ANNUAL REPORT

OF

THE PAPUA NEW GUINEA
OIL PALM RESEARCH ASSOCIATION

1988

EIGHTH ANNUAL REPORT

of the

PAPUA NEW GUINEA

OIL PALM

RESEARCH ASSOCIATION

1988

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MANAGEMENT BOARD

CHAIRMAN	F.E. McGuire
NEW BRITAIN PALM OIL DEVELOP. LTD.	J.R. Gilbert (to July) J.P.C. Baskett (from Aug)
DEPARTMENT OF PRIMARY INDUSTRY	J. Christensen (alternate to Secretary, D.A.L.)
HARGY OIL PALMS PTY. LTD.	J. Wynand
HIGATURU OIL PALMS PTY. LTD.	F.E. McGuire
MILNE BAY ESTATES	J.N. Hansen
KAPIURA PLANTATIONS PTY. LTD.	J. Montgomerie (from Oct)
DIRECTOR OF RESEARCH	T. Menendez (to April) Dr. H.L. Foster (from May)

In attendance

MANAGING AGENTS REPRESENTATIVE AND SECRETARY

A.R. McMaster

SCIENTIFIC ADVISORY BOARD
as at 13th October, 1988

F.E. McGuire	Chairman, PNGOPRA
J. Christensen	Dept. of Agriculture & Livestock
L. Chase	Higaturu Oil Palms Pty. Ltd.
J.N. Hansen	Milne Bay Estates Pty. Ltd.
D. Laing	Hargy Oil Palms Pty. Ltd.
Dr. C.J. Breure	New Britain Palm Oil Development Ltd
J. Montgomerie	Kapiura Plantations Pty. Ltd.
Dr. H.L. Foster	Director of Research

In attendance

A.R. McMaster	Secretary, PNGOPRA

By invitation

J.P.C. Baskett	Harrisons and Crosfield (PNG) Ltd
G. Masuru	Dept. of Agriculture and Livestock
Dr. R. Lockwood	Commonwealth Development Corp.
R.H. Lindesay	Harrisons and Crosfield PLC.
N. Hansen	Milne Bay Estates Pty. Ltd.
R.N.B. Prior	Senior Entomologist, PNGOPRA
A.S. Wilkie	Agronomist, PNGOPRA
I. Orrell	Soils Agronomist, PNGOPRA

EXECUTIVE STAFF

DIRECTOR OF RESEARCH	T. Menendez, B.Sc., DPB., M.I. Biol. (to April)
	Dr. H.L. Foster, M.A., M.Sc., Ph.D., (from May)
AGRONOMIST (Higaturu)	A.S. Wilkie, B.Sc., M.Sc.
ASSISTANT AGRONOMIST	P. Navus, B.Ag., Sc., M.Sc. (on study leave from January to August)
ASST.AGRONOMIST(Higaturu)	A. Oliver, B.Sc.
SOILS AGRONOMIST	I. Orrell, B.Sc.
RESEARCH ASSISTANT	P. Talopa, B.Ag.
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 (from June)
	PETRUS SOKIP
RECORDERS	JAPSON DAPO
	SIMON MAKAI
	ALPHONSE POKA (to October)
	PAUL LUS
	JASON YALIKUA
	HARRY MORAKI (from February)
SECRETARY	MONICA MAPE
ACCOUNTS CLERK	CAMILLUS GOLU
TYPIST/CLERK	LUDWINA LIKKY
RECORDS CLERK	BERNADINE BUBU
DRIVER/HANDYMAN	JAMES DUKE
HARGY	
SENIOR FIELD ASSISTANT	JOSEPH NAGI (to March)
	PHILIP SIO (from April)
HIGATURU	
TECHNICAL ASSISTANT	DANIEL TOMARE
JUNIOR SUPERVISOR	WAWADA KANAMA
RECORDERS	GOLBAN BETARI
	GRAHAM BONGA
	MAX YAURA
	ENOCK TOPENI
	LEONARD DOMBAKA
	READON ERUGA (from May)
CLERK	MACGILL TAIMBARI (to June)
	ARAMPORA SAU (from July)
DRIVER	ELGIN LUSCOMBE (to July)
	SERGIUS AMBARAGO (from July to November)
	JOHN GARIMOPA (from Dec.)
MILNE BAY	
FIELD ASSISTANT	DANNY STANLEY

CHAIRMAN'S STATEMENT

The recovery in palm product prices experienced towards the latter part of 1987, fortunately held up into 1988, and a degree of confidence and stability returned to the oil palm industry. Prices for CPO fluctuated markedly during the period (380-580 US$ CIF Europe), while kernels traded in a narrower range (230-260 US$ CIF Japan).

