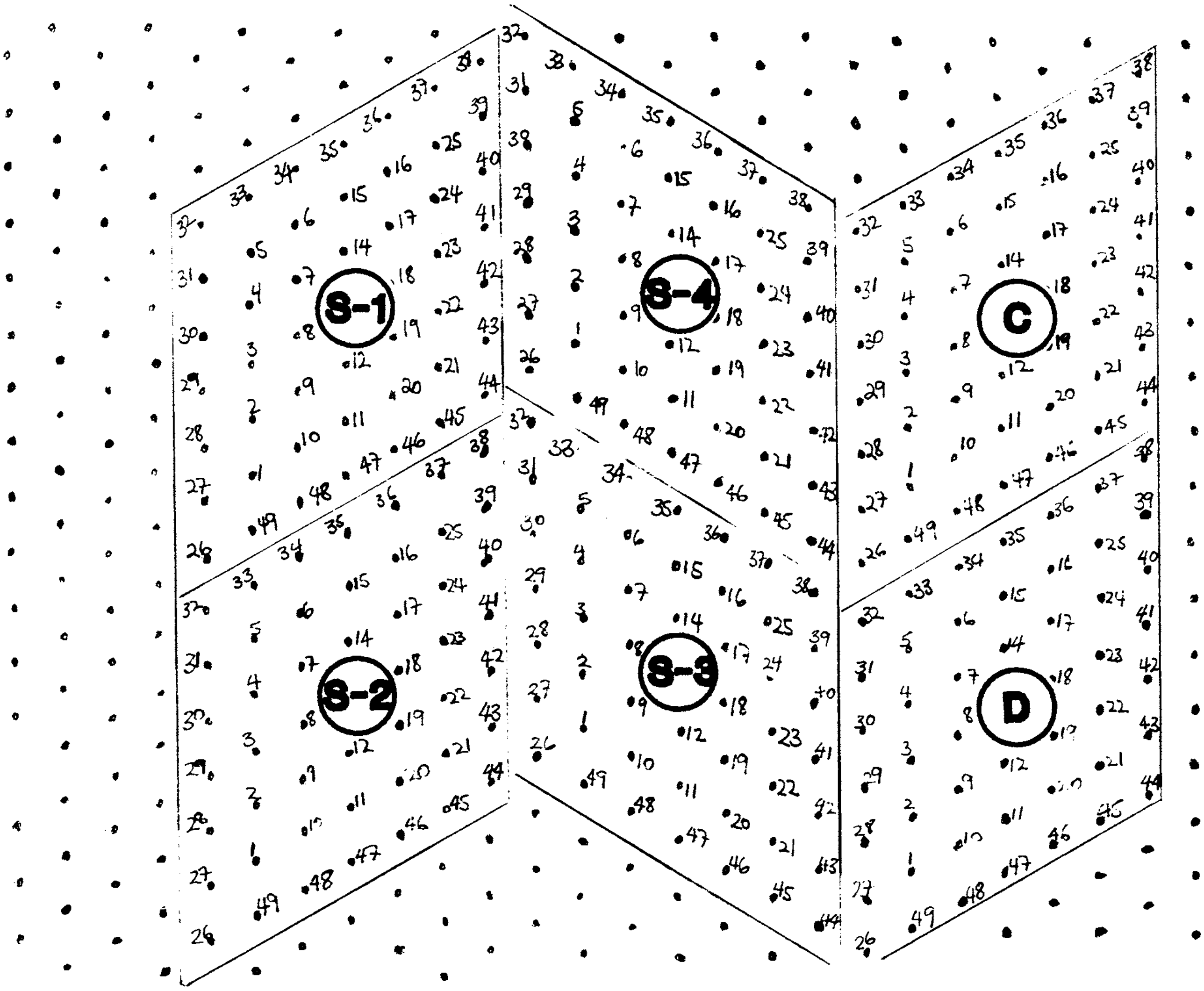


Table 72: Comparative Smallholder Baseline Performance Data

Location	Area	Block	First Hvst	Previous fertilizer	Year	Yield	Petiole c.s. D	Petiole c.s. C
West	Waseta	300029	19/7/82	1 kg MOP 8/88	1988	17.4	21.94	17
West	Waru	520003	11/9/80	1 kg MOP 1988	1988	7.5	34.66	29.95
West	Saiho	320012	6/12/86	1kg MOP & 0.5 kg SOA 1988; 1kg SOA 1989	1989	21.6	28.2	24.3
West	Agenahambo	390001	1987	1 kg MOP 1988 1 kg SOA 1988	1989	24.3	24.4	24
West	Isavene	080079	2/9/80	0.8kg MOP & 0.4 kg SOA 1988; 0.8kg MOP & 0.6kg AMC 1989	1989	12.9	24	25.7
West	Isavene	101179	6/5/81	None	1988	12.1	26.14	27.21
West	Igora	111578	21/5/82	1 kg MOP 8/88	1988	15.8	37.84	31.55
West	Igora	111611	26/2/82	BA 2.5 kg 10/87	1988	18.2	20.9	23.7
West	Sangara	050157	12/10/82	1 kg SOA 10/88	1988	18.6	24.9	27.44
East	Dobuduru	260002	10/9/82	?	1988	11.1	20.19	19.1
East	E Ambogo	030309	2/9/80	0.5 kg SOA 1988	1988	12	24.52	29.4
East	Ahora	230003	8/7/81	SOA 1kg/plm 9/88	1988	12.5	27.04	
East	Sorovi	040232	30/1/81	BA 1 kg 1/88	1988	7.9	33.44	37.49
East	Sorovi (Biru)	040266	13/3/81	0.5 kg MOP 1989	1989	16.2	78.1	76.1
East	Sorovi	121779	1984	None	1989	22.6	26.4	25.1
East	Awowota	220010	21/8/81	?	1988	16	30.9	23.12
East	Embi	881111	27/8/82	1 kg MOP 1987 2 kg SOA 1988	1988	7.3	30.83	25.56

RESULTS:

Baseline data

Tables 72 to 74 indicate available baseline data for crop performance, leaf and soil status respectively, for the sites at the commencement of the trial. Soil samples for the most recent sites are still under analysis.

1. Yield

Considering the short period for which the trial has been in existence, the yield responses are remarkable, confirming clear differences observable in the field, and mainly attributeable to nitrogen application. It is to be expected that the responses will increase as the trial progresses.

Yield results obtained in 1989 in control and demonstration blocks are shown in Table 75. On average demonstration plots out yielded the control plots by 33%.

Yield results obtained in 1989 for different fertilizer levels are shown in Table 76 and 77 for individual and grouped sites respectively. The greatest response to N occurred with application of only 1.25 kg of SOA increasing yield by 16% (1.9 t/ha). Higher applications further increased yields, but by smaller increments. Responses to MOP or TSP were relatively minor.

For statistical analysis of the results it is intended to fit regression equations, when a sufficient period has been allowed for response to be clearly expressed. In the mean time the major effects are clear from an examination of the grouped data.

The blocks have been split into 3 groups according to soil characteristics, as outlined under the site detail heading above. Table 77 indicates differences in response between the 3 groups as follows:

The blocks located on the sandy group were initially the lowest yielding, and provided the greatest response to N and the least to other nutrients. Application at rate N2 (2.5 kg SOA) provided a 30% (2.4 t/ha) increase in yield, whilst N3 provided a 41% (3.2 t/ha) increase. The demonstration plots also achieved a similar 41% yield increase.

The blocks located on the organic volcanic group responses to SOA up to level 2 and also to MOP with a maximum response at K1. Yields were raised 18% (2.4 t/ha) at N2 and 15 % (2.1 t/ha) at K1. Thus the combination of fertilizers on the demonstration plots provided a 41% boost to yield (4.7 t/ha).

Table 73: Smallholder Baseline Leaf Data

Location	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
West	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
West	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; 1kg SOA 1989			2.7	0.16	0.92	0.98	0.26		0.27
West	Agenahambo	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
West	Isavene	080079	C	0.8kg MOP & 0.4 kg SOA	1989	12.9	2.3	0.146	0.98	0.75	0.21		0.26
			D	1988; 0.8kg MOP & 0.6kg AMC 1989			2.4	0.144	0.96	0.85	0.2		0.24
West	Isavene	101179	C	None	1988	12.1	2	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
West	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
West	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
West	Sangara	050157	C	1 kg SOA 10/88	1988	18.6	2	0.167	1.03	0.8	0.21	0.18	0.15
			D				2.1	0.166	1	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	0.156	0.74	0.94	0.34	0.15	0.15
East	E Ambogo	030309	C	0.5 kg SOA 1988	1988	12	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
East	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
East	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
East	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
East	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
East	Awowota	220010	C	?	1988	16	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
East	Embi	881111	C	1 kg MOP 1987	1988	7.3	2	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 74: Smallholder Baseline Soil Data

	Area	Block	Plot	Year	Yield	pH	P	Extractable cations	m.e./ 100g			CEC	Percentage saturation				OM	P	Total
							µg/m	K	Ca	Mg	Na	me 100g	K%	Ca%	Mg%	Na%	%	rtn %	N%
West	Waseta	300029	C	1988	17.4	6	3	0.23	9.4	1.35	0.06	18	1.3	53	7.7	0.4	9.4	82	0.58
			D			6.1	4	0.19	7.7	1.25	0.03	16	1.2	48	7.8	0.2	7.6	77	0.44
West	Waru	520003	C	1988	7.5	5.7	3	0.18	1.9	0.36	0.12	22	0.8	9	1.6	0.6	15.4	96	0.61
			D			5.3	4	1.33	2.8	0.62	0.13	24	5.6	12	2.6	0.5	16.6	96	0.59
West	Saiho	320012	C	1989	21.6														
			D																
West	Agenahambo	390001	C	1989	24.3														
			D																
West	Isavene	080079	C	1989	12.9														
			D																
West	Isavene	101179	C	1988	12.1	5	4	0.74	1.3	0.36	0.14	27	2.8	5	1.4	0.5	15.4		0.56
			D			5.3	9	0.42	0.9	0.23	0.11	23	1.8	4	1	0.5	13.5		0.42
West	Igora	111578	C	1988	15.8	6.1	3	0.11	4.2	0.56	0.03	15	0.7	28	3.6	0.2	9.1	90	0.46
			D			6.2	4	0.1	4.6	0.63	0.02	14	0.7	33	4.4	0.2	8.5	86	0.37
West	Igora	111611	C	1988	18.2	6.3	3	0.25	7.3	1.3	0.04	13	2	58	10.2	0.3	2.9	28	0.2
			D			6.2	3	0.15	7.2	1.3	0.09	12	1.2	61	10.9	0.7	2.8	25	0.16
West	Sangara	050157	C	1988	18.6	6.3	25	0.13	9.1	1.33	0.04	15	0.8	60	8.8	0.2	4.7	34	0.16
			D			6.4	7	0.12	6.8	1.04	0.02	11	1.1	63	9.6	0.2	3.5	23	0.14
East	Dobuduru	260002	C	1988	11.1	6.2	10	0.07	5.2	0.65	0.03	9	0.7	55	6.9	0.3	4.3	37	0.2
			D			6.4	7	0.07	5.8	0.83	0.05	10	0.7	56	8	0.5	4.3	34	0.24
													0						
East	E Ambogo	030309	C	1988	12	6.9	46	0.07	9.2	0.72	0.02	11	0.6	81	6.4	0.2	3.8	18	0.13
			D			6.9	36	0.08	8.7	0.82	0.03	11	0.7	79	7.5	0.2	3.3	15	0.16
East	Ahora	230003	C	1988	12.5	6.4	29	0.4	24.5	8.59	0.16	38	1.1	64	22.3	0.4	4.3	35	0.25
			D			6.5	27	0.34	26.1	6.56	0.08	38	0.9	69	17.4	0.2	5.5	34	0.33
East	Sorovi	040232	C	1988	7.9	6.3	5	0.28	6.1	1.73	0.05	12	2.3	50	14.1	0.4	4.3	29	0.28
			D			6.2	4	0.32	5.8	1.48	0.04	13	2.5	46	11.8	0.3	4.4	42	0.21
East	Sorovi (Biru)	040266	C	1989	16.2														
			D																
East	Sorovi	121779	C	1989	22.6														
			D																
East	Awowota	220010	C	1988	16	6.1	5	0.08	6.9	1.52	0.06	13	0.6	52	11.4	0.5	3.2	40	0.14
			D			6.2	3	0.08	7.8	1.26	0.06	13	0.6	59	9.4	0.4	3.3	41	0.12
East	Embi	881111	C	1988	7.3	6.3	4	0.07	1.7	0.33	0.03	7	1	24	4.6	0.4	4.5	46	0.15
			D			6.3	4	0.08	1.7	0.49	0.05	8	1	20	6	0.6	4.6	52	0.2

Table 75: Trial 314 Comparison of FFB yields (t/ha) for 1989

Block No	Name	First full year	Grouping	C	%	D	%	1988 Block mean	%	1989 Block mean	%	Neighbours mean	%
030309	E Ambogo	1989	Sandy	10.4	94	10.5	95	12	108	13.1	118	21.1	190
040266	Sorovi	1990	Sandy							16.2			
040232	Sorovi	1989	Sandy	9.7	87	13.8	124	7.9	71	10.3	93	8.8	79
050157	Sangara	1989	Clay loam	17.7	159	23.6	213	18.6	168	21.3	192	12.2	110
080079	Isavene	1990	Volcanic							12.9			
101179	Isavene	1989	Volcanic	10.8	97	13	117	12.1	109	16.3	147	13.4	121
111578	Igora	1989	Volcanic	15.2	137	20.2	182	15.8	142	17.4	157	13.1	118
111611	Igora	1989	Clay loam	12.6	114	19.3	174	18.2	164	20.1	181	17.7	159
121779	Sorovi	1990	Sandy							22.6			
220010	Avovota	1989	Clay loam	14	126	11.1	100	16	144	15.6	141	8.6	77
230003	Ahora	1989	Clay loam	8	72	10.1	91	12.5	113	13.4	121	7.8	70
260002	Dobuduru	1989	Sandy	4.2	38	9.3	84	11.1	100	10.5	95	3.9	35
300029	Waseta	1989	Volcanic	11.8	106	19.9	179	17.4	157	18.9	170	18	162
320012	Saiho	1990	Volcanic							21.6			
390001	Agenahambo	1990	Volcanic							24.3			
520003	Waru	1989	Volcanic	7.8	70	11.5	104	7.5	68	12.4	112	2	18
881111	Embi	1989	Sandy	10.5	95	15.8	142	7.3	66	11.6	105		
MEAN OVERALL		(n=12)		11.1	100	14.8	133	13	117	15.1	136	10.5	95
MEAN SANDY		(n=4)		8.7	78	12.4	112	9.6	86	11.4	131	8.5	77
MEAN VOLC. ORG.		(n=4)		11.4	103	16.1	145	13.2	119	16.3	143	11.6	105
MEAN CLAY LM		(n=4)		13.1	118	16	144	16.3	147	17.6	134	11.6	105

Note: Yields in t/ha. Percentages based on the overall mean for control.

Yields from 5 newest sites not included in mean values

Table 76: Trial 314 block yield summaries (t/ha/yr) 1989

Category: Volcanic

Site:	Isavene 101179	Igora 111578	Waseta 300029	Waru 520003	Mean
N0	13.08	14.81	16.58	9.94	13.6
N1	14.12	17.23	16.15	12.67	15.0
N2	15.90	14.61	19.63	13.73	16.0
N3	17.49	14.67	17.67	14.08	16.0
K0	12.55	14.57	16.34	11.32	13.7
K1	15.98	17.39	17.91	11.87	15.8
K2	15.89	15.81	16.42	12.61	15.2
K3	14.14	14.44	16.35	12.04	14.2
P0	14.45	15.29	16.55	11.76	14.5
P1	14.67	15.72	17.61	11.71	14.9
C	10.78	15.17	11.76	7.98	11.4
D	12.96	20.22	19.86	11.45	16.1
D>C%	120	133	169	143	141

Category: Sandy

Site:	O Srvi 040232	Dobuduru 260002	E Ambogo 030309	Embi 881111	Mean
N0	5.80	8.45	8.35	16.34	8.8
N1	9.39	9.65	10.29	13.39	10.3
N2	10.0	10.19	12.60	14.17	11.4
N3	12.1	11.14	12.14	14.68	12.2
K0	8.48	9.94	13.58	11.53	10.8
K1	8.50	8.17	11.15	14.26	10.0
K2	8.83	10.79	9.01	14.61	10.3
K3	9.15	9.63	8.89	15.20	10.1
P0	9.21	9.68	10.27	15.39	10.5
P1	8.31	9.03	11.1	12.17	9.9
C	9.68	4.17	10.39	10.48	8.7
D	13.76	9.26	10.45	15.81	12.3
D>C%	142	222	101	151	154

(**Table 76 continued)**

Category: Clay loam

Site:	Sangara 050157	Igora 111611	Awowota 220010	Ahora 230003	
N0	14.57	15.73	13.09	10.83	13.6
N1	19.21	19.07	12.79	14.07	16.3
N2	19.46	19.38	13.59	13.07	16.4
N3	18.89	19.61	15.18	13.88	16.9
K0	16.59	18.41	11.46	11.39	14.5
K1	15.84	18.67	14.46	11.02	15.0
K2	18.83	15.98	12.11	13.08	15.0
K3	17.72	18.81	15.39	13.53	16.4
P0	17.03	17.7	11.40	12.16	14.6
P1	18.36	18.63	15.06	12.45	16.1
C	17.65	12.64	14.00	7.99	13.1
D	23.61	19.26	11.09	10.08	16.0
D>C%	134	152	79	126	123

Table 77: Trial 314 yield data summaries 1989

	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	%
N 0	12.1	100	8.8	100	13.6	100	13.6	100
N 1	14	116	10.3	117	15	110	16.3	120
N 2	14.7	121	11.4	130	16	118	16.4	121
N 3	15.2	126	12.2	139	16	118	16.9	124
K 0	13.1	100	10.8	100	13.7	100	14.5	100
K 1	13.7	105	10	93	15.8	115	15	103
K 2	13.6	104	10.3	95	15.2	111	15	103
K 3	13.7	105	10.1	94	14.2	104	16.4	113
P 0	13.3	100	10.5	100	14.5	100	14.6	100
P 1	13.8	104	9.9	94	14.9	103	16.1	110
C	11.1	100	8.7	100	11.4	100	13.1	100
D	14.8	133	12.3	141	16.1	141	16	122

The clay loam grouping is more variable in terms of soil analysis. The yield advantage on the demonstration plots averaged a lower value of 22% (2.9 t/ha). Yield response was mainly to SOA with the N1 rate 20% (2.7 t/ha) above N0. There is also an indication of a possible 10% response to TSP on these soils, which will need to be monitored.

Growth parameters are also being compiled in addition to yield.

2. Plant Analysis

Leaf results for the control and demonstration plots in 1989 are shown in Tables 78 a and b.

The control plots confirm generally low levels of leaf 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 during the first year, with the greatest increases being in N and Cl levels.

In considering individual plots, there were 9 with critically depressed N levels. Of these, 4 were in the clay loam group (ie every block in the group), 3 in the sandy group and 2 in the organic group. There were also 7 blocks with particularly low K levels. 5 of these were on the organic soils (out of a total of 7), 1 on the clay loam and 1 on the sandy soils.