However, our optimism was somewhat offset with the effects of the 1986 and 1987 droughts being felt with a vengeance. Yields from all sectors of the industry were depressed which in turn greatly affected our income with a resultant net deficit of some K74,606 for the year. Despite tight budgetary control, our cash reserves were severely eroded.

In this regard, it is again pleasing to note the ongoing support from the PNG Government, essential in view of our increased activity, and their continued support for our Association is most welcome.

Emphasis was again placed on nutritional experiments and it is pleasing to note that firm recommendations for all sectors of our industry were issued. Undoubtedly the key to increased productivity in PNG, nutritional experimentation must continue to be the major element of our research programme.

Smallholder needs were well catered for with an increased programme of demonstration and rehabilitation blocks being effected. Coupled with this was a much closer liaison with Department of Agriculture and Livestock (DAL) staff, aimed at improving and intensifying advice to smallholders. The importance of this sector to the well being of our Association must not be underestimated, and I am sure our efforts are well justified, to the mutual benefit of growers and Association alike.

Mr. Menendez retired as Director of Research (DOR) during the year and we welcomed Dr. Hugh Foster as his successor. His experience, particularly in the key 'nutritional' area, will be of great benefit to the PNG oil palm industry and our best wishes and thanks go to the DOR and all his staff for their efforts and support during the year.

Finally, as I shall shortly be leaving Papua New Guinea, I would wish to express my thanks to all those involved with PNGOPRA over the years. My best wishes for continued success in the future.

F.E. McGuire

PART 1. ADMINISTRATION AND DEVELOPMENT

MANAGEMENT BOARD AND SCIENTIFIC ADVISORY BOARD

The Management Board met twice, at Lae on 24th March and at New Britain Palm Oil Development Ltd, Mosa Management Centre, on 14th October. The Seventh Annual General Meeting of the Association was held in Lae on 24th March at which Mr. F.E.McGuire was re-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 Dami Oil Palm Research Station, W.N.B.P. on 13th October. This was preceded by an informal meeting between Scientific Advisors and PNGOPRA staff on 12th October and a field trip to surrounding estates, attended by most Board members.

FINANCE

The research levy was increased from 65 toea at the start of the year to 80 toea per tonne of fresh fruit bunches with effect from 1st April 1988 and the Government grant for the year was increased to K100,000. However the budget for 1988 was based on an expected cess of K1.00 per tonne with effect from April and the FFB crop was 15-20% down against estimate. Hence income for the year was K150,298 less than estimated.

Expenditure for the year was K52,182 less than the budget estimate, resulting in an excess of expenditure over income amounting to K74,606. Thus accumulated funds have been reduced from K159,332 to K84,726 during the year, the latter including fixed assets valued at K88,927. Hence the Association ended the year with net liabilities of K4,201.

Full details of the Association's Accounts for 1988 and the Auditor's Report are presented in Appendix II.

Messrs. Price Waterhouse were re-elected as auditors for 1989.

STAFF

The year saw the establishment of a new team at PNGOPRA, under the direction of Dr. Foster, who took over from Mr.Menendez in April, as Director of Research. Mr. Wilkie, Officer-in-Charge, PNGOPRA Higaturu and Mr. Orrell, Soils Agronomist, both of whom had arrived late in 1987, fully settled in during 1988. Mr. Talopa, a graduate from Unitech, Lae, joined Dami as a Research Assistant in March. Mr. Navus, Extension Agronomist, successfully completed his M.Sc. course at Reading University, U.K. and returned to duties in September. Thus at the end of 1988, PNGOPRA had a full establishment of 4 expatriate executive officers, including a DAL Senior Entomologist attached to PNGOPRA, and 3 national executive officers. Four of these executive staff are stationed at Dami

Headquarters, and two at Higaturu sub-station. With an increase in activities in Milne Bay Province, an additional national executive is expected to be recruited for Higaturu next year.

At the end of the year non-executive staff numbered 15 at Dami, 10 at Higaturu and one each at Hargy and Milne Bay.

TOURS AND CONFERENCES

Regular visits have been made by agronomy and entomological staff at Dami to Bialla and Kapiura in West New Britain and occasionally across to Oro Province to check on trials, to give advice on pests and other problems and to carry out soil surveys. Similarly staff at Higaturu have made regular visits to the Kokoda valley in Oro Province and to Milne Bay. The Director of Research attended Research Advisory Meetings at the Coffee Research Institute and the Cocoa and Coconut Research Institute, and the Officer-in-Charge PNGOPRA Higaturu also attended a Coffee Research Meeting.