Nearly all blocks had low Cl levels, and for this reason inclusion of Ammonium chloride in the fertilizer programme is desirable. Most blocks do not appear to require K application.

Table 78a: Trial 314 - Leaf data 1989 (Individual blocks)

		N	%	P	%	K	%	Ca	%	Mg	%	Cl	%	First full year	Grouping
030309	D	2.09	97	0.144	101	0.85	101	0.75	99	0.24	110	0.18	82	1989	Sandy
	C	1.89	91	0.141	100	0.84	105	0.78	102	0.21	93	0.08	40		
040266	D	2.2	102	0.147	103	0.93	111	0.84	111	0.24	110	0.18	82	1990	Sandy
	C	2.3	111	0.151	107	1	125	0.81	105	0.23	102	0.16	81		
040232	D	1.97	91	0.133	93	0.8	95	0.55	73	0.2	91	0.17	77	1989	Sandy
	C	2.06	99	0.14	99	0.9	112	0.61	79	0.19	84	0.2	101		
050157	D	2.17	101	0.145	101	0.78	93	0.74	98	0.18	82	0.25	114	1989	Clay loam
	C	1.84	89	0.131	93	0.8	100	0.67	87	0.16	71	0.14	71		
080079	D	2.4	111	0.144	101	0.96	114	0.85	113	0.2	91	0.24	109	1990	Volcanic
	C	2.3	111	0.146	104	0.98	122	0.75	98	0.21	93	0.26	131		
101179	D	2.12	98	0.132	92	0.76	91	0.74	98	0.2	91	0.22	100	1989	Volcanic
	C	1.99	96	0.134	95	0.69	86	0.72	94	0.21	93	0.15	76		
111578	D	2.16	100	0.136	95	0.8	95	0.81	107	0.14	64	0.3	136	1989	Volcanic
	C	2	96	0.13	92	0.71	89	0.82	107	0.16	71	0.27	136		
111611	D	1.94	90	0.133	93	0.72	86	0.76	101	0.18	82	0.17	77	1989	Clay loam
111611	C	2.01	97	0.135	96	0.72	90	0.74	96	0.18	80	0.23	116		
121779	D	2.4	111	0.157	110	1.03	123	0.64	85	0.26	119	0.15	68	1990	Sandy
121779	C	2.2	106	0.149	106	0.95	118	0.74	96	0.24	106	0.15	76		
220010	D	1.99	92	0.136	95	0.77	92	0.69	91	0.24	110	0.17	77	1989	Clay loam
	C	2.21	107	0.146	104	0.7	87	0.73	95	0.23	102	0.19	96		
230003	D	1.81	84	0.137	96	0.7	83	0.78	103	0.3	137	0.16	73	1989	Clay loam
	C	1.73	83	0.135	96	0.76	95	0.69	90	0.28	124	0.09	45		
260002	D	2.01	93	0.142	99	0.96	114	0.67	89	0.24	110	0.19	86	1989	Sandy
	C	1.66	80	0.134	95	0.72	90	0.6	78	0.33	146	0.14	71		
300029	D	2.44	113	0.157	110	0.88	105	0.81	107	0.2	91	0.12	55	1989	Volcanic
	C	2.28	110	0.153	109	0.73	91	0.97	126	0.25	111	0.1	51		
320012	D	2.7	125	0.16	112	0.92	110	0.98	130	0.26	119	0.27	123	1990	Volcanic
	C	2.4	116	0.144	102	0.87	108	0.8	104	0.25	111	0.27	136		
390001	D	2.5	116	0.149	104	0.78	93	0.79	105	0.19	87	0.48	218	1990	Volcanic
	C	2.6	125	0.156	111	0.76	95	1.07	139	0.29	128	0.39	197		
520003	D	1.91	88	0.128	90	0.75	89	0.65	86	0.18	82	0.2	91	1989	Volcanic
	C	1.81	87	0.127	90	0.68	85	0.73	95	0.19	84	0.26	131		
881111	D	1.9	88	0.147	103	0.88	105	0.78	103	0.28	128	0.29	132	1989	Sandy
	C	2	96	0.143	101	0.83	103	0.82	107	0.24	106	0.28	141		

Table 78b: Trial 314 - Leaf data 1989 (Mean results)

		N	%	P	%	K	%	Ca	%	Mg	%	Cl	%
MEAN	D	2.159	104	0.143	101	0.839	105	0.755	98	0.219	97	0.22	111
	C	2.075	100	0.141	100	0.802	100	0.768	100	0.226	100	0.198	100
MEAN	D	2.095	101	0.145	103	0.908	113	0.705	92	0.243	108	0.193	97
SANDY	C	2.018	97	0.143	101	0.873	109	0.727	95	0.24	106	0.168	85
MEAN	D	2.319	112	0.144	102	0.836	104	0.804	105	0.196	87	0.261	132
ORG/VOLC	C	2.197	106	0.141	100	0.774	97	0.837	109	0.223	99	0.243	123
MEAN	D	1.978	95	0.138	98	0.742	93	0.742	97	0.225	100	0.188	95
CLAY LM	C	1.947	94	0.137	97	0.745	93	0.708	92	0.213	94	0.163	82

Counts:

Total	17
Sandy	6
Org/Volc	7
Clay loam	4

Note: Categorisation of the new blocks has not yet been finalised.

3. Soil

A summary of the soil profile at each site is given in Table 79.

The soils have been categorised into 3 major groupings as follows:

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.

The remainder of the soils are less easily characterised as a group, and generally posess 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 80 indicates the chemical characteristics of the 3 soil groups.

Table 79: Trial 314 Summary of site soil profiles

Block No	Name	Grouping	Depth cms	Description:	Corresponding Estate soil family
030309	E Ambogo	Sandy	0-25	Black sandy loam	Ambogo
			25+	Sand	
040266	Sorovi	Sandy			
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	
121779	Sorovi	Sandy			
220010	Avovota	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	
300029	Vaseta	Volcanic	0-21	Dark brown silt loam	
			21-82	Olive brown sandy silt loam	
320012	Saiho	Volcanic			
390001	Agenahambo	Volcanic			
520003	Waru	Volcanic	0-52	Black organic silt loam	Ohita
			52-97	Brown sand and pumice	
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 80: Experiments 314 and 315 0 - 20cm Soil Group data

Detail	Grouping: 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 initial data highlights the essential requirement for correct fertilization to ensure reasonable yields in all trial areas.

It also indicates the potential value of the trial in providing basic data regarding nutrition and yield in the various smallholder locations.

On the basis of the limited existing data, realistic preliminary smallholder fertilizer recommendations would be as shown in Table 81

Table 81: Trial 314 Preliminary Fertilizer recommendations in kg/palm/yr

Category	Fertilizer	Rate
Sandy	AMC	2
Alluvial	AMC	2
Volcanic organic	SOA	2

In subsequent years it would make sense to alternate between AMC and SOA as the N source, to maintain a balanced supply of anions.

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.

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. If this objective is to be achieved it is first necessary to achieve economic responses on the blocks. Once the responses have been achieved it is also necessary for the extension services to make use of the blocks to bring home the need for fertilizer to the surrounding block owners. The DAL are planning to commence such work in 1990.

SUMMARY :

Remarkable first year yield responses have been obtained, with an overall yield benefit on the demonstration plots (in comparison with the unfertilized control plots) of 32%. Yields were as low as 4.2 t/ha on control areas, emphasising the extent of the loss of yield which can be occasioned by failure to fertilize.

The sites have been broadly characterised into 3 groups (sandy, volcanic organic, and clay loam) on the basis of soil characteristics.

In each group there was a substantial response to N, and application of reasonable amounts of N fertilizer throughout the smallholder areas should be considered the first priority.

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: Recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam subsoil, and with seasonally high water tables.
Planting date: 1979.
Density: 143 palms per hectare.
Size: The trial comprises 102 plots: 204 experimental points, 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.

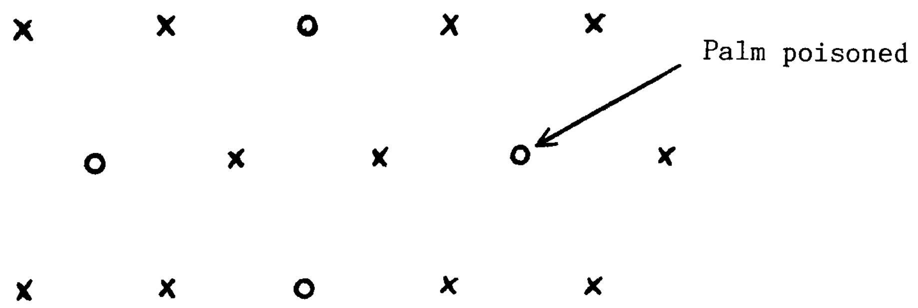
The thinning was at hexagonal centres (see Figure 16). This work was carried out entirely by HOPPL, and OPRA was not initially consulted or involved. The lack of any experimental design for the thinning rendered it difficult to draw any reliable conclusions from the exercise.

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.

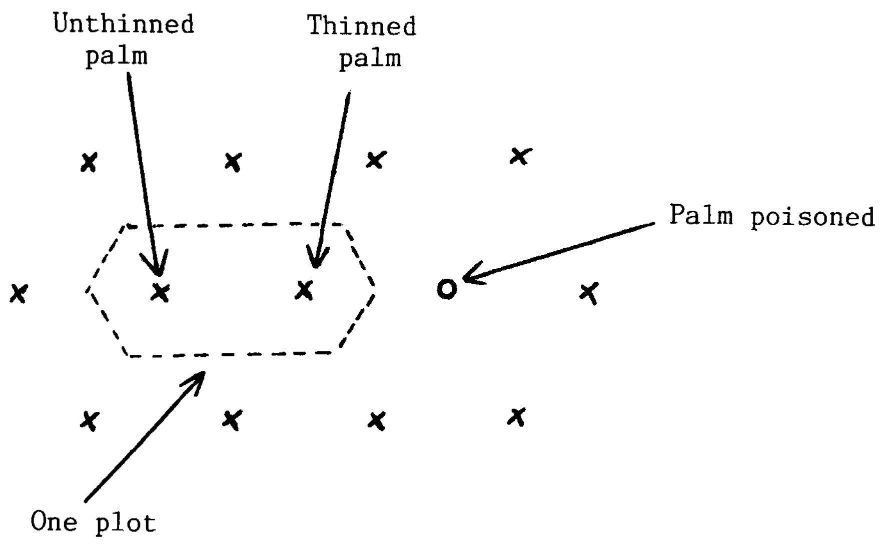
Survey of the field identified a number of sites where small areas had not been thinned, and 102 pairs of palms were selected, scattered throughout the area, where an unthinned palm was sited adjacent to a thinned palm. These pairs were then mapped, marked and measured, to provide comparison of the vegetative effects of thinning.

Fig. 16 Trial 321, Diagrams of thinning pattern and plot layout

a) Thinning method



b) Plot layout



RESULTS

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, indicative of more recent growth, and the difference between frond 41 and frond 9 used as an assessment of the most recent height increment.

Table 82 indicates that the initial effect of thinning has been a significant increase in the height of the thinned palms. Since this result was opposite to the significant reduction in annual height increment observed in Expts 104 and 105 after thinning palms at Bebere (PNGOPRA Annual Report 1986), all data has been double checked. It is suggested that different competition factors (which include light, nutrition and moisture) may be involved in the different trials.

In other trials, increased yield has been linked with an increase in the vertical increment, and it is therefore possible that the palms are responding to the thinning with increased leaf production, which may be associated with increased bunch production and later increased yield.

In terms of individual frond weights and areas there was no statistically significant difference, although the thinned palms did record values 1 or 2 % greater than the unthinned palms.

Calculation of the LAI indicated a substantial reduction effected by thinning, although even after thinning a reasonable value was maintained.

Table 82: Trial 321 palm growth data 1989

TRTMNT	Frond wt (kg)	Frond 9 to Frond 41 (cm)	Frond area (m^2)	LAI (assuming oil= 2.1xcarbohydrate energy)
Unthinned	4.19	**186**	11.1	**6.67**
Thinned	4.24	**195**	11.3	**5.82**
lsd	0.19	7.9	0.4	0.23
c.v.(%)	16	15	13	13

SUMMARY

The initial result of thinning has been an increase in vertical growth amounting to 9 cms in the first 15 months of the trial. Thinning has also substantially reduced the leaf area index, whilst leaving individual frond weights and areas largely unaffected.

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: Recent alluvial origin, with (sandy) clay loam soils and a seasonally high water table.
Planting date: April 1986.
Density: 127 palms per hectare.
Size: The trial comprises 1397 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

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 consist 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 are only guarded on 2 sides, since the remaining 2 sides directly abut the neighbouring plot.
Trial commencement: July 1986.
Trial progress: Ongoing.

Treatments:

Table 83: Treatment rates (in kg/palm) for Trial 501

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							
6	10/86	0	0.3	0.6	0	0.5	0	0.25	0.5		
12	4/87	0	0.6	1.2	0	0.5	0	0.50	1.0		
18	10/87	0	0.6	1.2	0	0.5	0.5	1.50	2.50	0	0.05
24	4/88	0	0.9	1.8	0	0.5	0.5	1.50	2.50		
36	10/88	0	0.9	1.8	0	0.5	0.25	1.25	2.25	0	0.05
42	4/89	0	0.9	1.8	0	0.5	0.25	1.25	2.25		

Applications are now continuing at the 36 and 42 month rates.

RESULTS :

1. Production

Problems with the construction of the Mill at Milne Bay have unfortunately seriously delayed the commencement of yield recording, but vegetative measurement has continued.

The 1989 results (Tables 84, 85 and 86) confirm previous data, with a major MOP response, and also a growing reponse to SOA applications.

Table 84: Trial 501 Palm Growth and Conversion data

TRTMNT	1989 Leaf prdn (n)	1989 Dry Frond weight kg (FW)	1989 Frond DM tha (FDM)	88-89 Dry Frond weight kg (FW)	88-89 Frond DM tha (FDM)	1988 August Bunch Count	1989 December Bunch Count	88-89 Mean Bunch Count
N 0	**21.2**	**1.74**	**4.45**	**1.49**	**4.0**	10.3	14.1	**12.2**
N 1	**21.9**	**1.83**	**4.76**	**1.57**	**4.35**	11.3	15.6	**13.4**
N 2	**22.2**	**1.85**	**4.9**	**1.58**	**4.46**	11.4	15.1	**13.2**
P 0	21.7	1.81	4.7	1.55	4.27	10.8	15	12.9
P 1	21.8	1.8	4.7	1.55	4.28	11.2	14.9	13
K 0	22.0	**1.62**	**4.23**	**1.39**	**3.89**	**9.7**	**16**	12.8
K 1	21.6	**1.9**	**4.92**	**1.61**	**4.42**	**11.4**	**13.6**	12.5
K 2	21.7	**1.91**	**4.96**	**1.64**	**4.51**	**11.9**	**15.2**	13.6
B 0			4.69					
B 1			4.71					
lsd (N&K)	0.45	0.076	0.17	0.06	0.19	1.4	1.4	0.95
lsd (P)	0.37	0.062	0.14	0.05	0.15	1.1	1.1	0.78
lsd (B)			0.12					
c.v.(%)	3	6	11	6	7	19	14	11

(No significant interactions occurred.)

Fertilizer responses within the trial will generally be under-estimated, partly due to lack of guard rows leading to poaching between adjacent plots, and also in the case of MOP due to the "K0" treatment receiving 0.5 kg of MOP per annum, to avoid the severe impairment initially observed when no MOP was applied.

The absence of response to TSP continued throughout 1989.

Table 85: Trial 501,Relative % Frond Dry Matter t/ha 1989

K0N0 = 4.15 t/ha

	K0	K1	K2
N0	100	120	119
N1	110	126	133
N2	117	130	129

Table 86: Trial 501, Relative % Frond Dry Matter t/ha 1988/89

K0N0 = 3.59 t/ha

	K0	K1	K2
N0	100	117	118
N1	109	124	131
N2	116	128	128

The first borate applications were made in October 1987, and none of the measurements made to date give any evidence of benefit, in spite of mean boron values below 9 ppm in 1988, even after the first boron application.

FDM measurements are generally highly correlated with yield, and therefore provide the best guidance to likely yield response to fertilizer if yield figures are unavailable. Combination of figures for 88 and 89 provides a more reliable estimate by smoothing out single year fluctuations which may be atypical.

Table 85 indicates that the major response has been to MOP alone, with increasing responses in 1989. For the 2 year figures in Table 86, the K1N0 rate provided a 17% response, with an additional response of 7% between K1N0 and K1N1, and a further response of 7% between K1N1 and K2N1, to provide a maximum response of 31% at K2N1.

This confirms the continued primary requirement at Milne Bay for unusually high MOP applications (between 2.5 and 4.5 kg/palm/an) with a developing requirement for N, in the region of 2 kg/palm/an of SOA.

2. Plant Analysis

The leaf results in Tables 87 and 88 indicate the levels corresponding to the various fertilizer rates.

The most noticeable effects are a K response to MOP, which is most marked with a doubling of K levels in the rachis. Chloride levels have also been increased by MOP, although even on the unfertilized plots levels appear reasonable at above 0.4%.

Table 87: Trial 501 Leaf Analysis related to fertilizer treatments: September 1988

	N0	N1	N2	P0	P1	K0	K1	K2	lsd NK	lsd P	sd	cv
N%	**2.56**	**2.8**	**2.86**	2.72	2.76	2.68	2.74	2.8	0.126	0.103	0.188	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	0.01	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	0.079	10
%	100	101	100	100	98	100	132	136				
Ca%	0.888	0.892	0.897	0.886	0.899	0.872	0.893	0.911	0.062	0.051	0.092	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	0.036	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	0.011	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	0.035	0.064	13
%	100	105	102	100	92	100	108	112				
Fe ppm	82.2	86.9	91.8	90.4	83.6	81.6	91	88.4	12.8	10.4	18.9	22
%	100	106	112	100	92	100	112	108				
Mn ppm	**54**	**117**	**170**	113	114	111	111	119	10.6	8.6	15.6	14
%	100	217	315	100	101	100	100	107				
Zn ppm	**20.4**	**18.1**	**17.8**	19.1	18.4	19.2	18.5	18.6	1.16	0.94	1.71	9
%	100	89	87	100	96	100	96	97				
Cu ppm	7.28	7.78	8.44	7.89	7.78	8.06	7.33	8.11	1.1	0.9	1.63	21
%	100	107	116	100	99	100	91	101				
B ppm	8.61	8.83	8.94	8.85	8.74	9.33	8.72	8.33	0.82	0.67	1.21	14
%	100	103	104	100	99	100	93	89				

SOA application has boosted N levels in the leaf, in line with the responses observed.

Boron has also been substantially increased in line with application to the trial, from levels below 9ppm, into the range 12-15 ppm during 1989. However, this change has not been accompanied by any observable change in plant performance.

Table 88: Trial 501 Progressive changes in yield and nutrient status

N0K0		88	89 (1)	AVG
	Yield		100	100
	N%	2.1	2.4	2.25
	P%	0.159	0.157	0.16
	K%	0.72	0.7	0.71
	RK%		0.32	0.32
	Ca%	0.9	0.79	0.85
	Mg%	0.53	0.45	0.49
	Bppm		11.6	11.6
	Cl%	0.56		0.56

N1K0		88	89	AVG
	Yield		118	118
	N%	3	2.83	2.92
	P%	0.195	0.172	0.18
	K%	0.68	0.64	0.66
	RK%		0.28	0.28
	Ca%	0.92	0.82	0.87
	Mg%	0.42	0.36	0.39
	Bppm	8	14	11
	Cl%	0.38		0.38

N0K1		88	89	AVG
	Yield		115	115
	N%	2.7	2.58	2.64
	P%	0.181	0.172	0.18
	K%	0.87	0.76	0.82
	RK%		0.9	0.9
	Ca%	1.03	0.84	0.94
	Mg%	0.44	0.34	0.39
	Bppm	10	13.4	11.7
	Cl%	0.51		0.51

N2K2		88	89	AVG
	Yield		129	129
	N%	2.9	2.81	2.86
	P%	0.18	0.167	0.17
	K%	0.82	0.72	0.77
	RK%		0.8	0.8
	Ca%	0.99	0.84	0.92
	Mg%	0.41	0.33	0.37
	Bppm	8	14.9	11.45
	Cl%	0.57		0.57

(1) Note: 1989 yield figure is percentage FDM production.

SUMMARY:

The major MOP effect has continued, and an increasing benefit from SOA applications has also emerged.

There was no evidence of any benefit from TSP or borate applications.

The major response was provided by the K1 application (2.5 kg MOP per palm).

Substantial additional responses were obtained by increasing N to rate 1 (1.8 kg SOA) and increasing K to rate 2 (4.5 kg of MOP per palm). This confirms the particularly high K requirement.

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 (eg 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). Details are listed in Table 89 and locations marked on the map in Fig.17.
Genetic material: Dami commercial DxP crosses.

Soils: Both existing blocks lie on alluvial soils, which are predominant in the area, and are described under trial 501.
Density: 127 palms per hectare.
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.

Fig. 17 Smallholder demonstration block locations

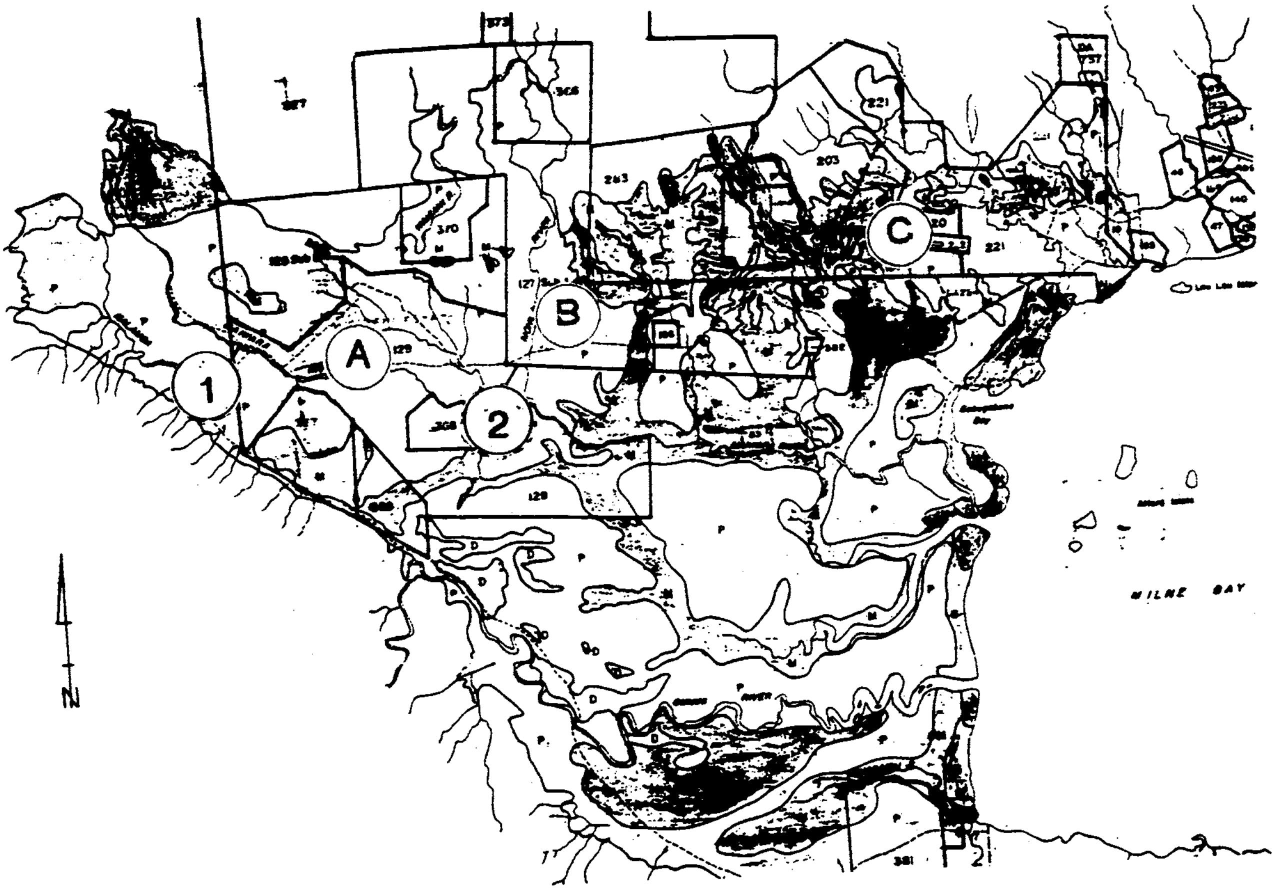


Table 89: Key to smallholder areas map

Area	Block	Map Number
Baraga	04016	1
Kera Kera	01022	2

(Other locations :

Waigani Estate : A
Hagita Estate : B
Gurney Airstrip : C)

DESIGN AND TREATMENT DETAILS :

Statistical background: Each smallholder block provides a single replicate. Within this there are up to 6 plots, comprising 2 with overall treatments, and up to 4 with systematic applications of N and K fertilizers, each applied in a gradient at right angles to the other. 2 of these 4 plots also receive TSP, and 2 do not.
Layout: To clarify details of the layout please refer to the map of a typical smallholder demonstration block in Figure 18, and the Table 90 indicating the arrangement of the systematic treatments.

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 receeives 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: 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.

Fig. 18 Example of trial block lay-out (Kera Kera)

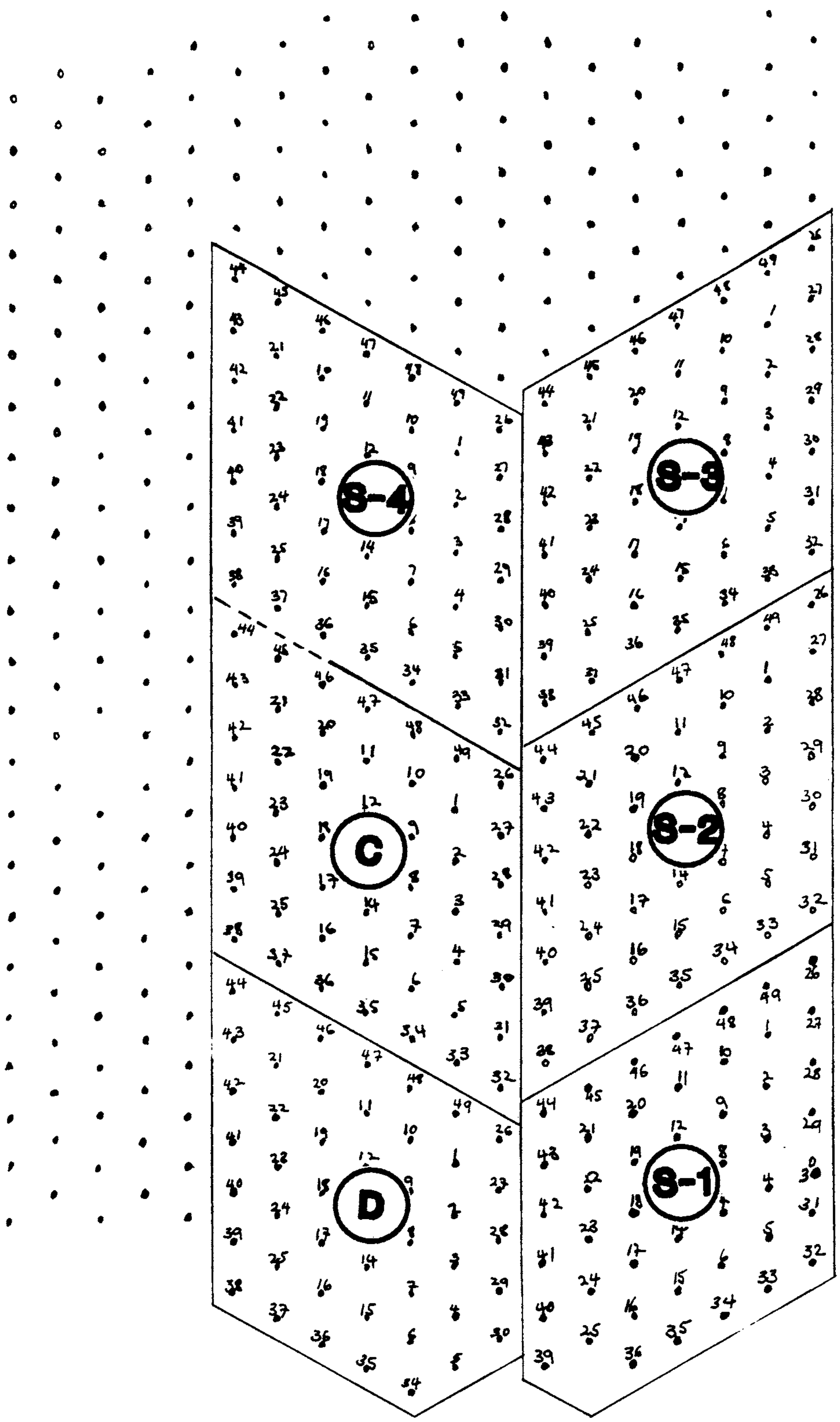


Table 90: Trial 506, Example of systematic fertilizer allocation (Kera Kera)

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	0	1	0	33	0	1	0	34	0	1	0	35	0	1	1	36	0	1	2	37	0	1	3	38	0	1	4
31	0	1	0	5	0	1	0	6	0	1	0	15	0	1	1	16	0	1	2	25	0	1	3	39	0	1	4
30	0	1	0	4	0	1	0	7	0	1	0	14	0	1	1	17	0	1	2	24	0	1	3	40	0	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	2	1	0	2	2	1	0	9	2	1	0	12	2	1	1	19	2	1	2	22	2	1	3	42	2	1	4
27	3	1	0	1	3	1	0	10	3	1	0	11	3	1	1	20	3	1	2	21	3	1	3	43	3	1	4
26	4	1	0	49	4	1	0	48	4	1	0	47	4	1	1	46	4	1	2	45	4	1	3	44	4	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	4	0	4	33	4	0	3	34	4	0	2	35	4	0	1	36	4	0	0	37	4	0	0	38	4	0	0
31	2	0	4	5	2	0	3	6	2	0	2	15	2	0	1	16	2	0	0	25	2	0	0	39	2	0	0
30	3	0	4	4	3	0	3	7	3	0	2	14	3	0	1	17	3	0	0	24	3	0	0	40	3	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	0	0	4	2	0	0	3	9	0	0	2	12	0	0	1	19	0	0	0	22	0	0	0	42	0	0	0
27	0	0	4	1	0	0	3	10	0	0	2	11	0	0	1	20	0	0	0	21	0	0	0	43	0	0	0
26	0	0	4	49	0	0	3	48	0	0	2	47	0	0	1	46	0	0	0	45	0	0	0	44	0	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	0	1	0	33	0	1	0	34	0	1	0	35	1	1	0	36	2	1	0	37	3	1	0	38	4	1	0
31	0	1	0	5	0	1	0	6	0	1	0	15	1	1	0	16	2	1	0	25	3	1	0	39	4	1	0
30	0	1	0	4	0	1	0	7	0	1	0	14	1	1	0	17	2	1	0	24	3	1	0	40	4	1	0
29	0	1	1	3	0	1	1	8	0	1	1	13	1	1	1	18	2	1	1	23	3	1	1	41	4	1	1
28	0	1	2	2	0	1	2	9	0	1	2	12	1	1	2	19	2	1	2	22	3	1	2	42	4	1	2
27	0	1	3	1	0	1	3	10	0	1	3	11	1	1	3	20	2	1	3	21	3	1	3	43	4	1	3
26	0	1	4	49	0	1	4	48	0	1	4	47	1	1	4	46	2	1	4	45	3	1	4	44	4	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	4	0	4	33	3	0	4	34	2	0	4	35	1	0	4	36	0	0	4	37	0	0	4	38	0	0	4
31	4	0	2	5	3	0	2	6	2	0	2	15	1	0	2	16	0	0	2	25	0	0	2	39	0	0	2
30	4	0	3	4	3	0	3	7	2	0	3	14	1	0	3	17	0	0	3	24	0	0	3	40	0	0	3
29	4	0	1	3	3	0	1	8	2	0	1	13	1	0	1	18	0	0	1	23	0	0	1	41	0	0	1
28	4	0	0	2	3	0	0	9	2	0	0	12	1	0	0	19	0	0	0	22	0	0	0	42	0	0	0
27	4	0	0	1	3	0	0	10	2	0	0	11	1	0	0	20	0	0	0	21	0	0	0	43	0	0	0
26	4	0	0	49	3	0	0	48	2	0	0	47	1	0	0	46	0	0	0	45	0	0	0	44	0	0	0

Table 91: Trial 506 Annual fertilizer rates in kg/palm

	MOP	SOA	TSP
Years 1 & 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 92 gives background information on the sites. Initial leaf analysis data is shown in Table 93.

Table 92: Trial 506 Smallholder Background Data

Area	Location	Name	Block	First Planting	Fertilizer kg/palm before trial MOP	SOA	TSP
Gumini valley	West	Baraga	04016	3/6/88	0.17	0.17	0.17
Gumini valley	South	Kera Kera	01022	20/7/87	0.55	0.55	0.48

Table 93: Trial 506 Leaf Analysis 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
	D	2.12	0.142	0.60	0.80	0.42	0.49
01022	C	2.11	0.144	0.56	0.86	0.43	0.35

At the start of the trial Kera Kera had poorer K nutrition than Baraga. Overall the available data confirms plant analyses to be almost identical to the estates, indicating the validity of extending estate trial results to the smallholdings in these surrounding areas.

Again K nutrition is the main problem, with particularly low levels at Kera Kera. 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 noticeable response so far, although it would be expected to develop in due course in line with the results on the estates.

The initial results confirm a primary requirement on the smallholdings for MOP. For palms above 2 years, application at around 2 kg per annum should be seen as a minimum. In addition a response to SOA will develop, and may already be present at certain sites, so that application of at least 1 kg per annum should be made.

When harvesting commences there will be an increased drain on K in the plant, and it will be necessary to consider increasing the MOP rate - possibly to 3 kg per palm per annum.

4. Discussion

The initial data highlights the essential requirement for correct fertilization to ensure reasonable yields in all trial areas.

It also indicates the potential value of the trial in providing basic data regarding nutrition in the various smallholder locations.

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 the basis for extension work to bring about correct fertilizer use by other block owners. If this objective is to be achieved it is first necessary to achieve economic responses on the blocks. Once the responses have been achieved it will also be necessary for the extension services to make use of the blocks to bring home the need for fertilizer to the surrounding block owner's.

At this stage insufficient data is available to support such extension, and a full year's yield recording will be necessary, subsequent to the opening of the mill in 1990. The initial yield results will therefore not be available as a basis for extension until 1992.

SUMMARY :

The preliminary data obtained on the existing demonstration blocks indicates broad conformity with the estate trial results, confirming that meaningful extrapolation is possible.

On the basis of the initial data, minimum recommendations for smallholder palms of 2 years and older would be 2 kg of MOP and 1 kg of SOA. Correct fertilizing will be essential to the maintenance of satisfactory yield.

III SMALLHOLDER TRIALS

WEST NEW BRITAIN PROVINCE

(P.Navus)

At Buvussi Subdivision fertilizer trials were continued during the year, on selected smallholder blocks in the mature palm areas (EXPERIMENT 112). As reported in the 1988 Annual Report, 7 new trial sites have been established covering more extensive areas of the Hoskins Project (EXPERIMENT 121). The emphasis is on: 1) preventing yield decline which occurs in the absence of fertilizer and 2) demonstrating fertilizer application based on PNGOPRA's official fertilizer recommendation (Advisory Leaflet No.3). The selected sites are being characterized, based on soil collection, leaf samples, and management assessment.

Yield assessment.

Bunch number and bunch weight are the two components involved in FFB production. Recording full harvest every fourth month has been implemented in the smallholder related operations in the Hoskins Project commencing in March 1989. This system is working satisfactorily.

Extension

The extension of research information to the farmers is presently confined to the following. There are three main approaches of passing on the relevant technology as they become available. These include the state extension service, the contact farmers and the research arm of the industry. Communication of research findings is being pursued at individual, group and mass level in that order of priority. A network of on-farm method field demonstrations has been planned and initiated. Very close liaison with the DA&L (Oil Palm) extension staff and farmers has been necessary to achieve the progress made to date.

Services provided.

1. Investigation of Tamba problem areas. 4 blocks.
2. Gule mini-estate. Leaf analysis taken during 1989.
3. Magnesium uptake. Leaf analysis taken in 1989.

EXPERIMENT 112: NITROGEN AND PHOSPHATE TRIAL

PURPOSE.

Aim: 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.

SITE DETAILS.

Location: As shown in Figure 19. DA&L Hoskins Oil Palm Scheme, Buvussi Sub-division on 8 individual smallholder blocks in Sections 1, 5, & 6.
Soil type: Awaiting classification/description.
A total of 82 small pits (0 - 10cm in depth) were dug covering each 2 X 8ha of each block. The extent of hardpan layers found at varying depths did not have any relationship with the poor ffb output; nor did the level of management.
Genetic material: Dami D X P
Planted: 1980
Density: 120 palms/ha

DESIGN AND TREATMENT DETAILS.

Design: 8 Replicates of 3 treatments (- , P, N+P)

Treatment Details: 1. Nil 2. 1kg/palm/year TSP
3. 1kg/palm/year TSP + 2kg/palm/year AC
Date of first treatment: April/May 1986.
Revised in November 1988: Ammonium Chloride was increased to 2kg/palm/year from 1kg/palm/year.

Duration: Ongoing

RESULTS:

Table 94 and Fig. 20 show the behaviour of yield estimated from partial recordings over the period January to December 1989. When averaged over all blocks, both the 1989 FFB and bunch number production show very significant differences (at 5% level of significance) between treatments.