Mr. Prior presented a paper at an Entomological Conference in Vancouver during his long leave in July and Mr. Orrell attended a Soil Management Workshop at Honiara in September.

BUILDINGS

Minor modifications were made to the offices at Higaturu and additional non-executive housing was rented at Dami during the year. The allocation of buildings, rented from New Britain Palm Oil Development, Higaturu Oil Palm and Hargy Oil Palm is shown in Appendix III.

VEHICLES

A new 4WD twin-cab Utility was purchased for the Director of Research in March and a 4WD single-cab Utility was obtained for the Officer-in-Charge, Higaturu in May. The Senior Entomologist's Utility is now 5 years old and urgently in need of replacement. A second-hand Daihatsu Delta truck was purchased in May to replace the previous truck in use at Dami which had blown its engine. Details of all vehicles at the end of the year are shown in Appendix IV.

EQUIPMENT

No new equipment was purchased at Dami during the year, except for an additional hard disc for the computer. At Higaturu, a new IBM computer, printer and UPS, a photocopier, a drying oven and a deep freeze were all purchased during the year, bringing the facilities into line with those at Dami. In addition a telephone has now been installed at Higaturu, making communication with HQ much easier. A new drying oven has also been installed at Milne Bay, in expectation of much increased leaf sampling.

VISITORS

To Dami:

Antony G. University of New England, New South Wales, Australia
Balele J.M., Manager, Smallholder Affairs, Mosa, with a party of 30 smallholder leaders (CAC members).
Baskett J.P.C., Harrisons and Crosfield (PNG) Ltd., Lae.
Benjamin M., Walindi Plantation, West New Britain.
Boema N., D.A.L. Nahavio.
Breure C.J. Dr., Harrisons & Fleming Advisory Services, London.
Chase L., Commonwealth Development Corporation, London.
Christensen J., Dept. of Agriculture and Livestock, Konedobu.
Crabb T.M., Harrisons and Fleming Advisory Services.
Cronin M., Harrisons and Crosfield (PNG) Ltd., Lae.
Dogra A., PNG Coffee Research Institute, Kainantu.
Dori F., Laloki Research Station, D.A.L.
Firnkes F.C., S.E.A.F.C.O., Singapore.
Gilbert J., Harrisons and Crosfield, (PNG) Ltd., Lae.
Greasely W.A., Harrisons and Fleming Advisory Services, London.
Greer H., Harcros Trading (PNG) Ltd., Kimbe.
Gurnah A.M., Agric. Dept., Unitech, Lae.
Hanold D. Dr., Waite Institute, Australia.
Hansen N., Milne Bay Estates, Alotau.
Harding P., PNG Coffee Research Institute, Kainantu.
Holmes J., Monsanto Ag. Co., Cairns, Queensland, Australia.
Hopkinson D.H.L. Mr.&Mrs., Harrisons and Crosfield PLC
Jenkins R., ICI, Lae.
Kargbo C., Agric. Dept., Unitech, Lae.
Kauzi G., Department of Agriculture and Livestock, Konedobu.
Kennedy A., Post Courier, Port Moresby.
Kennedy D., Post Courier, Port Moresby.
Kesavan V. Prof. Unitech, Lae.
Kiara J.M., Coffee Research Institute, Kainantu.
Kidd D., U.N.D.P.
King D., Analytical Services Ltd., Cambridge, New Zealand.
Laing D., Hargy Oil Palms, Bialla.
Libitino I., Reforestation Dept., Stettin Bay Co, Ltd., Buluma.
Liddle J. Dr., Analytical Services, Cambridge, New Zealand.
Liggitt J., Harrisons and Crosfield (PNG) Ltd., Lae.
Lindesay D., Harrisons and Crosfield PLC, London.
Little F., World Bank, U.S.A.
Little L., Mitcham, Victoria, Australia.
Lockwood G. Dr., Commonwealth Development Corporation, London.
McGuire F.E., Higaturu Oil Palms Pty. Ltd., Popondetta.
McLeod J., Harrisons and Crosfield PLC, London.
McMaster A.R., Harrisons and Crosfield (PNG) Ltd. Lae.
Montgomerie J., Harrisons and Crosfield (PNG) Ltd., Mosa.
Ovasuru T., PNG Cocoa and Coconut Research Institute, Kerevat.
Philemon O., Post Courier, Lae.
Philemon P., Post Courier, Lae.
Prentice T., Harrisons and Crosfied, London, U.K.
Preston T.D. Mr.&Mrs., Harrisons and Crosfield (PNG) Ltd.
Pugh P., Harrisons and Crosfield PLC, London.