Fig. 19 Experiment 121, Distribution of smallholder demonstrations in West Nakanai Oil Palm Scheme

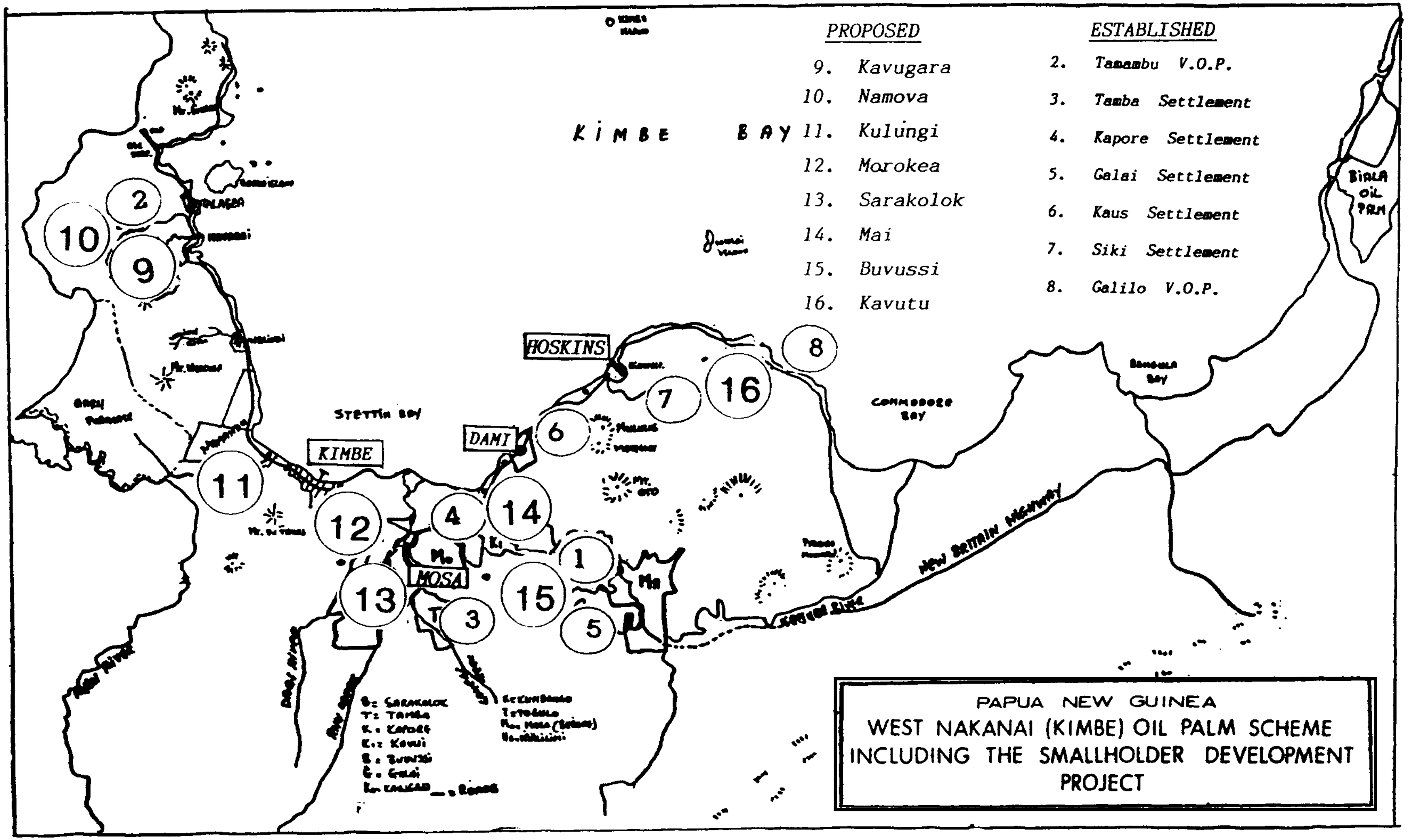


Table 94 Expt. 112: Total Production, Jan - Dec 1989.

	FFB t/ha				Bunch No. per ha				Bunch Weight. Kg			
Site	(-)	P	N+P	Mean	(-)	P	N+P	Mean	(-)	P	N+P	Mean
01	11.25	11.33	09.21	10.60	620	572	460	551	18.15	19.81	20.02	19.33
02	10.64	15.27	20.35	15.42	552	852	896	767	19.28	17.92	22.71	19.97
03	15.35	15.85	21.20	17.47	1008	1156	1076	1080	15.23	13.71	19.70	16.21
04	18.15	20.89	21.69	20.24	996	1216	996	1069	18.22	17.18	21.78	19.06
05	18.59	21.99	25.45	22.01	972	984	1140	1032	19.13	22.35	22.33	21.27
06	14.63	18.77	17.35	16.92	888	1032	836	919	16.48	18.19	20.75	18.47
07	14.41	15.24	16.28	15.31	756	872	884	837	19.06	17.45	18.42	18.32
08	14.48	20.73	20.00	18.40	928	1044	952	975	15.60	19.86	21.01	18.82
Mean	**14.69**	**17.51**	**18.94**	17.05	**840**	**966**	**905**	904	**17.64**	**18.31**	**20.84**	18.93
L.S.D. 5%		2.23				99				1.66		
C.V. (%)		12.2				10.2				8.2		

Table 95 Experiment 112, Comparison of annual FFB means and bunch number by block in 1989.

Block	FFB t/ha/yr	Bunch No. per ha	Bunch Weight kg
05	22.01	1032	21.27
04	20.24	1069	19.06
08	18.40	0975	18.82
03	17.47	1080	16.21
06	16.92	0919	18.47
02	15.42	0767	19.97
07	15.31	0837	18.32
01	10.60	0551	19.33
Mean	17.05	0904	18.93

Discussion

Yields on average have been increased by the use of fertilizer by 24% during 1989. Considering FFB production in which both N and P were present (Figs. 21 and 22) the means are not significantly different from one another, but both are significantly better than the nil plot.

It may be noted that bunch number has been significantly increased by the P treatment whilst N treatment has increased bunch weight.

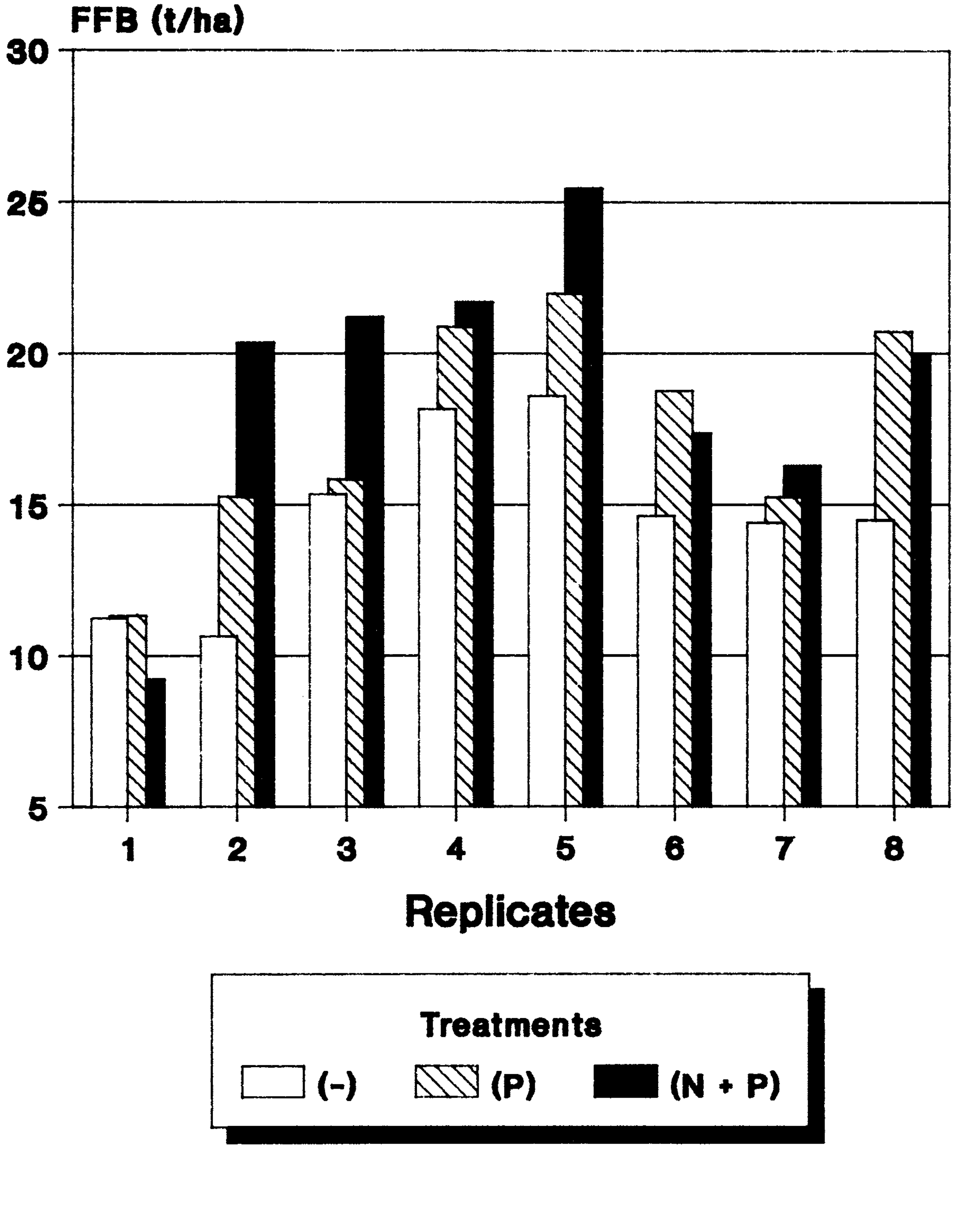


Fig.20 Experiment 112, FFB Yield Production, Jan-Dec89

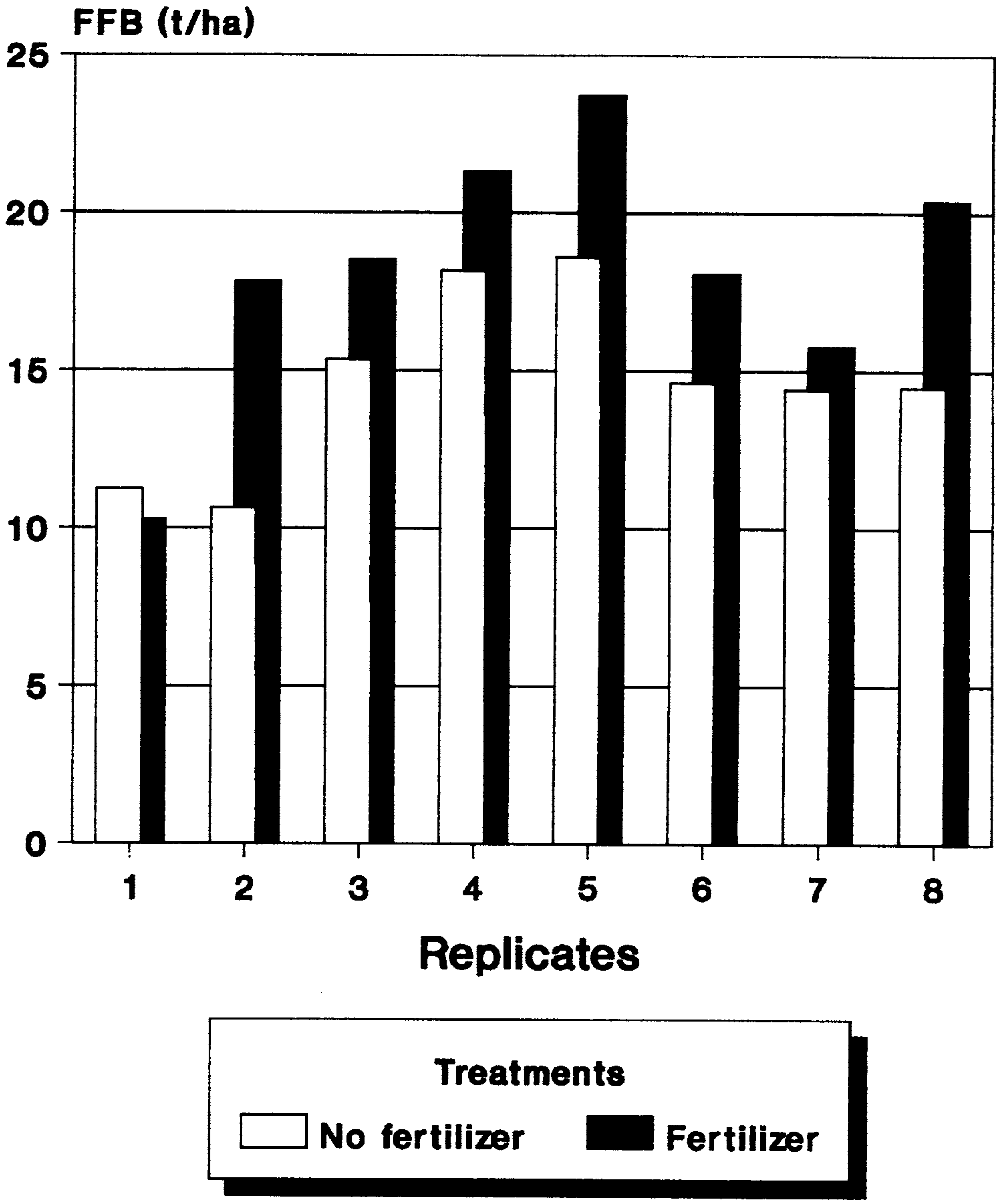


Fig. 21 Experiment 112, FFB Yield Production, Jan-Dec89

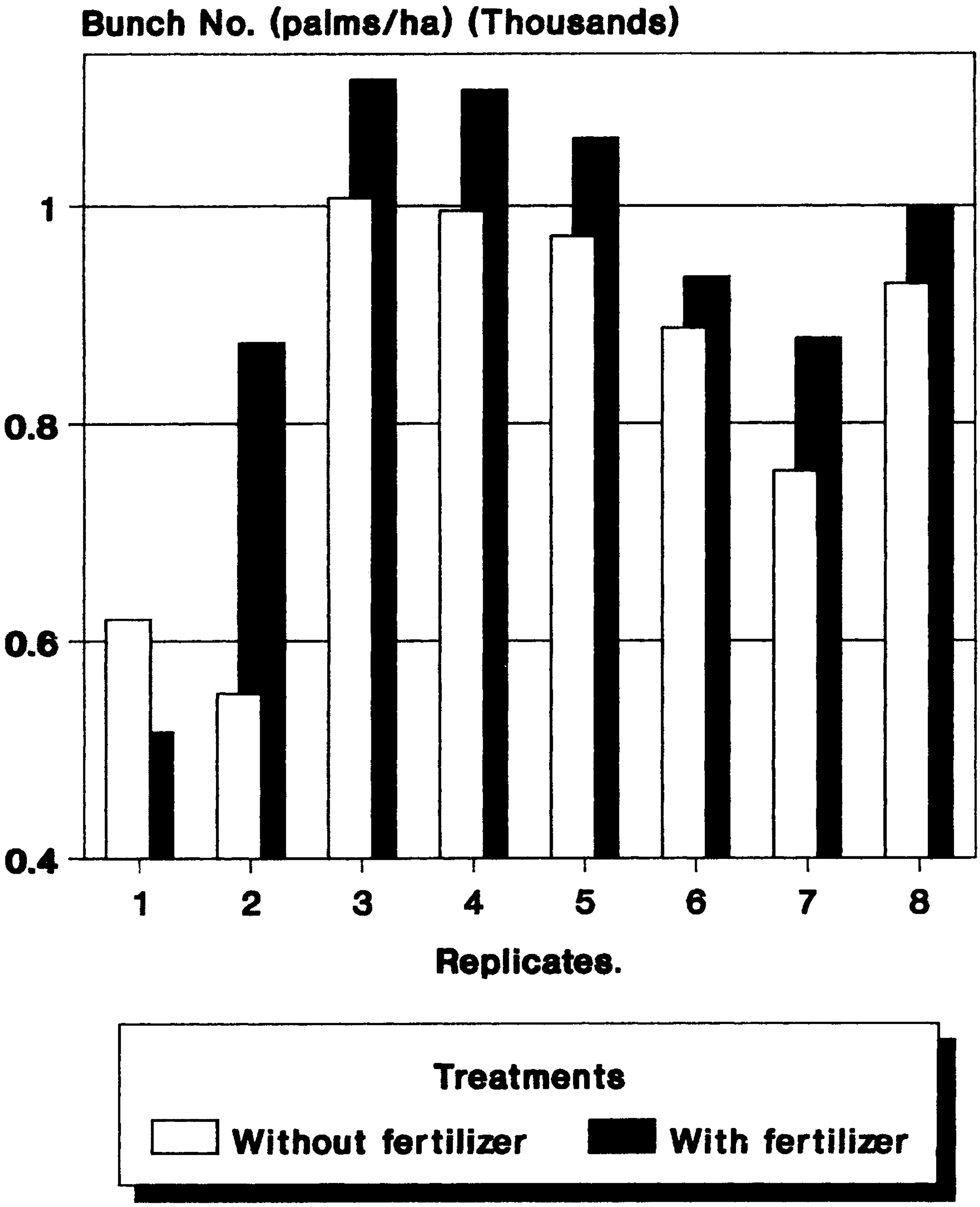


Fig. 22 Experiment 112, Bunch Production, Jan-Dec89

Of the fertilized plots, in 1989 only one performed below Subdivision level (14t/ha/yr) whilst the remaining 7 blocks produced either similar or better yields (e.g. over 25t/ha/yr at site 05) than the Subdivision mean. As illustrated in Fig. 23 there was over 50% yield increase in 1987 which is largely attributed to improved management at the start of the project. Since then fertilized plots have consistently given at least 20% more yield than the control plots, an effect which increased further in 1989.

Table 96 Experiment 112, FFB treatment means and 1989 leaf 17 nutrient levels.

Treatment	FFB t/ha/yr	N %	P %	K %	Ca %	Mg %	Cl %
Nil	**14.69**	**2.15**	**.136**	.87	.93	**.15**	**.11**
P	**17.51**	**2.17**	**.140**	.93	.93	**.17**	**.09**
P+N	**18.94**	**2.29**	**.145**	.78	.89	**.15**	**.33**
Mean	17.05	2.201	.140	.859	.916	.157	.176
LSD (5%)	2.23	0.08	.005	.07	.04	.015	.11
C.V. (%)	12.2	3.3	2.99	7.8	4	8.8	56.9

A similar trend existed for bunch number production and single bunch weight means. Considering FFB output, Fig. 20 clearly illustrates the response due to the presence of fertilizer when applied both separately and in combination.

Table 96 indicates leaf nutrient levels in 1989 and clearly shows ammonium chloride as an important source of nitrogen and chlorine in raising FFB. It is interesting to note that the only significant effect of applying superphosphate alone on leaf nutrient levels is an increase in leaf Mg. Leaf P is significantly increased only when both N + P fertilizers are applied together.

Although the 1989 nutrient levels are still below the required minimum, the substantial yield increases illustrate the significant effect of the presence of any fertilizer, either TSP alone or with N.