Sar S., Kuk Research Station, D.A.L., Mt.Hagen.
Saul J., PNG Cocoa and Coconut Research Institute, Kerevat.
Sherrington J., Kuk Research Station, D.A.L., Mt. Hagen.
Talopa P., University of Technology, Lae.
Taylor J.G., Harrisons and Fleming Advisory Services, London.
Uexkull H.R.von Dr., Potash and Phosphate Institute, Singapore.
Vatasan G., and 5 undergraduate students, Forestry Dept., Lae.
Waugh C., UIM Agrochemicals (Aust) Pty Ltd.
Wynand J., Hargy Oil Palms, Bialla.
Zaved Z., PNG Coffee Research Institute, Kainantu.

To Higaturu:

Aggeman K., Physics Dept., University of PNG.
Chase L., Commonwealth Development Corporation, London.
Kila K., Physics Dept., University of PNG.
King D., Analytical Services Ltd., New Zealand.
Liddle J. Dr., Analytical Services, New Zealand.
Marshall R., Commonwealth Development Corporation, London.
Ours St de Dr., Vulcanologist, Rabaul.
Sergeant C., Commonwealth Development Corporation, London.
Smallholder leaders to a briefing given by PNGOPRA.
Turner P.D. Dr., PNG Cocoa and Coconut Research Inst., Kerevat.
Yadieribo F., Farmset Ltd.

REVIEW OF RESEARCH

(H.L.F.)

I. INTRODUCTION

The Papua New Guinea Oil Palm Research Association carries out research and extension for the benefit of oil palm growers in both the estate and smallholder sectors of the country. Consistent high production in both sectors has been shown to depend crucially on the maintenance of optimum fertility - hence nutrition currently has the highest priority in our research programme and extension efforts are largely directed to improving fertilizer use. Based on trial results, estates are provided with optimum fertilizer recommendations and the emphasis of smallholder demonstrations is to show the benefit and correct use of fertilizers. However other fields concerned with oil palm management are not neglected. In particular, pollination and crop protection are given special attention. Whilst PNGOPRA is not involved in breeding work, it is planned to carry out comparisons of commercial planting materials in the future.

Nine experiments were concluded at the end of the year, including all the factory waste experiments in West New Britain, whilst 33 existing experiments will be continued next year. In addition another 20 new experiments have been approved for 1989, which will bring the total number of experiments next year up to 53. A particular effort has been made recently to increase smallholder demonstrations and a total of 14 sites at Popondetta, 13 sites in West Nakanai and 2 sites at Milne Bay have been established, making a total of 29 current demonstrations altogether.

II. NUTRITION

Nitrogen

1) Advisory leaflet No.3, which gives minimum fertilizer recommendations for smallholders, was released during the year. Particular emphasis is given to the importance of maintaining nitrogen levels on volcanic soils in all oil palm growing areas, through the application of ammonium fertilizers.

2) Yield and leaf N levels in **Experiments 305, 306 and 309** at Popondetta, have all shown a drastic decline in the absence of N fertilizer. FFB yields have fallen in three years from over 30t/ha/yr in all trials, to 22t/ha/yr on the most fertile soil and only 8t/ha/yr on the poorest soil. Leaf N levels have fallen concomitantly from 2.6% to 2.0% or less. These results dramatically emphasise the importance of regular N fertilizer application to prevent serious yield decline with time.

3) Major yield responses to N fertilizers continued to be recorded in **Experiment 108** at Mosa, **Experiment 112** on smallholder blocks in West New Britain and **Experiments 305** and **306** at Higaturu, whilst new **Experiments 116, 117 and 118** at Mosa are all now starting to show marked N responses. A nitrogen requirement is also indicated in **Experiment 201** at Hargy and in **Experiment 501** at Milne Bay.

4) Of the types of N fertilizer, **Experiment 110** now clearly shows that Ammonium Chloride is superior to Ammonium Sulphate if chloride levels are low, whilst **Experiment 117** indicates that response to Urea is erratic and ineffective at high rates. **Experiment 110** also warns that Ammonium Nitrate is depressive in low chloride areas.

5) The existing series of factory waste trials at Mosa **Experiments 109a** and **109b**), Hargy **(Experiment 202)** and Higaturu **(Experiment 309)** were all closed during 1988 and a report on the use of factory wastes is in preparation. **Experiments 108** and **110** at Mosa also include empty bunch mulch treatments. All these experiments have clearly demonstrated a significant beneficial effect of both mill effluent and empty bunch application. In all areas the latter has generally improved nitrogen uptake in particular. However EFB rates above 50t/ha have given little extra response, perhaps due to the limiting effect of another nutrient (such as magnesium).

6) New factorial fertilizer trials, including N as a major treatment, were laid down during the year on estates at Isavene **(Experiment 311)** and Ambogo **(Experiment 312)** in Oro Province, and at Navo **(Experiment 204)** and Kapiura **(Experiment 401)** in West New Britain Province, to determine optimum methods of N fertilizer application in these additional environments. An EFB mulch treatment is included in **Experiments 311** and **312**, which will allow direct comparison of this soil amendment with the effects of the inorganic N and K fertilizer treatments.

7) Because of the dominating importance of nitrogen in maintaining and increasing yields in all areas, more detailed studies of N in the oil palm system will be started next year. **Experiment 716** will investigate the effect of cropping and crop residue management on soil nitrogen availability in existing trials, (including **Experiment 115** which is currently comparing methods of frond placement), with the aim of determining the best system for maintaining soil N fertility. **Experiment 720** will compare the efficiency of different methods of applying N fertilizer in a full scale field trial, which will be tied in with **Experiments 712** and **713** in which detailed measurements will be made in specially designed lysimeters and run-off plots in order to quantify N leaching and run-off losses under different conditions.

Chlorine

1) Advisory leaflet No.3 for smallholders, strongly recommends the application of N fertilizers in the chloride form if chloride fertilizers have not recently been applied. However since chlorine has the undesirable effect of stimulating calcium uptake (**Experiments 108,305** and **306**), Ammonium Sulphate is recommended once chlorine levels have been built up.

2) Rachis analysis in **Experiments 305** and **306** has revealed an extraordinarily large increase in chlorine levels due to application of KCl fertilizer, from less than 0.1% to more than 1% in some cases, which is accompanied by a significant increase in uptake of all cations, which are required to maintain ionic balance. Both chlorine and calcium (being the most immobile cation) accumulate in the leaflets, the latter effect tending to depress K concentration.

3) Potassium chloride fertilizer markedly increases yields in trials in the Popondetta area (**Experiments 305** and **306**), but whether this is due to the K or Cl constituent, or possibly both, has not yet been resolved. Strong yield correlations are shown with both leaf Cl and rachis K levels.

4) Existing **Experiments 110, 309,** and **310** are investigating the effect of chlorine in comparison with other anions, but only **Experiment 110** has been established long enough to give significant yield effects. In 1988, Ammonium Chloride gave a significantly higher yield response compared with Ammonium Sulphate, thus indicating a definite benefit of chlorine.

5) Disappointing responses to fertilizer have so far been recorded in **Experiment 107** on a young replant at Mosa, which also appears unusually susceptible to fan blight attack. None of the current fertilizer treatments contain chlorine and a common salt treatment will be introduced next year to determine if an improvement in the chlorine status will increase response to the major fertilizer treatments and possibly reduce fungal attack.

6) Two new trials (**Experiments 119** and **120**) comparing N fertilizer applied together with different anions, due to be established on Malilimi and Dami estates in West New Britain Province next year, are also designed to help resolve the chlorine issue.

Potassium

1) Marked responses to K fertilizer are generally shown by oil palm when the percentage of K in the leaflets of frond 17 falls below approximately 25% of total leaf bases. Such low leaf K levels have been recorded only in **Experiment 309** (18%) in an area near Popondetta previously under food crops and in **Experiment 501** (17%) at Milne Bay. Thus the response to EFB

mulching in **Experiment 309** and to KCl fertilizer in **Experiment 501** is almost certainly mainly due to the K constituent in these amendments.

2) In all other trials, either no response to K amendments has been observed, or chlorine levels are low indicating that response could be to this nutrient.

3) Analysis of rachis samples has also indicated fairly high concentrations of K (exceeding 1 %) in most trials. In cases of severe K deficiency, the concentration of K in the rachis is always found to be below the concentration in the leaflets and this has only been observed in **Experiment 309** (rachis data is not available for **Experiment 501**).