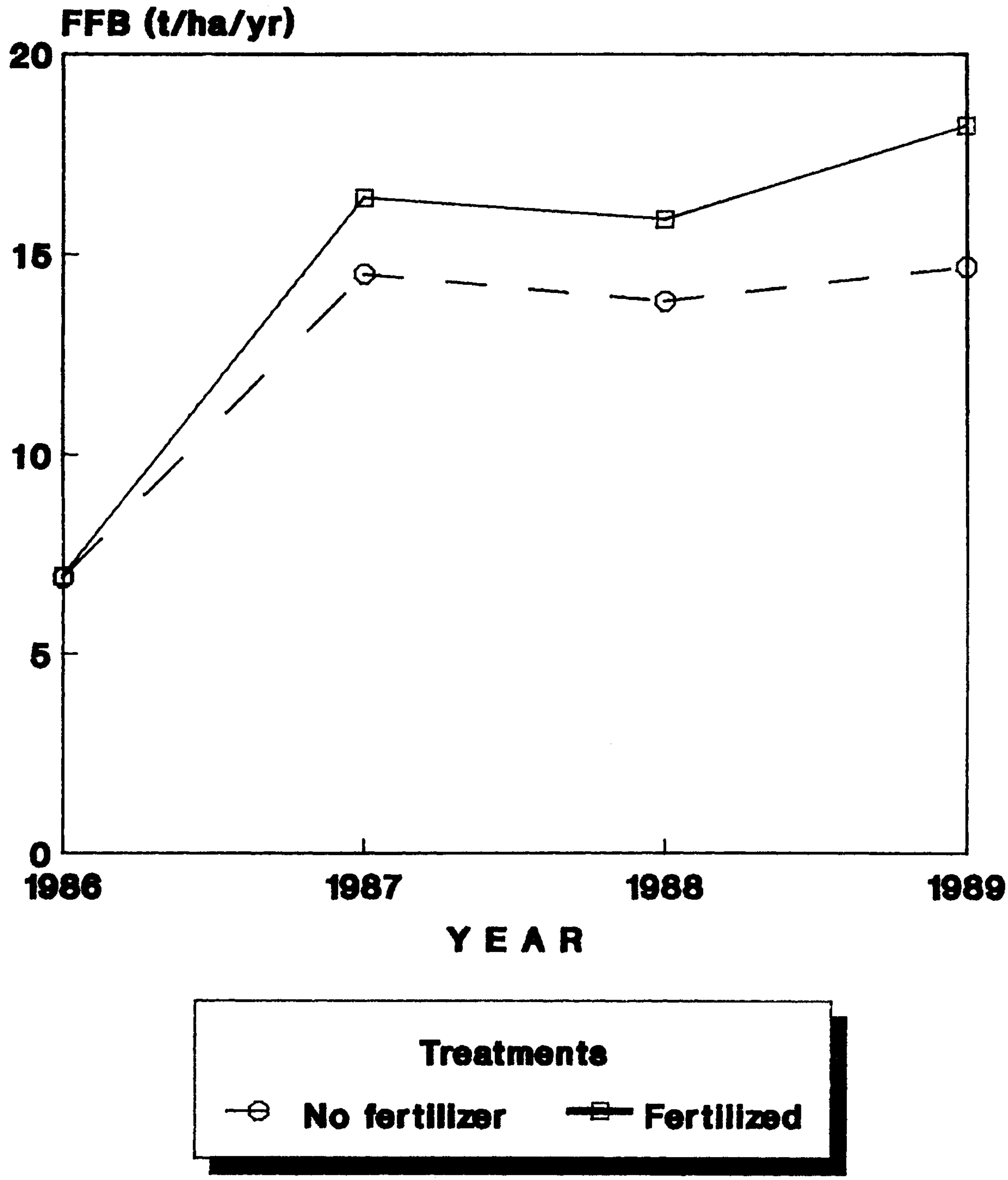


Fig. 23 Experiment 112, FFB Yield Production 1986-89

EXPERIMENT 113: INTERCROPPING AND FERTILIZER DEMONSTRATION ON REPLANTED OIL PALMS.

PURPOSE.

To demonstrate that replanted oil palm can be intercropped with food crops for up to 18 months or so.

To estimate the benefits the farmer obtains from the food crops themselves.

SITE DETAILS.

Location: DA&L Hoskins Oil Palm Scheme Kavui Sub-division.
Site Details.
Two hectares each from two smallholder blocks were selected allowing for a single replicate. Each was further demarcated, to accomodate three main ethnic groups from among the non-indigenous settlers of the Hoskins Oil Palm Development.

1.	Kavui	Block No 1121
2.	Kavui	Block No 1130

Soil type: Awaiting classification
Genetic material: Dami D X P
Planted: Replanted in January 1987
Density: 120 palms/ha

DESIGN AND TREATMENT DETAILS.

Design: Unreplicated demonstration plots on two sites.
In block 1121, represented were typical Sepik, and Tolai food gardening,i.e. there was one control and two treatments.
In block 1130, only typical Chimbu garden was represented, i.e. there was one control and one treatment.

Treatment:

1. Control - applied to this plot was the establishedment nitrogen (with Ammonium Chloride as the N source) to palms and leguminous cover crop only.
2. Intercropped - implemented here was the recommended fertilizer in replanted oil palm with food crops.

Duration: Dicontinued at the end of 1988.

CONCLUSION.

The short-term demonstration of the effect of establishment N on replanted oil palm was successfully concluded (see 1988 Annual Report p68) in three areas (Kapore, Sarakolok and Buvussi). The intercropping demonstrations with foodcrops have not been very successfull (Kavui) since PNGOPRA has little control over harvesting.

EXPERIMENT 121: DEMONSTRATION OF RECOMMENDED NITROGEN FERTILIZER ON OIL PALM SMALLHOLDINGS.

PURPOSE.

To emphasise the need and the value of adopting an acceptable level of management and to demonstrate applying the recommended doses of inorganic fertilizer.

SITE DETAILS.

Location: DA&L Hoskins Oil Palm Scheme, located at various Sub-division sites as in Fig 3.1. The first 7 fertilizer demonstration plots in the Hoskins Oil palm Scheme have been established at;

1.	Tamambu West VOP	Block No 0020
2.	Tamba settlement	Block No 0565
3.	Kapore settlement	Block No 0396
4.	Galai settlement	Block No 1538
5.	Kaus settlement	Block No 0754
6.	Siki settlement	Block No 1066
7.	Galilo East VOP	Block No 0005

Additional sites proposed are for one each at Kavugara, Sarakolok, and Buvussi settlements, including Namova, Kulungi, Morokea, Mai and Kavutu VOPs.

Soil type: Awaiting classification.
Genetic material: Dami D X P
Planted: [1983 - 1985]
Density: 120 palms/ha

DESIGN AND TREATMENT DETAILS.

Design: Each smallholder block of 2ha provides a single replicate. Within these 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 (KCL) 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:1. The CONTROL plots receive no fertilizer.
2.The DEMONSTRATION plots receive whatever fertilizer is considered most appropriate for the block. This may vary from time to time.
Date of first treatment: May 1989.

Duration: ongoing.

RESULTS:

Table 97 Experiment 121 pre-treatment characterisation of the sites. Included are vegetative measurements, leaf and soil nutrient levels in 1988/89.

Location:	(1)	(2)	(4)	(6)	(7)	(3)	(5)
Name:	TBU	TBA	GAL	SIK	GLO	KAP	KAU
Block No.	0020	0565	1538	1066	0005	0396	0754
Planted:	1982	1983	1985	1984	1982	1984	1985
Phase:	New	Repl	III	New	New	Repl	New
* FFB (t/ha):	20.4	22.8	20.0	25.0	15.7	19.2	23.8
1989 Leaf 17.							
Leaf area: (m^2)	7.51	6.28	6.07	6.92	4.47	3.39	6.42
Leaf Wt: (kg)	2.86	2.77	2.21	2.65	1.81	NR	NR
% N	2.4	*2.1*	2.4	2.4	*2.2*	2.6	*2.3*
% P	0.162	0.163	0.171	0.171	0.164	0.229	0.153
% K	1.00	1.10	1.07	1.00	0.99	1.04	0.87
% Mg	*0.17*	*0.19*	*0.30*	*0.24*	*0.25*	*0.31*	*0.16*
% Ca	0.95	0.90	1.09	0.99	1.22	1.13	0.96
% Cl	*0.23*	*0.11*	*0.06*	*0.12*	*0.18*	*0.22*	*0.20*
% S	0.16	0.17	0.18	0.17	0.17	0.18	0.15
% Na	0.01	0.01	0.01	0.01	0.01	0.01	0.01
ppm Fe	70	76	79	59	49	58	49
ppm Mn	44	54	46	51	35	75	38
ppm Zn	22	23	25	22	18	21	19
ppm Cu	10	6	7	6	7	6	5
ppm B	11	9	10	11	10	10	8
Soil Nutrient Status							
% O.M.	5.6	*3.10*	5.00	*3.80*	5.90	4.00	4.00
% Total N	0.44	*0.18*	0.41	*0.24*	0.36	0.25	0.26
BD g/ml	0.74	0.86	0.75	0.94	0.82	0.76	0.87
pH	6.6	6.5	6.6	6.4	6.6	6.5	6.5
P-Olsen ug/ml	6	4	3	6	4	6	7
K me/100g	0.50	0.33	0.22	0.13	0.72	0.40	0.14
Ca me/100g	14.6	6.0	13.5	9.0	13.1	10.3	9.4
Mg me/100g	1.49	0.76	1.03	0.70	1.47	1.32	0.87
Na me/100g	0.18	0.16	0.14	0.11	0.11	0.19	0.14
CEC me/100g	22	10	17	12	19	17	14

Note: * Source: DAL (Oil Palm/OICs). **"NEW"** means the area is planted for the first time with Oil Palm (OP). **"REPL"** means an area replanted with OP and "III" refers to the 3rd phase area of the initial planting of OP.

Initial pretreatment data are shown in Table 97 indicating the available background information for each site. This data highlights the essential requirement for correct fertilization to ensure reasonable yields. As in Oro Province, 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, taking into consideration the leaf nutrient data and field observations and reports, leads to the following interpretations. Confirming the results from the formal trials carried out on the nucleus estate, the major limiting factor is nitrogen. This situation is clearly shown by the low N leaf levels at Tamba (2.1%), Galilo and Kaus.

Chlorine is also well below recommended minimum levels for these areas and is exceptionally low in Galai (0.06%) and again Tamba (0.11%), with Siki no better off.

Similar to the diagnostic results made on NBPOD Plantations magnesium is also limiting at Tamambu (0.17%) and Tamba (0.19%) confirming the visual observations that exist on those blocks.

Potassium leaf status is generally better overall.

Limited information on soil nutrient status indicates low organic matter and total nitrogen in those blocks that are already low in leaf nitrogen and chlorine levels.

This data highlights the essential requirement for correct fertilization to ensure reasonable yields. As in Oro Province, this baseline data indicates the potential value of the trials in providing guidelines regarding nutrition in the various smallholder locations in the Province.

Table 98 Expt. 121 Initial yield assessments from Jan-Dec 1989.

Site	CONTROL PLOTS + FFB t/ha/yr	CONTROL PLOTS + Bunch No. per ha	ALL FERTILIZED PLOTS + FFB t/ha/yr	ALL FERTILIZED PLOTS + Bunch No. per ha	AVERAGE * BLOCK YIELDS FFB t/ha/yr
1	06.40	0500	08.60	0580	20.03
2	27.30	2064	26.07	2332	22.80
3	07.74	1080	13.25	1336	19.16
4	12.80	1224	14.89	1209	20.00
5	10.86	0657	15.20	0806	23.76
6	23.28	2070	23.29	1779	25.00
7	08.82	1101	08.87	1195	15.66
Mean	13.89	1242	15.74	1320	20.97

(+ Estimated from yield recording in 2 months only.
* Information from DAL records for all months).

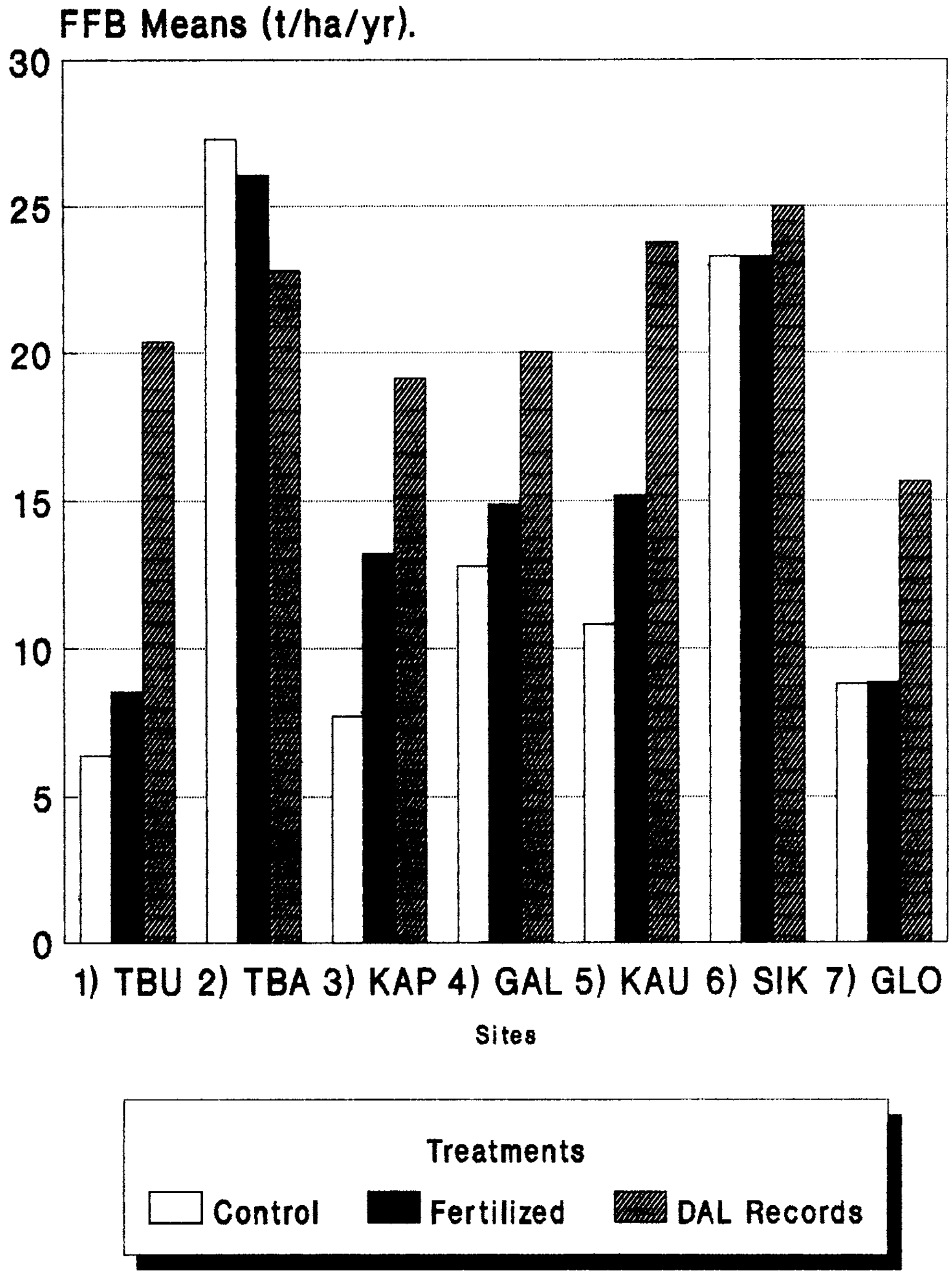


Fig. 24 Experiment 121, Yield Assessment in Fertilizer Demonstrations, 1989

Preliminary yield results

The yield estimates are very preliminary. On average there were only 2 months of recorded harvest that occurred during 1989 in June/July and October/November. Except for Tamba, (see Tables 97, 98 and Fig. 24) the production means for the 6 demo plots appear to give a fair estimation when compared with the actual values (FFB only). Yield figures based on recording throughout the year were supplied by the officers-in-charge of the Subdivisions. The effect/presence of fertilizer [N+P+K+Mg] after 6 months already appears to be showing an effect on increased FFB production in four of the blocks.

IV. GENERAL AND BASIC INVESTIGATIONS

EXPERIMENT 102a : DENSITY AND FERTILIZER TRIAL AT DAMI

(P. Talopa)

PURPOSE:

To investigate the effect of two densities and ammonium chloride on palm production.

TRIAL HISTORY:

The palms were planted in October 1970 and poisoned for replanting in July 1989. Extensive records on growth, flowering and production since the start of this trial by OPRS Dami can be found elsewhere (Rosenquist, 1980; numerous reports by Breure, 1977, 1982, 1983, 1985; and in PNGOPRA Annual Reports 1982, 1983, 1984, 1986, 1987 and 1988). In 1989, replicates I and IV were dropped as some palms in these replicates were felled for another investigation.

Ammonium chloride application commenced in 1986 and the two extreme densities (56 and 185 palms ha^{-1}) were dropped in 1988, leaving only two middle densities, 110 and 148 palms ha^{-1} to be considered. The final recording in this trial was done in June 1989 when poisoning of palms commenced for replanting.

SITE DETAILS

The soils are andosols, derived from recent volcanic deposits with little or no profile development. An accumulation of organic matter in the surface horizon only extends to a maximum of about 15 cm. Drainage of the soil is excellent. The profile at the site (Dami) clearly shows alluvial deposits of mineral and pumiceous sands washed by the adjacent creeks.

DESIGN AND TREATMENT DETAILS:

The current results are based on a split-plot design with two replicates of two planting densities (main-plots) and four levels of ammonium chloride (sub-plots) as follows:

Density (palms ha^{-1})	Ammonium Chloride level ($kg\ palm^{-1} yr^{-1}$)			
	0	1	2	3
110	0	2	4	6
148	0	2	4	6

RESULTS

Yield results were analyzed for two successive 12 month periods as shown in Table 99. The precision of determining treatment effects has been somewhat reduced by the reduction in the number of replicates. Nevertheless differences in production due to fertilizer rates were observed for single bunch weight, over the 24 month period. As shown in Table 99 differences in the single bunch weight results significant at 5% level were observed between fertilizer rates in the cumulative period (July'87-June'89) with both densities. The average effect of density was also significant at 5% for single bunch weight in the cumulative results.

Although statistically not significant, FFB production increased during the July '88-June '89 period from a lower production for the same period in the previous year and the increment was larger at the lower density. The main increase in the FFB production over the total 24 month period was due to an increase in the single bunch weight in the second 12 months (July '88-June '89) as a direct effect of the fertilizer applied.

Table 99 Experiment 102a: Yield Production.

Density	Fertilizer	July '87 - June '88			July '88 - June '89			July '87 - June '89		
(palms ha^{-1})	(NH_4Cl) (kg $palm^{-1}yr^{-1}$)	Bunch Number (per ha)	FFB (tonnes/ha)	SBW (kg)	Bunch Number (per ha)	FFB (tonnes/ha)	SBW (kg)	Bunch Number (per ha)	FFB (tonnes/ha)	SBW (kg)
110	0	729.7	17.76	23.29	805.0	19.07	23.87	768.0	18.42	**23.58**
	2	702.9	15.54	21.60	772.0	21.01	27.25	738.0	18.28	**24.42**
	4	824.5	19.54	25.42	972.0	25.47	26.46	898.5	22.51	**25.94**
	6	555.6	15.59	25.63	887.0	27.88	26.46	721.5	21.74	**28.58**
148	0	596.7	12.81	20.99	1029.0	24.60	23.91	813.0	18.71	**22.45**
	2	756.8	17.40	23.92	818.5	21.23	26.21	787.5	19.32	**25.60**
	4	678.7	14.71	20.82	909.0	23.95	26.31	794.0	19.33	**28.56**
	6	742.6	15.34	20.20	1077.0	27.45	24.45	910.0	21.40	**22.33**
$LSD_{0.05}$*		319.78	9.65	6.81	319.35	12.23	7.339	284.29	7.05	2.618
$LSD_{0.05}$**		335.0	9.27	11.15	286.29	10.66	13.14	346.02	8.28	2.954
c.v (%)		14.21	18.62	8.97	10.89	16.01	8.92	14.45	14.47	4.36
MEAN										
110		703.20	17.11	23.99	859.00	23.36	27.28	781.50	20.24	**25.63**
148		693.70	15.07	21.48	958.38	24.31	25.22	826.13	19.69	**23.35**
$LSD^{0.05}$		1064	22.64	4.59	417.7	3.859	6.73	741.29	13.25	1.07
c.v (%)		23.99	22.15	3.18	7.23	2.55	4.03	14.52	10.45	0.688

* LSD compares means within the densities
** LSD compares means between the densities

CONCLUSION

There was a general effect of nitrogen fertilizer observed from the increases in the FFB production after the initial application of ammonium chloride in November 1986 and thereafter at 6 month intervals. The increase in the FFB resulted from an increase in the single bunch weight rather than number of bunches. It may be concluded that at late stages of production an intensive competition exists among palms for nutrients and light and the former shortage can be alleviated by additional fertilizer application if light is not limited by too high a density.