<u>Magnesium</u>

1) As with K fertilizer, marked responses to Mg fertilizer are usually observed when leaf Mg makes up less than 25% of total leaf bases. On this criterion, palms in many oil palm areas of the country would seem to be Mg deficient, which is supported by the frequent symptoms of Mg deficiency often shown by lower fronds. Exceptions are soils having high levels of extractable Mg due to the presence of minerals rich in this element, such as **Experiment 306** at Popondetta and **Experiment 501** at Milne Bay.

2) Despite the apparent need for magnesium, yield responses to applied Mg fertilizer are not frequent or marked. This would appear to be due to the difficulty in achieving Mg uptake from high Ca soils, since Kieserite application generally brings about only a slight increase in rachis and leaflet Mg levels. Indeed results from **Experiment 305** and **306** indicate that chloride and phosphate anions can be more effective than Kieserite in increasing magnesium levels in the rachis. However accumulation of Mg in the leaflets depends on the balance with other cations in the rachis and if these are also increased, leaflet Mg may actually be depressed. Thus the net effect of chloride fertilizers is generally to decrease leaflet Mg (e.g. effect of Ammonium Chloride in **Experiment 108** and of Potassium Chloride in **Experiment 306**) but phosphate fertilizer can appreciably increase leaflet Mg as shown in **Experiment 201** at Hargy.

3) Three years after Kieserite application during immaturity, yields are still significantly higher due to this treatment in **Experiment 106** at Mosa and cumulative yields in the neighbouring **Experiment 107** have also been significantly raised by Kieserite. Thus in extreme situations (e.g. where leaflet Mg accounts for less than 20% of total leaf bases) Mg fertilizer application does seem worthwhile. Furthermore if Mg fertilizers are withheld, response to other major fertilizers may be limited as indicated in **Experiment 108** at Mosa.

Phosphorus

1) Analysis of most oil palm soils in Papua New Guinea reveals a low level of extractable P and often a high phosphate retention capacity, indicating a low availability of phosphate as commonly found in volcanic soils elsewhere in the world.

2) Pot tests on soils from both West New Britain (**Experiment 102b**) and Oro Province (**Experiment 313b**) using maize as a test plant have confirmed the low availability of phosphate to plants in these soils, at least in the short term. Pot tests using oil palm and cocoa seedlings as test plants (**Experiment 313d** and **313e**) are still in progress.

3) Despite the apparent low levels of available phosphate, as indicated by both soil and pot tests, significant yield responses to triple superphosphate have not been recorded in **Experiments 106** and **107** at Mosa, **Experiment 112** on smallholdings in West Nakanai or in **Experiments 305** and **306** at Higaturu. Furthermore average leaflet P levels in these trials are reasonable, being at least 0.15%, and in no case have they been significantly increased by TSP application.

4) Only in **Experiment 201** at Hargy, which is sited on a soil recently derived from airfall ash material, has a significant yield response to P fertilizer been recorded. Leaf P levels in the absence of fertilizer were below 0.15% and were significantly increased by TSP application. However the P fertilizer also significantly increased both leaf N and Mg levels (which were both extremely low) and at least part of its benefit may have been due to these effects.

5) As well as the factorial trials mentioned above, phosphate is being tested in all the anion trials (**Experiments 110, 119, 120, 309** and **310**) and in new factorial trials at Kapiura (**Experiment 401**) and Navo (**Experiment 204**), the latter being on another soil derived from air-fall ash. These trials, plus others planned for Milne Bay and the Kokoda valley in Oro Province, cover a wide range of environments and should establish the broad situations in which a response to P fertilizer by oil palm can be expected. It may then be worthwhile to carry out soil studies, including characterisation of phosphate retention and mycorrhizal activity, in order to further clarify these situations.

Trace Elements

1) Leaf nutrient data indicates generally low levels of manganese and boron on the volcanic soils of Papua New Guinea. The level of manganese generally improves with time as a result of soil acidification by N fertilizer, but boron tends to decline further with palm age.

2) **Experiment 102b** has indicated no major trace element deficiencies in soil from the Mosa area, in pot tests carried out with maize.

3) **Experiment 313a** has indicated no significant trace element deficiencies in soils collected from new developments in Oro and Milne Bay Provinces, in pot tests with maize, although on soils from Mamba, yields tended to be lower in the absence of zinc, whilst on soils from Milne Bay, yields tended to be lower in the absence of manganese.