Experiment 102c: PHOSPHATE POT TEST EXPERIMENT (P.Talopa)

PURPOSE:

To compare two sources of phosphate fertilizers, North Carolina Rock Phosphate and Triple superphosphate, and to observe the effect of sulphur on these phosphate fertilizers on dry matter yield in maize (*Zea mays*) plants.

EXPERIMENTAL DETAILS

Soil samples were obtained at the site of **Experiment 102a** at Dami, away from ring-weeded and fertilizer areas at a depth of 9-10cm. Generally the soil at the current site is of volcanic origin with relatively high pH (> 6) and a very high proportion of the CEC occupied by calcium. Thoroughly mixed soil was filled in medium large polythene bags (volume, 17 litres) and fertilizers mixed in the top 10-12cm. Two maize seeds were planted per bag initially and thinned to one after germination in the field. The whole plant was harvested after 7 weeks before tasseling and roots were separated from stalk and leaves. These were then dried in an oven at 70°C and dry weight results were analyzed.

DESIGN AND TREATMENT DETAILS

The experiment consisted of 4 treatments, one each of TSP and Rock P and two additional treatments each with 4 grams of flowers of sulphur added to the TSP and Rock P treatments as follows:

Fertilizer (grams bag^{-1})	level 0	1	2	4	8
TSP	0	0.85	1.70	3.40	6.80
TSP + S	0	0.85+S	1.70+S	3.40+S	6.80+S
Rock P	0	1.28	2.56	5.14	10.24
Rock P+S	0	1.28+S	2.56+S	5.14+S	10.24+S

(where S = 4 grams of flowers of sulphur.)

The treatments were replicated four times and the five phosphate levels were increased by two-fold.

The two phosphate fertilizers supply the same amount of phosphate (about 0.1785 grams of P_2O_5 at the lowest rate). An additional fixed rate of nitrogen and magnesium each at 2.7 grams of ammonium nitrate and 3.4 grams of kieserite respectively were added. No potassium was applied as it had no significant effect in a previous test (see **Experiment 102b**, 1988 Annual Report).

RESULTS

Data was analyzed separately, the above ground components (leaves and stalk) together and roots on their own. The results are given in Table 100. In effect the results were almost identical in that roots followed a similar pattern to the rest of the above ground components.

The differences in the dry matter yield for the plant components between the two phosphate fertilizers were highly significant ($p<0.001$) but the addition of sulphur treatments had no significant effect on the dry matter yield. There were large differences in the dry matter yield due to the different levels of phosphate for the TSP treatment, but not for the rock phosphate treatment.

Figure 25 shows the regression curves for the total dry matter yields against the phosphate levels. A much larger regression coefficient or slope was obtained for the TSP curve as compared to the Rock P curve indicating that TSP is much more effective in increasing the dry matter. Yields continue to increase at high levels of TSP but for Rock P it levelled off at P levels of around 4 (about 0.7140 grams of P_2O_5). Extending these curves by extrapolation would show a drop for TSP at level 9 and for Rock P at level 6.

CONCLUSION

The differences in the yield between these phosphate fertilizers were highly likely due to differences in their solubility in these slightly acid soils which determine how readily P is available to be taken up by the plants. This test has been done over a short duration on an annual crop and TSP comes out on top with much higher total dry matter yields in maize. Furthermore the increase in the level of phosphate, which shows a significant effect for the TSP treatment but not for rock phosphate, could be related to TSP being more soluble compared to rock phosphate. Although the differences in effectiveness of the two fertilizers would be less over a larger time period as in perennial crops such as oil palm, it is concluded that on most oil palm soils in PNG the pH is too high for North Carolina rock phosphate to be very effective.

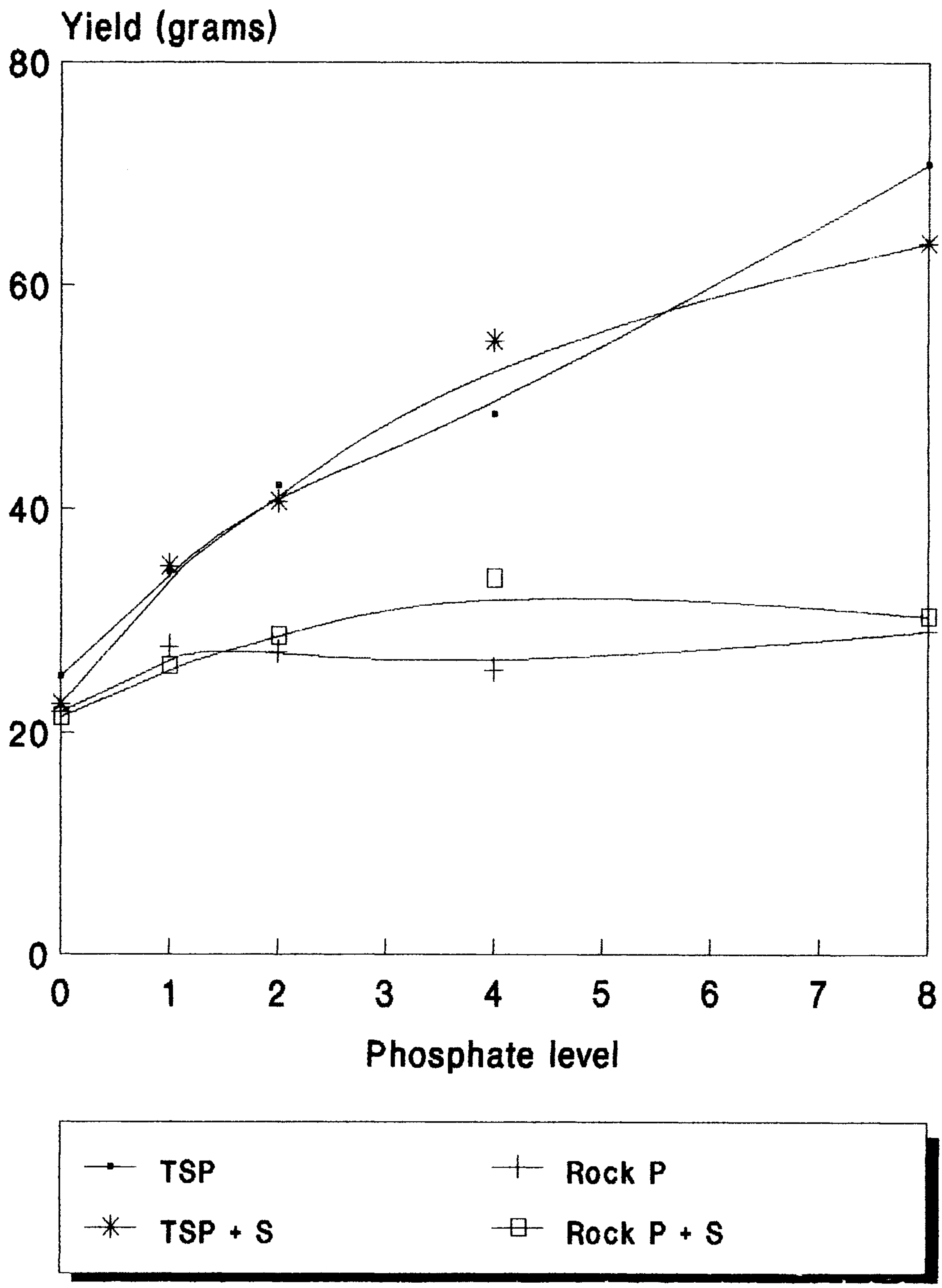


Fig. 25 Experiment 102C, Total dry matter of maize plants

Table 100 Dry Matter Results for Root, Stalk + Leaf and Total (root + stalk + leaf).

FERTILIZER	LEVEL 0	1	2	4	8	**MEAN**	
				ROOT			
TSP	4.60	5.93	6.73	6.45	8.28	**6.39a**	
TSP + S	4.73	6.28	5.98	8.03	8.60	**6.72a**	**lsd 0.05 1.61**
Rock P	4.45	5.13	5.28	4.70	5.00	**4.91b**	
Rock P + S	4.73	5.40	5.50	5.78	4.87	**5.25b**	
MEAN	**4.63a**	**5.68ab**	**5.87b**	**6.24bc**	**6.69c**		**c.v % 18.3**
			lsd 0.05 1.175				
				STALK + LEAF			
TSP	20.42	28.42	35.25	41.92	62.50	**37.70a**	
TSP + S	17.79	28.55	34.62	46.79	55.10	**36.61a**	**lsd 0.05 9.70**
Rock P	17.40	22.52	21.90	20.90	24.02	**21.35b**	
Rock P + S	16.65	20.50	33.07	28.00	25.50	**22.74b**	
MEAN	**18.07a**	**25.00b**	**28.72b**	**34.65b**	**41.73c**		**c.v.% 24.03**
			lsd 0.05 5.969				
				TOTAL (root + stalk + leaf)			
TSP	25.02	34.35	41.97	48.37	70.71	**44.10a**	
TSP + S	22.51	34.82	40.60	55.00	63.70	**43.33a**	**lsd 0.05 9.07**
Rock P	21.85	27.65	27.20	25.60	29.02	**26.26b**	
Rock P + S	21.37	25.90	28.57	33.77	30.37	**28.00b**	**c.v.% 21.8**
MEAN	**22.69a**	**30.68b**	**34.59b**	**40.69b**	**48.47c**		
				lsd 0.05 6.77			

** Mean figures with different letters differ from each other significantly and no significance difference for same letters.*

EXPERIMENT 115: FROND PLACEMENT TRIAL. (P.Navus)

Background information.

The plantation management is initially maintaining the treatments with the role of PNGOPRA restricted to recording yields and growth measurements. If differences in palm performance become apparent, full yield recording will later be introduced.

PURPOSE.

To determine the optimum placement of cut fronds in the Mosa environment.

SITE DETAILS.

Location: Kumbango Plantation Division II. Field D11 - 13.
Soil type: Awaiting classification.
Genetic material: Dami D X P
Planted: 1976
Density: 135 palms/ha

DESIGN AND TREATMENT DETAILS.

Design: 12 replicates of two paired treatments.
Treatment Details: testing the effect of; 1) Fronds stacked in alternate row 2) Fronds spread uniformly except in paths.
Plot size : 6 - 7 lines consisting of 102 - 119 palms, the central 56 - 71 palms being recorded.
Date of first treatment: February 1987.

Duration: ongoing.

RESULTS:

Tables 101 and 102 record the monthly single bunch weights and black bunch behaviour since the first treatment was applied in February 1987.These results are illustrated in Figs. 26 & 27.

Discussion:

Monthly recording activities commenced at different times after frond placement was differentiated into the two treatments in February 1987. Bunch weight was recorded later at 9 months and bunch production at 12 months respectively. Table 101 shows the progressive details for both treatments, whilst Table 102 shows the 1989 performance by replicate. As expected it has taken some time for the effects to build up. Table 99 shows stacked fronds for the first time has significantly (P= 0.1))increased single bunch weight. No effect is detectable when considering yield estimates as shown in Table 102. Since an indication of a response has now been obtained, detailed (twinrow) recording of FFB and annual leaf production assessment will be introduced in 1990.

Table 101 Expt. 115. The monthly mean single bunch weights and bunch number production since Nov 1987 and March 1988 respectively.

Months	Single bunch weights (kg)		Bunch counts	
	SPREAD	STACKED	SPREAD	STACKED
1	25.9	28.5	NR	NR
2	24.8	24.3	NR	NR
3	21.8	23.6	NR	NR
4	22.3	23.2	NR	NR
5	21.4	22.1	3.2	3.5
6	NR	NR	3.2	3.3
7	23.3	21.3	2.9	2.9
8	18.7	18.7	2.0	2.1
9	17.0	16.1	2.1	2.4
10	20.9	19.6	2.2	2.2
11	20.9	20.9	2.2	2.2
12	22.9	22.8	2.5	2.4
13	22.3	23.4	2.7	2.6
14	24.1	29.8	3.4	3.8
15	25.1	24.9	3.4	3.8
16	NR	NR	3.2	3.1
17	24.1	24.6	NR	NR
18	24.0	26.0	3.4	3.6
19	23.6	24.5	2.6	2.6
20	25.2	25.6	3.0	3.1
21	25.8	22.5	2.5	2.5
22	24.4	25.6	2.3	2.4
23	23.5	25.3	2.7	2.8
24	24.8	26.2	2.7	2.7
25	26.8	29.7	3.1	3.3
26	27.9	30.0	3.8	3.5
Mean	**23.40**	**24.13**	2.81	2.87

It is also intended that the Nitrogen investigation work (Expt. 713) will be incorporated into this trial. It is proposed to investigate both the customary method of fertilizer broadcasting by estates (who normally apply fertilizer at the weeded circle periphery) and overall (inter-row included) broadcasting.

Table 102 EXPT. 115 Monitoring of palm performance in 1989.

	SPREAD	STACKED	SPREAD	STACKED
	Bunch Weight (kg)		Black Bunch Count (no per palm)	
Rep	1/89	- 12/89	1/89	- 12/89
1	23.92	24.89	2.86	2.26
2	24.17	25.30	3.34	2.96
3	22.65	26.31	2.13	2.48
4	25.35	26.55	2.75	3.05
5	26.34	27.51	2.87	2.95
6	25.29	24.61	2.93	3.25
7	25.09	24.04	2.81	2.83
8	23.83	25.70	2.19	2.83
9	26.25	28.03	3.03	2.72
10	28.05	23.01	3.35	3.23
11	21.98	26.54	2.96	3.10
12	26.43	26.07	3.48	3.65
Mean	24.95	25.71	2.892	2.942
d =	0.76		0.05	

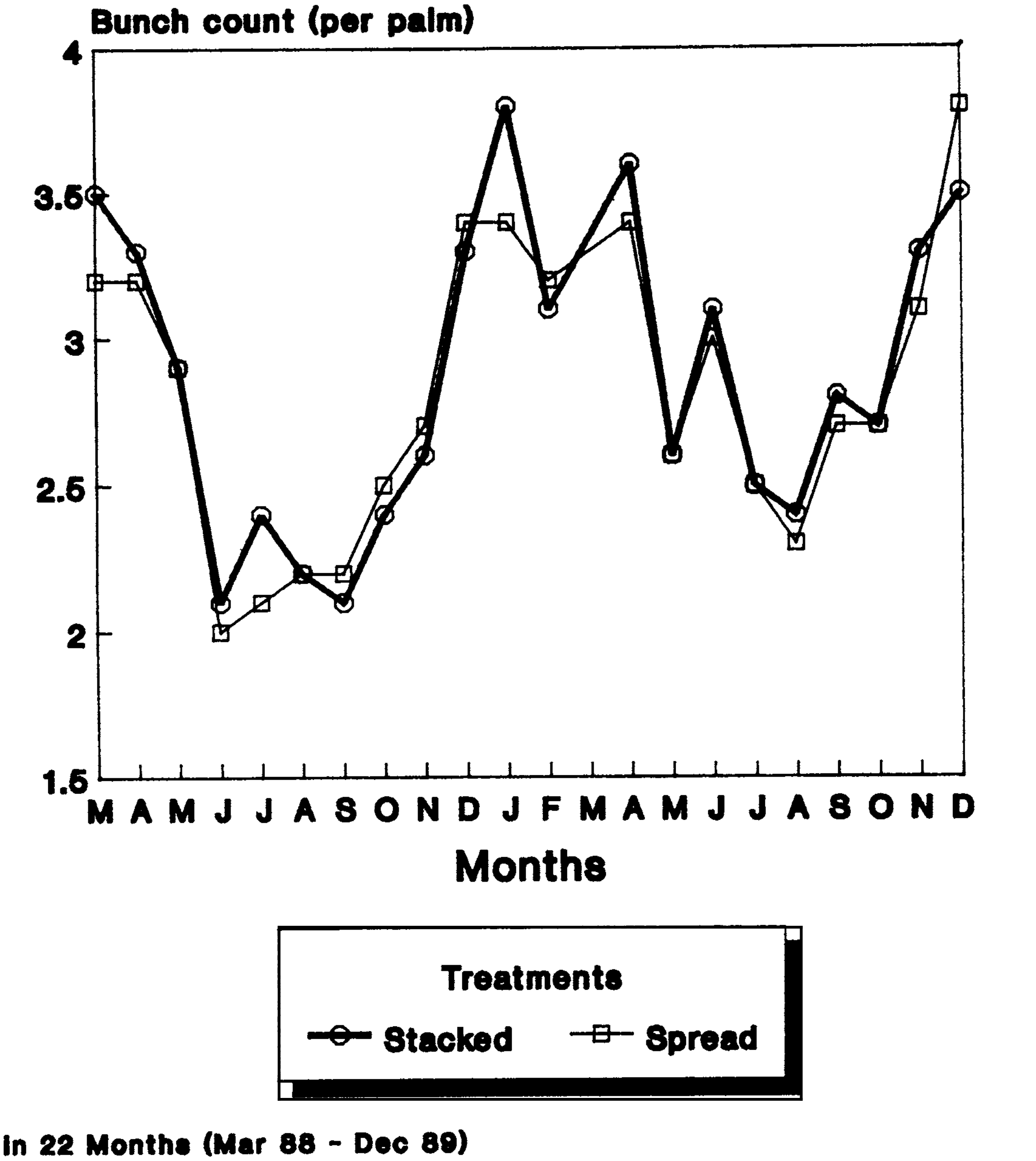


Fig. 26 Experiment 115, Assessment of palm performance with different frond placement treatments