III. SMALLHOLDER EXTENSION

1) Yields and leaf nutrient levels in many smallholder plots in both West New Britain and Oro Province are similar to those recorded in control plots of fertilizer trials (e.g. many smallholder FFB yields are as low as 8t/ha as in **Experiment 309**). It is clear that the low yields in many smallholdings are mainly due to inadequate nutrition. As shown by fertilizer trials on similar soils, yields in many smallholdings could be increased by at least 50% through the application of recommended fertilizers. The emphasis in all smallholder demonstrations is thus on the application of the optimum fertilizers indicated from trial results. However other recommended practices are also promoted by explaining that fertilizers will be wasted if other management tasks are neglected.

2) The eight smallholder demonstrations at Buvussi in West Nakanai district comprising **Experiment 112**, showed very encouraging results to smallholders during the year, giving on average a marked response to the recommended nitrogen fertilizer.

3) In the Popondetta district of Oro Province, two new series of smallholder demonstrations were initiated, a total of 14 sites being established during the year. All demonstrate recommended fertilizer practice. **Experiment 314** involves sites in good condition chosen to demonstrate overall recommended management, whilst **Experiment 315** involves sites initially in poor condition chosen to demonstrate rehabilitation.

4) In the West Nakanai district of West New Britain Province, 5 sites for a new series of smallholder demonstrations (**Experiment 121**), each to be carried out in a different subdivision, were chosen at the end of the year. They are all intended to demonstrate overall good management as well as specific fertilizer recommendations.

5) In the Milne Bay area, two sites for proposed smallholder demonstrations (**Experiment 506**) were chosen at the end of the year. Emphasis will be given to fertilizer use, since **Experiment 501** has shown that this is absolutely essential right from planting in this new development.

6) All smallholder demonstrations have additional research plots to check whether fertilizers additional to the recommended application may be needed in some cases. Furthermore all smallholder sites are fully characterised, including the collection of soil and leaf samples, in order to be able to explain the variation in recorded yields and responses in the different areas.

7) Regular meetings with smallholders have been organised, in conjunction with the Department of Agriculture and Livestock, at the various demonstration sites, to explain and demonstrate improved management practices.

8) Illustrated posters are being prepared to encourage the use of fertilizers and to demonstrate their correct application. These posters will be distributed and explained at meetings held with DAL staff at demonstration sites.

9) To date, a total of 29 demonstration plots have been established in different sub-divisions throughout West New Britain, Oro and Milne Bay Provinces. It is intended to increase the number of these demonstrations, which are sited on both Settlement and Village Oil Palm schemes, to at least 40 next year.

IV. OIL PALM MATERIAL

1) PNGOPRA is not involved in breeding, seed production or clonal propogation, but several trials to compare available planting materials are planned.

2) In the small existing progeny **Experiment 709**, Cameroon material is significantly shorter and produces less vegetative dry matter per year than Dami material. However only the "High Bunch Number" Dami material has very significantly out yielded the Cameroon material. Fruitset in the lowest yielding Cameroon material is distinctly poorer despite very open bunches.

3) The clonal **Experiment 705** has now been reduced to a small observation block, in which UF12 and UF15 are now producing normal inflorescences.

4) The proposed International Seed Trial, **Experiment 711**, originally designed to test elite commercial mixtures, will now compare known material from only IRHO and Dami sources, at different densities at Mamba in Oro Province.

5) The proposed Dami Seed Trial has been cancelled, but known DxP crosses will be included in the agrogenetic fertilizer **Experiment 319** proposed for Warisota in Oro Province.

V. ENTOMOLOGY and PATHOLOGY

Pollination and Fruitset

1. In **Experiment 603** fruitset continued to be monitored at representative sites throughout the country to check the adequacy of pollination. Fruitset remained above 50 percent throughout the year in the Bialla area, but a very low average fruitset of below 40 percent was recorded over a 4 month period at a site in the Popondetta area despite an adequate pollination force.

2. At one site in the Popondetta area, the low fruitset could be explained by the stress of a yield peak six months earlier, but a similar correlation was not observed at a second site in the area.

3. Fruitset measured in adjacent high and low fertilizer plots in a trial near Popondetta was found to be very similar throughout the year despite marked yield differences. This suggests that neither yield nor nutritional stress are the direct cause of fluctuations in fruitset.

4. Correlation studies are due to be carried out with the data in **Experiment 603** in an attempt to identify the factors which cause variation in fruitset. **Experiment 603** will also be extended to measure the effect of partial disbudding on fruitset, in order to determine any relationship between fruitset and high yield stress.