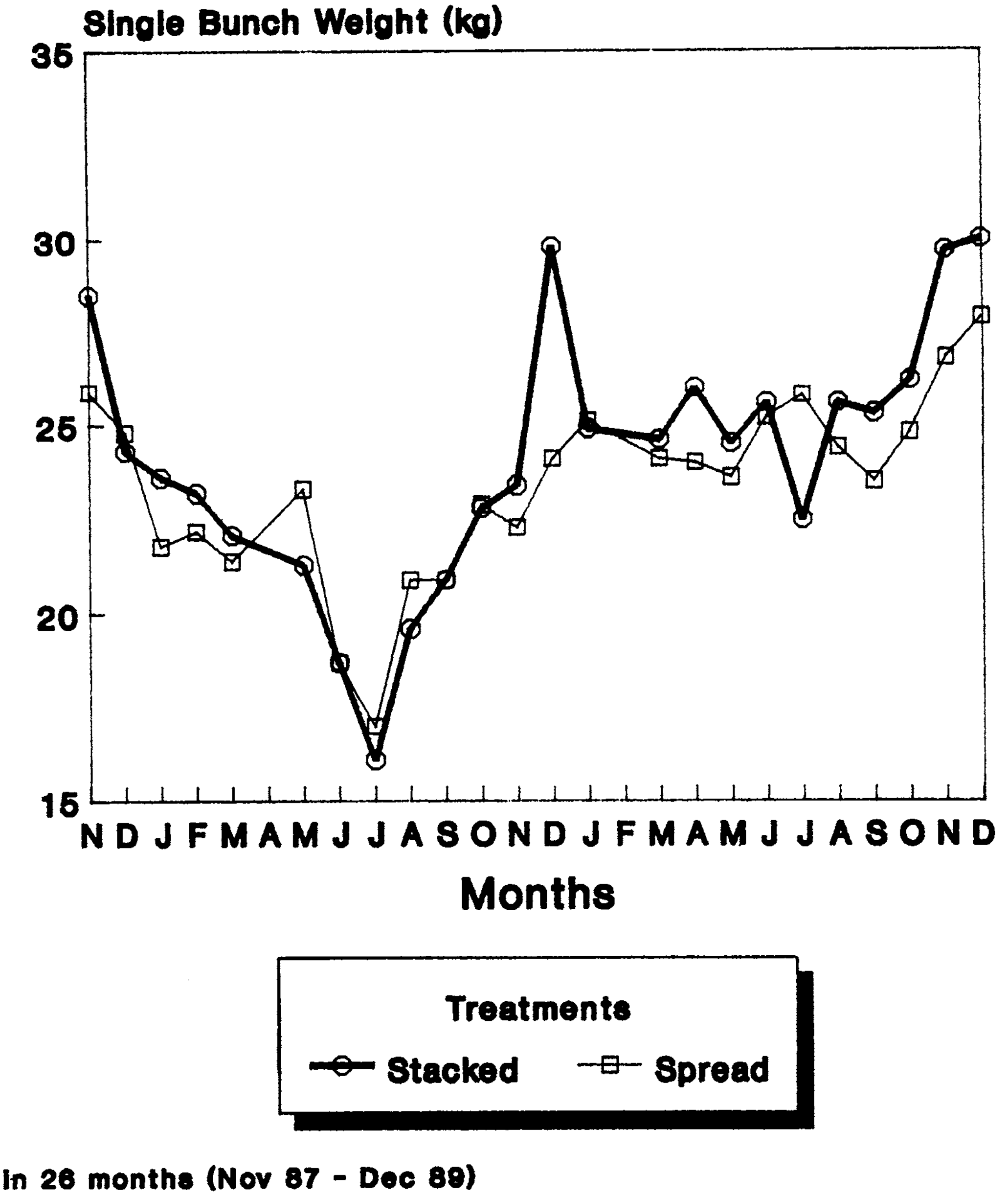


Fig. 27 Experiment 115, Assessment of palm performance with different frond placement treatments

EXPERIMENT 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) Popondetta Agricultural College, 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) Kapiura Plantation, Kautu Estate, West New Britain.

This site is near to Experiment 401 fertilizer trial, but no previous pollination studies have been done at this location. Kapiura 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

All the material is in the nurseries at present, with unfortunately two planting dates due to the loss of the first batch of I.R.H.O. material sent to Popondetta, which has subsequently been replaced. Recording will be adjusted for this difference of about six months. It is expected to begin planting this trial in May/June 1991.

V. ENTOMOLOGY

(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.

It was decided in 1988 to shelve further investigations on a second backup pollinator until sufficient funds were available to properly advance the work required. A recent study by the I.R.H.O. in Africa (Mariau et al.(1989). Proc. NIFOR Int.Conf. on Palms & Palm Products, Benin City) indicates that similar poor pollination occurs there from time to time even in the presence of nearly all the oil palm pollinating insects known. This information appears to support the theory that a mechanism can be operated by some palms to limit fruitset. With planting material in some areas of P.N.G. recording consistently 20 percent higher fruitset than others, with the same pollinator, the exact reasons for this should be of value to plant breeders.

Studies with clonal material under Investigation 703 may elucidate the principal factors involved in fruitset variation.

INVESTIGATION 603: *ELAEDOBIUS KAMERUNICUS* FIELD STUDIES

PURPOSE: To introduce the insect pollinator *Elaeidobius kamerunicus* to areas of oil palm in Papua New Guinea and to regularly monitor the population of the pollinator and its effectiveness in determining fruitset.

Fruitset

In West New Britain the Dami material at the Buluma site averaged 62 percent fruitset over the year with no marked fluctuation seasonally, (Fig.28). The Dami material on Hargy Plantation Bialla produced a record average of 65 percent with one depression in September averaging only 49 percent, (Fig.29). None of the other parameters measured (ie) rainfall, male/female flower ratio, or weevil emergence data give any indication of the cause of the poor fruitset in this one month. The I.R.H.O. material, also on Hargy Plantation, continued its very high fruitset trend with an average of 76 percent with one depression in March of 64 percent, (Fig.30).

Fig.28 Percentage average fruitset, Buluma, W.N.B.
(1979 planting, Dami seed)
(Average fruitset over 13 months = 62%)

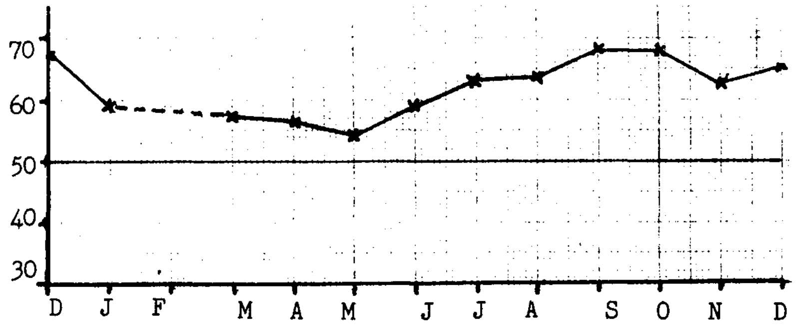


Fig. 29 Percentage average fruitset, Hargy, W.N.B.
(1979 planting, Dami seed)
(Average fruitset over 13 months = 65%)

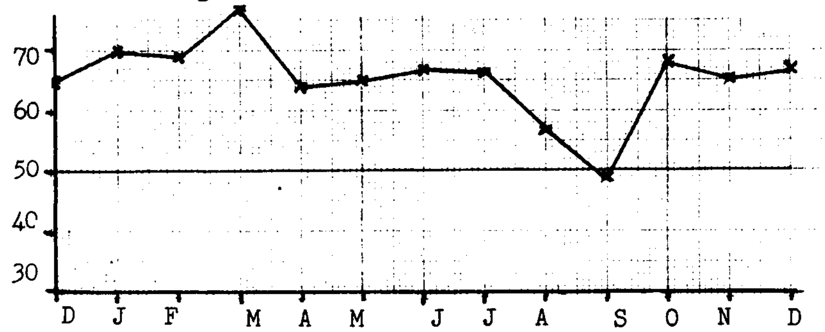


Fig. 30 Percentage average fruitset, Hargy, W.N.B.
(1973 planting, IRHO seed)
(Average fruitset over 13 months = 76%)

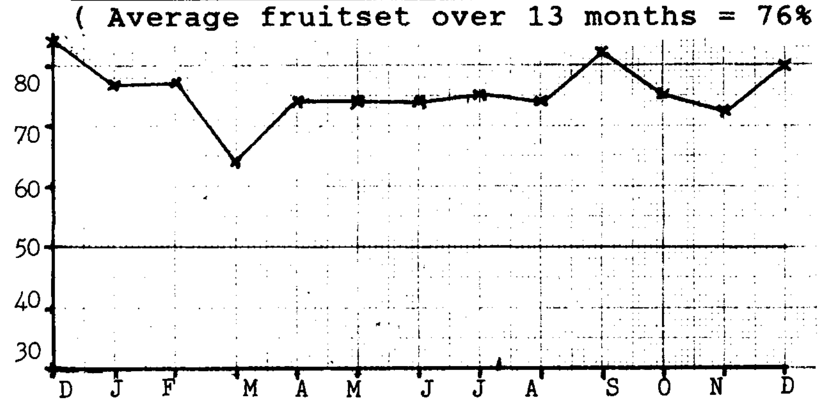
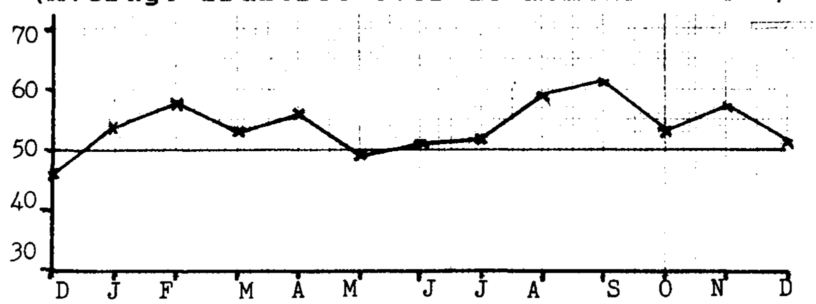


Fig. 31 Percentage average fruitset, Ambogo, Oro Province
(1980 planting, Dami seed)
(Average fruitset over 13 months = 54%)



In Oro Province the Dami material on Ambogo plantation averaged 53 percent with no marked fluctuation during the year, (Fig.31). Fruitset recording on Arehe plantation was discontinued in May and for that recorded period averaged 68 percent, (Fig.32).

Routine recording of fruitset will cease as from the end of this year except for the Ambogo site in Oro Province where a modified experiment is being continued until the end of 1990.

Weevil population density:

Weevil population density expressed as the number of weevils per hectare based on male flower numbers, weevil emergence and numbers of palms per hectare, is a rough guide as to the number of weevils available for pollination and is referred to as the pollination force. Generally it is found that a pollination force of around 200,000 weevils per hectare provides adequate pollination, to achieve approximately 60 percent fruitset. In West New Britain the range in 1989 was between 191,000 and 547,000 with an average of 306,000 weevils per hectare to give an average of 62 percent fruitset over the year. In Oro Province in 1989 the pollination force ranged from 86,000 to 456,000 per hectare with an average of 235,000 weevils per hectare to give an average of 53 percent fruitset for the year.

At Dami and Popondetta counts of both male and female inflorescences in anthesis are recorded on the same hundred palms at the same time every week. A few female inflorescences may be missed, but this method prevents double counting and hence an over estimate to be made, as anthesis only lasts for 3 or 4 days. At Buluma, Dami, West New Britain there is no significant difference ($p>0.05$) in male to female sex ratio between the 3 years 1987-89, which averaged 2.6:1. Compared with the Ambogo site at Popondetta where only a few months recording was carried out, there is a significant difference ($p<=0.026$) in male to female. The mean at the Buluma site W.N.B. was 2.6 male : 1 female and at the Ambogo site at Popondetta it was 1.8 male : 1 female. Although significantly less the ratio at Popondetta should theoretically still enable adequate pollination levels to be reached.

***E. kamerunicus* introduced into Milne Bay Estates:**

This 5500 hectare estate development with 300 hectares village oil palm smallholdings will come on line for processing fruit on completion of the factory in June 1990. The main release sites were Waigani and Hagita estates where each site had approximately 44,000 weevils to emerge from cut spikelets sent by air from Dami, West New Britain. A further 23,000 weevils were released on a smallholding at Kapurika. The date of release in all three sites was 27th April 1989 and establishment over 300 metres from the sites was confirmed on 14th June.

Weevil emergence data for November was 118 and 152 per spikelet and in December 79 and 121 for the two main estates Hagita and Waigani. These figures are on the high side compared with all other areas of P.N.G. The weevil was well distributed in all areas in October and the first weevil pollinated bunches are expected in January next year. A sample of 10 bunches from Hagita plantation in December averaged only 9 percent fruitset.

The main area of concern with this development is the likely imbalance of receptive female to receptive male inflorescences which creates pollen shortage. Preliminary sex ratio data is very variable but does indicate a difference between the estates with Hagita having a good balance of 1:2 male to female and Waigani with a lower male flower count per hectare resulting in a 1:6 ratio. No conclusions can be drawn from this data but next year sufficient data from all three parameters; fruitset, weevil emergence and sex ratio should give a good indication of factors likely to adversely affect oil extraction rates.

Rainfall (Figs. 33 - 35)

In West New Britain rainfall at Dami and Hargy (Fig.33) was less than the preceding two years, but with no pronounced dry period.

In Oro Province (Fig.34) both recording sites were around the seasonal average with marked monthly fluctuation between 100 and 400mm. June rainfall on both sites was very low at 38 and 35mm.

Milne Bay (Fig.35) for most of the year recorded a relatively even distribution between 200 and 400mm with their driest months in November, December and January recording a range of 72 - 148mm per month.

INVESTIGATION 601: SEXAVA CHEMICAL CONTROL.

PURPOSE: To monitor 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.

Through out this year todate, Sexava damage in West New Britain has been restricted to two plantations and several smallholder blocks in the divisions in the Hoskins scheme. However at Bialla W.N.B. widespread infestation of both smallholder, V.O.P. and plantation continued from last year up to the end of this year.

Fig. 32 Percentage average fruitset, Arehe, Oro Province, (1983 planting)

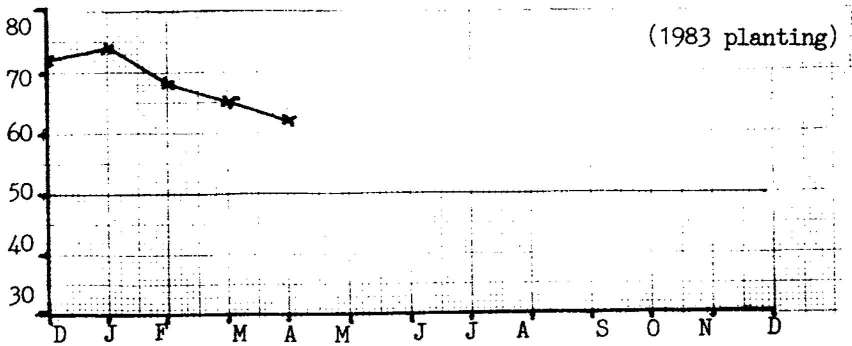


Fig. 35 Rainfall in mm Milne Bay Province (two sites)

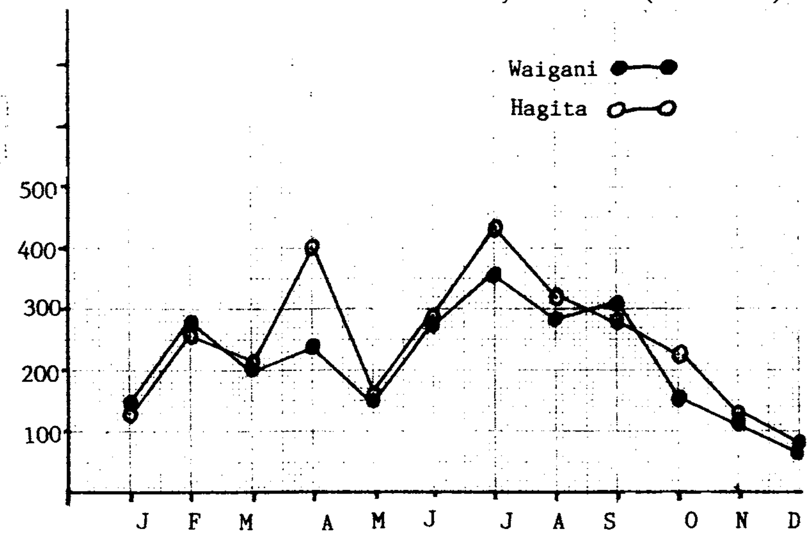


Fig. 33 Rainfall in mm West New Britain Province (two sites)

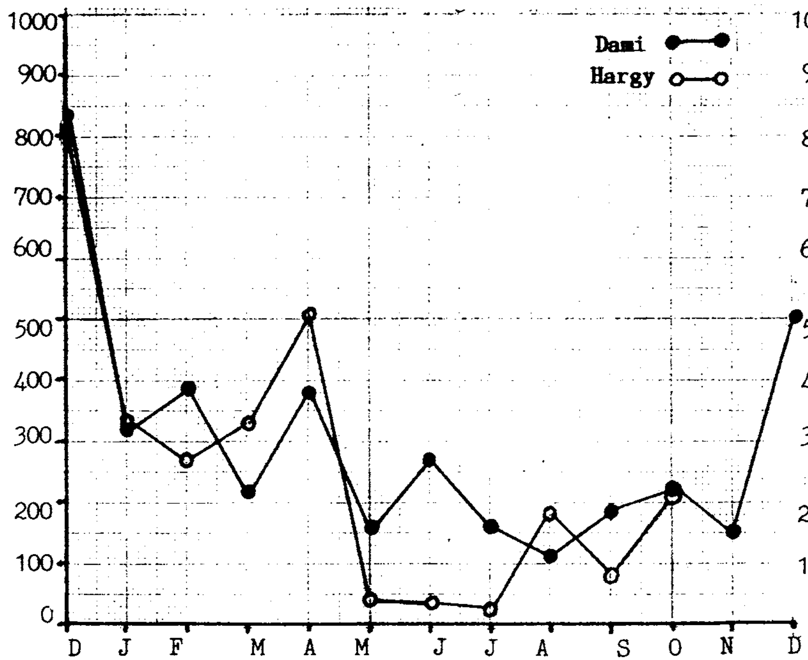
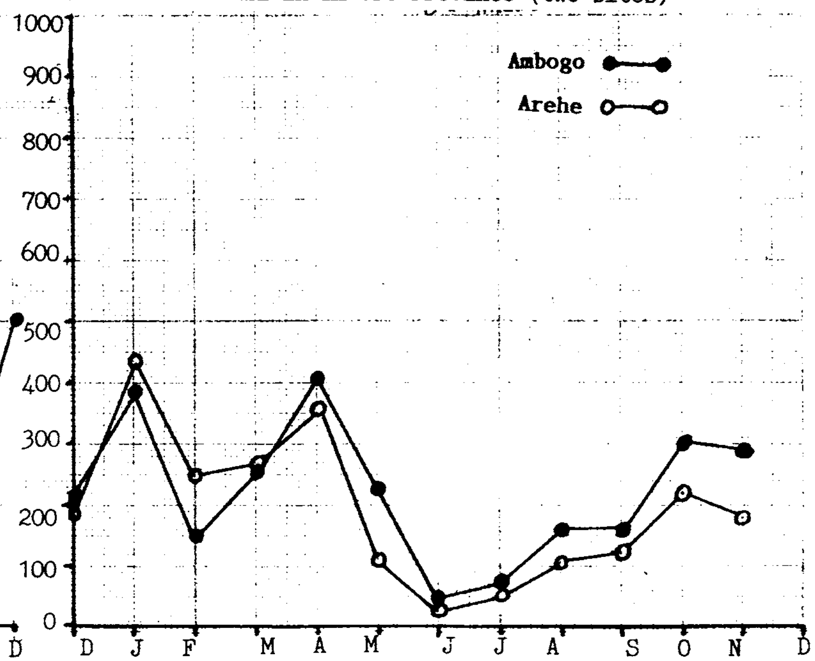


Fig. 34 Rainfall in mm Oro Province (two sites)



Areas in the Hoskins scheme affected were Gule V.O.P. (18 blocks) treated in February; Kavugara (9 blocks) treated in August. Navarai Plantation, 50 hectares treated in August. Kavugara (29 blocks) treated in December; Rikau and Gule V.O.P. (13 blocks) treated in December. Dami plantation, 25 hectares treated in December.

Areas in the Bialla oil palm scheme requiring treatment were Hargy Plantation:- an unspecified hectarage in nearly all divisions treated from January to the end of July when the infestation appeared to have been brought under control.

In the Bialla sub-divisions:- on Tiauru a 105 blocks were treated between January and March, 16 blocks from Sale/Malasi and V.O.P.'s treated between January and March and a further 17 in April. 16 blocks in Uasilau sub-division were treated between April and June and 14 blocks in Silanga sub-division were treated and a further 32 blocks were treated in November.

The area of smallholders treated in total is about 1000 hectares including some blocks that were treated twice. The cost of this operation to the small farmer is in the region of 70,000 kina and illustrates why it so important to treat before Sexava becomes well established and spreads to neighbouring blocks.

In Oro Province very few blocks required treatment; a combination of Sexava and the cockchafer *Dermolepida* sp. caused moderate damage to two blocks on Iseveni and Sehora, and 3 blocks at New Warisota and Kipore in April. 8 blocks were treated for Sexava at Sorovi in May. Further slight damage has not required treatment.

INVESTIGATION 607: SEXAVA BIOCONTROL

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.

Mass rearing and release of the Sexava egg parasite *Leefmansia bicolor* continued throughout the year. Some of the material used to supply eggs for the cultures came from the parthenogenetic race of *Segestes decoratus* from Navarai plantation and some *Segestidea defoliaria* from the Bialla district.
Successful recovery of *L. bicolor* from Navarai plantation six months after its release confirmed field establishment in January this year.

Over 300,000 parasites were released throughout the region at the following localities:-

Release site	Numbers of *L. bicolor released*
Kumbango plantation	56,745
Navarai plantation	20,000
Hargy estates	68,000
Tiauru sub-division, Bialla	16,000
Wilelo sub-division, Bialla	48,320
Gule V.O.P. Hoskins	12,800
Dami Research Station	47,170
*Kilenge, coconuts, Cape Gloucester	33,520

(* This release was done at the request of the W.N.B. Provincial D.A.L. office and the patrol paid by them. Very serious damage over a large area of coconuts had occurred, but the remote location and difficult access to many blocks made chemical treatment too difficult and costly. Hopefully the establishment of *L. bicolor* may help reduce outbreaks in future.)

In October a visit was made to New Hanover Island, New Ireland Province to re-collect both major Sexava egg parasites. *Leefmansia bicolor* and *Doirania Leefmansii*. The former was collected to start a new culture of *L. bicolor* which has now been continuously mass reared at Dami for five years. It is considered desirable to start with fresh field collected material to avoid any adverse genetical selection which could occur with laboratory reared material over a period of time. The new culture at the years end is well established under the usual technique. The second parasite *Doirania leefmansii* was lost in culture at the end of 1987. This species has now been re-established and is developing satisfactorily.

It was significant that, as on our previous visits in 1978 and 1985, the village coconuts at Lavongai remain with light to moderate damage by the indigenous Sexava species, *Segestidea leefmansi* (Willemse) confined to a few palms. Most of the Sexava eggs were collected from epiphytes, ferns and other plants, growing on the coconut palm trunks and approximately 80 percent of the eggs had parasite emergence holes. With the assistance of village children several hundred unhatched Sexava eggs were collected during the two days we spent at Lavongai.

It is noteworthy that this location, where *Leefmansia bicolor* was imported from the Molluca's and released on New Hanover in the 1930's, has remained unchanged. Both introduced and native egg parasites establishing and apparently maintaining an equilibrium with the Sexava population with only moderate levels of damage occurring to a few palms from time to time. The village people confirmed that they have never lost production or suffered severe Sexava damage to their coconuts.

Work on testing systems of in vitro rearing of one or both parasites has begun and when equipment and diets are ready tests will be run on the same lines as used by the Chinese entomologists who are successfully controlling several major crop pests by in vitro rearing and release of several million parasites a day. Attendance at next year's symposium in Texas should hopefully finalise the techniques and programme for the in vitro rearing of the Sexava egg parasites.

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.

(a) *Scapanes australis*:-

The field observation plots of 2000 palms at Bebere plantation, W.N.B., of underplanted standing poisoned palms and clear felled replanting, were discontinued in September 1988. Results are summarised in the Annual Report for 1988. This year there have been no reports of significant damage by *Scapanes* to underplanted palms in an increasing area of estate replanting and smallholdings.

(b) *Oryctes rhinoceros*:-

Oil palm developments in P.N.G. have been outside areas where *Oryctes* occur, until early this year, when redevelopment of old cocoa/coconut plantations took place on New Ireland.

In October a visit to this development, known as Poliamba, revealed an ideal breeding ground for *Oryctes*, with hundreds of felled coconut logs lying exposed on the ground. Partial decay had occurred and large numbers of *Oryctes* larvae were found in the partially rotted logs. A few dead larvae which were brown in color and with their body contents entirely liquid, appeared to have the *Oryctes* virus which had been released in New Ireland in 1981-83 by the P.N.G. Government. The diseased larvae were sent to Dr. Philip Entwistle of the Institute of Virology and Environmental Microbiology, Oxford. In subsequent correspondence it was considered advisable to release a fresh batch of virus by inoculating captured adult beetles and releasing them. This project is proposed for early next year.

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.

Throughout this year the continuing dryer weather favoured development of bagworms. In April severe damage by *Mahasena corbetti* to a few palms in the vicinity of Kumbango Plantation Mill compound W.N.B. warranted treatment, although sampling the population revealed 86 percent natural mortality. Subsequently a much larger area of about 20 hectares became infested and required treatment at the end of August. A very high natural mortality was still found in the sample taken, but dry weather with high winds enabled this insect to spread to other areas quite rapidly. On Togulo plantation a moderate outbreak of *Mahasena* was reported in June but sampling revealed seventy percent natural mortality including 18 percent parasitism by Tachinids. Treatment was not recommended and subsequently damaged palms recovered without economic loss.

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.

Longicorn beetle: ***Mulciber linnaei*** in Oro Province. No damage by this insect this year has been reported.

Stick Insects: ***Eurycantha insularis*** Lucas (Phasmidae) in Oro Province. The identity of this insect was received in August this year after the British Museum specialist, Dr. J. Marshall received the male specimens sent from Popondetta. This species has developed a minor pest status in Oro Province and this year four smallholder blocks at Igora were treated by monocrotophos trunk injection in April and June after moderate damage had occurred. One block at Tunana also required treatment in October plus three blocks at Koropata in December. Details of this insects biology are being obtained by laboratory studies.

Cockchafer: ***Dermolepida noxium*** **and** ***D. proxium*** also caused damage to a few smallholdings in Oro Province in conjunction with *Segestidea nouvaeguinae*. Cockchafers appear to be quite seasonal and after large numbers appeared during early March they have not appeared again in significant numbers. Five affected blocks were treated in four sub-divisions as detailed under Sexava chemical control (Investigation 601).

Sugarcane Weevil: *Rhabdoscelis obscurus* (Coleoptera, Curculionidae). No damage by this insect to unripe or ripe bunches has been reported this year. *R. obscurus* was found associated with spear rot in young underplanted palms on Bebere plantation W.N.B., but was only secondarily attracted to the rotting tissues.

Rat Damage:-

In Oro Province both male flowers and black unripe bunches became severely damaged during April, and this continued at a high level to the end of the year but was confined mainly to Ambogo and Arehe estates. On other areas, including smallholdings, damage was slight to moderate.

PATHOLOGY

In West New Britain several cases of spear rot have occurred in young underplanted palms on Bebere plantation but, with an incidence rate of less than three percent and with a high recovery in the form of new spears produced, it remains an insignificant problem. Basal stem rot caused the collapse of a few mature palms in one area on Togulo plantation and it was note worthy that the affected palms were situated close together and not on particularly poorly drained ground.

In Oro Province 2 palms were affected by basal stem rot in March at Awowota sub-division and in July eleven were found to be diseased, probably due to *Phellinus noxius*, on Isavene sub-division. In this case deficiency symptoms of either magnesium or potassium indicated that poor nutrition could have aided the development of the disease. In October another block on Isavene had stem rot caused by organisms not identified.

In New Ireland Province, on Poliamba's Katu plantation, a visit in October to an old (1968 planting) D.A.L. oil palm trial plot revealed one diseased oil palm which had a complete 'skirt' of collapsed green fronds, with 4 or 5 unopened spears at its apex. On the trunk base were several bracket fungus fruiting bodies which, along with photographs, were sent to Dr. Peter Turner, Director of the Cocoa and Coconut Research Institute at Rabaul. Dr. Turner confirmed that the organism was a pathogenic strain of Ganoderma and expressed concern at the large number of coconut stumps left in the ground on this development which may be a source of Ganoderma to infect the new oil palm development. This is the first confirmed case of Ganoderma killing an oil palm in P.N.G.

In the Mosa area of West New Britain underplanting the old oil palm stand is now standard estate practice. The old palms are poisoned six to nine months after planting and left to rot in situ. Two experiments have been set up in the area to monitor any incidence of lower stem rot:

EXPERIMENT 801: INCIDENCE OF GANODERMA DISEASE (H.L.F.)

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.

RESULTS:
In 1989, seven years later, there were no visual signs of infection of the young palms by *Ganoderma*.

EXPERIMENT 803: GANODERMA PATHOGENICITY TESTS (H.L.F.)

PURPOSE: To determine the pathogenicity of oil palm wood infected with *Ganoderma*.

In this experiment established in 1983 in the Dami beach area, infected palm wood was buried at the base of young field palms. In 1989, six years later, no visual signs of any infection by *Ganoderma* was observed.

PUBLICATIONS

Foster, H.L. (1989). Benefits of Research by the Papua New Guinea Oil Palm Research Association. In Proc. INA/Rural Industries Council Agriculture Seminar, Institute of National Affairs Discussion Paper No. 38, pp 102-108. INA, Port Moresby.

Foster, H.L. (1989). Progress in the assessment of oil palm fertilizer requirements. In Proc. NIFOR International Conference on Palms and Palm Products, Benin City. NIFOR, Benin City, Nigeria.

PNGOPRA (1989). Minimum fertilizer recommendation for oil palm grown in smallholdings on volcanic soils in Papua New Guinea. PNGOPRA Advisory Leaflet No.3.

Wilkie, A.S. and Foster, H.L. (1989). Oil Palm response to fertilizers in Papua New Guinea. In Proc. 1989 PORIM Inter national Palm Oil Development Conference. PORIM, Kuala Lumpur.

APPENDIX I

Table 103: Meteorological Data, Dami, 1989

	Rainfall mm		Rainy days		Sunshine (h/m)	
	1970-89	1989	1970-89	1989	1970-89	1989
January	627.8	320.4	24.7	23	116.6	130.8
February	636.0	390.6	24.1	26	108.7	84.9
March	506.6	218.6	24.5	16	124.4	135.1
April	357.0	384.4	21.3	24	148.3	123.2
May	230.8	167.0	17.7	16	167.1	165.4
June	158.4	277.4	15.8	12	161.3	165.6
July	187.4	162.8	15.8	16	153.7	190.1
August	156.7	111.4	15.1	15	180.5	202.3
September	179.5	199.0	13.9	14	180.2	194.8
October	177.4	224.3	15.3	17	177.8	166.9
November	243.7	152.4	17.8	18	173.9	167.7
December	416.0	506.0	22.6	21	127.3	107.0
Total	3877.2	3114.3	228.4	218	1819.9	1833.8

Table 104: Rainfall (mm) all sites 1989

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
W.N.B. PROVINCE													
Dami	320	391	219	384	167	277	163	111	199	224	152	506	3113
Bebere	311	422	251	358	289	136	137	83	190	133	216	511	3037
Kumbango	203	509	264	288	205	96	98	48	144	169	203	472	2698
Hargy	329	276	331	509	47	41	28	NA	83	216	347	589	NA
Navo	260	NA	370	307	208	144	112	188	202	270	450	402	NA
ORO PROVINCE													
Arehe	365	198	283	329	104	51	59	125	224	180	224	420	2562
Ambogo	392	153	263	407	229	53	65	159	132	221	186	307	2567
Isavene	267	246	320	361	87	84	75	142	261	226	226	328	2623
MILNE BAY PROVINCE													
Hagita	128	252	210	401	157	290	431	317	281	225	128	83	2903

(NA = Not Available)

Table 105: Meteorological Data, Higaturu 1989

	Rainfall mm			Sunshine hrs			Rainy days		
	1988	1989	1981-89	1988	1989	1981-89	1988	1989	1981-89
January	387	320	264	132	131	154	23	21	18
February	183	390	268	154	85	121	21	19	20
March	232	219	334	170	135	162	25	21	20
April	249	384	269	177	123	165	24	18	19
May	140	167	179	205	165	177	11	17	15
June	138	277	176	123	166	143	11	14	16
July	306	163	103	190	190	170	5	19	11
August	113	111	115	187	202	182	10	14	14
September	232	199	163	187	194	176	16	14	13
October	311	224	228	206	167	184	12	24	19
November	217	152	227	184	168	185	12	20	17
December	192	506	317	143	107	149	23	22	20
Total	2700	3112	2643	2058	1833	1968	193	223	202

APPENDIX II

THE ASSOCIATION'S ACCOUNTS FOR 1989

Auditor's Report to the members of Papua New Guinea Oil Palm Research Association Inc.

We have audited the balance sheet and profit and loss account in accordance with International Auditing guidelines. In our opinion the attached balance sheet, income and expenditure statement and accompanying notes thereon are drawn up so as to give a true and fair view of the state of affairs of the Association as at 31st December 1989 and of its income and expenditure for the year ended on that date.

Price Waterhouse
Lae, 27th March 1990

Balance sheet as at 31st December, 1989

	KINA	
Accumulated funds	1989	1988
	246,282	84,726
Represented by:		
FIXED ASSETS (Note 2)	122,288	88,927
CURRENT ASSETS:		
Cash at bank and on hand	106,995	6,769
Debtors	106,698	89,850
	213,693	96,619
CURRENT LIABILITIES:		
Trade Creditors	56,350	78,897
Other Creditors and Accruals	33,349	21,923
	89,699	100,820
Net Current (liabilities) Assets	123,994	(4,201)
	246,282	84,726

Statement of Income and Expenditure for the year ended 31st December 1989

	KINA 1989	1988
INCOME:		
FFB Levy................................	506,976	372,541
Profit on Disposal of Fixed Assets.......	3,979	-
Interest received.......................	5,324	3,845
Government grant received................	150,000	100,000
Member Grants received...................	120,000	-
Sundry income............................	7,535	-
	793,814	476,386
EXPENDITURE;		
Agency, Audit, Legal and Professional fees	15,038	13,917
Bank charges............................	378	975
Depreciation............................	34,257	27,581
Direct experiment costs..................	84,456	59,981
Electricity, water and gas...............	15,743	14,547
Insurance...............................	10,128	2,518
Laboratory..............................	82	886
Medical.................................	4,187	4,424
Motor vehicle...........................	30,714	24,769
Office expenses.........................	17,836	22,906
Rentals and other accommodation costs....	90,082	84,312
Repairs and Maintenance - buildings......	16,890	19,166
Salaries, wages and allowances...........	292,696	248,941
Staff recruitment.......................	2,671	7,972
Staff training..........................	1,870	2,499
Travel and entertainment.................	15,230	12,724
Loss on disposal of fixed assets.........		2,874
	632,258	550,992
(DEFICIT)/SURPLUS FOR THE YEAR	161,556	(74,606)
ACCUMULATED FUNDS BROUGHT FORWARD	84,726	159,332
ACCUMULATED FUNDS CARRIED FORWARD	246,282	84,726

The accompanying notes form part of these accounts.

NOTES TO AND FORMING PART OF THE ACCOUNTS
31 December 1989

STATEMENT OF ACCOUNTING POLICIES

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.

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 as follows:-

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

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

FIXED ASSETS

	KINA	
	1989	1988
Household, office and laboratory, furniture and equipment at cost.........	80,224	64,138
Less accumulated depreciation...........	24,325	18,759
	55,899	45,379
Motor vehicles at cost..................	114,149	95,173
Less accumulated depreciation...........	47,758	51,625
	66,391	43,548
Total written down values...............	122,290	88,927

CAPITAL COMMITMENT

Capital expenditure authorised and contracted for totalled K Nil (1988 K Nil).

MANAGEMENT BOARD'S STATEMENT 31 DECEMBER 1989

We, J.N. Hansen and J.P.C. Baskett, 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 is drawn up so as to exhibit a true and fair view of the state of affairs of the Association at 31 December 1989 and the statement of income and expenditure is drawn up so as to give a true and fair view of the results of the business of the Association for the period ended on that date.

For and on behalf of the Board

J.N. HANSEN

J.P.C. BASKETT

Lae
28th March 1990

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 1989 and of the results for the period ended on that date.

A.R. McMASTER
SECRETARY

Lae,
28th March 1990

APPENDIX III

ALLOCATION OF RENTED BUILDINGS

NEW BRITAIN PALM OIL DEVELOPMENT LTD.

Offices and laboratory (7 rooms)	1
Entomological building	1
Store (4 rooms)	1
"SM" houses	1
"A" houses	3
"AR" houses	1
"IB" houses	4
"JG" houses	6
"DLQ" houses	1
"SMQ" houses	2

HARGY OIL PALMS PTY LTD.

Office	1
Bossboi quarters	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	1
Labour houses	3

MILNE BAY ESTATES PTY LTD.

Office	1
Intermediate house	1

APPENDIX IV

ALLOCATION OF VEHICLES

Vehicle	Reg.No.	User	Purchased	Km run
Toyota Hilux 4WD (twin)	AFL 659	DOR	3/88	36,855
Toyota Hilux 4WD (single)	AFH 562	Oic, Higaturu	5/88	50,348
Toyota Hilux 4WD (single)	AFF 235	Soils Agron.	8/87	95,912
Toyota Hilux 4WD (single)	AHA 967	Entomologist	6/89	23,111
Daihatsu Delta	AFO 225	Driver (Dami)	5/88	(N.R)
Toyota Dyna	AGC 505	Driver (HOPPL)	8/89	9,190
Daihatsu Scamp 4WD	AKA 951	Ext. Agron.	1/86	70,860
Yamaha XT 125	AO 057	Agron (HOPPL)	9/87	37,025

(N.R.= Not recorded)

APPENDIX V

LIST OF INVESTIGATIONS

Number	Location	Number	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 trial	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	
111	Malilimi		Nitrogen and phosphate fertilizer trial	1985	1987
112	Buvussi		Nitrogen & phosphate fertilizer trial	1985	
113	W.Nakanai		Smallholder N fertilizer and food cropping demos	1985	1988
114	Togulo		Discoloured frond investigation	1985	1986
115	Kumbango		Frond placement trial	1987	
116	Bebere		Systematic nitrogen fertilizer trial	1987	
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	
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	Kapiura		NPKMg Fertilizer Trial	1989	

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
321	Ambogo	Thinning Observation	1989	
501	Hagita	Establishment fertilizer trial	1986	
503	Hagita	Nursery fertilizer trial	1987	1988
505	Waigani	Trace element trial	1988	1988
506	Milne Bay	Smallholder demonstration trials	1989	

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	
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