5. In **Experiment 703**, possible factors which affect weevil pollination will be monitored intensively in two trials which will be planted simultaneously next year with clonal material, one in Oro Province and the other in West New Britain. Particular attention will be given to differences between the two environments.

Pest control

1. During 1988 there was again minimal damage by oil palm pests, including Sexava, Scapanes and bagworms, in the Hoskins and Popondetta areas. However Sexava damage was widespread in the Bialla area.

2. In **Experiment 608** observations were concluded at the end of 1988 in the two areas of replants at Mosa being monitored for *Scapanes* damage. One area was clear-felled and the other underplanted in late 1986. Since establishment, damage by *Scapanes* has been minimal in both areas and no cause for concern.

3. The few areas in the Hoskins scheme and most of the areas around Bialla, requiring chemical treatment to control Sexava, had not previously been infested; nor had parasites been released in these areas, suggesting that biological control may be working in West New Britain.

4. In **Experiment 607**, approximately half a million Sexava egg parasites *(L.bicolor)* were released at different sites during 1988. Lack of Sexava resurgence in these areas was encouraging, but the continued failure up to the end of the year to recover the parasite from Sexava eggs collected in the field was disappointing. However early in 1989 the parasite *Leafmansia bicolor* was successfully recovered from Sexava eggs collected from a site in West New Britain where the parasite had been released six months earlier. This is the first proof that the parasite is establishing itself and is a very encouraging indication that the biological control of Sexava in Papua New Guinea may be successfully achieved.

Pathology

1. In Oro Province, crown and stem rotting has been observed in a number of smallholdings. In almost every case, a poor nutritional status appears to have predisposed them to infection.

2. In **Experiment 801** at Mosa in West New Britain, in which oil palm seedlings were planted close to the stumps of a previous oil palm planting felled by various methods, no sign of any *Ganoderma* infection was observed in the sixth year.

2. In **Experiment 803** at Dami, in which infected palm wood was buried at the base of young field palms, no sign of any infection by *Ganoderma* was noted in the fifth year.

3. The two experiments in West New Britain indicate that the risk of *Ganoderma* infection in replants in this province, is minimal.

AGRONOMY TRIALS

WEST NEW BRITAIN PROVINCE

(I.O.)

EXPERIMENT 106: Factorial fertilizer experiment on young, replanted palms, Bebere Plantation.

Site Details: The area was planted in August 1982 at a density of 135 palms ha^{-1}. 1152 palms are used in the experiment, covering an area of approximately 8.5ha. The site had previously been under oil palm for 14 years.

Design: Two replicates of a $3^2 2^2$ factorial (N,Mg, P and Age of Planting Material). The 72 plots are arranged in 6 blocks of 12 plots. Each plot consists of 16 recorded palms without guard rows between plots.

Treatment: Fertilizer treatments, the last of which was in June 1985, were applied twice yearly at rates increasing with age. The rates of fertilizers applied, in kg $palm^{-1}$ were as follows:

	N			P		K			Mg		
LEVEL	**0**	**1**	**2**	**0**	**1**	**0**	**1**	**2**	**0**	**1**	**2**
Months from planting											
6	0.25	0.25	0.4	0	0	0	0	0	0	0	0
10	0	0.3	0.6	0	0.2	0	0.5	1.0	0	0.2	0.4
16	0	0.6	1.2	0	0.2	0	1.0	2.0	0	0.4	0.8
22	0	0.6	1.2	0	0	0	1.5	3.0	0	0.6	1.2
28	0	1.2	2.4	0	0	0	1.25	2.5	0	1.0	2.0
34	0	1.2	2.4	0	0	0	1.25	2.5	0	1.0	2.0

Nitrogen was applied as Sulphate of Ammonia, phosphate as Triple Superphosphate, potassium as Bunch Ash (later as Muriate of Potash) and magnesium as Kieserite. Triple Superphosphate was applied during the first year only. Bunch ash was applied 3 months after the nitrogenous fertilizer to prevent risk of ammonia volatilization. The ratio of potassium to magnesium was kept constant in plots fertilized with the combination of potassium and magnesium. Seedlings were planted at either 16 or 24 months of age. An atypically long drought immediately after planting checked growth.

Results and Discussion: The plot data means of the treatment main effects on FFB production, number of bunches produced and single bunch weight, are presented in Tables 1 and 2 for the periods January to December 1988 and January 1986 to December 1988 respectively.

Table 1: Experiment 106, Production per hectare, Jan-Dec 1988

	Wt. of bunches ($t\ ha^{-1}yr^{-1}$)	No. of bunches ($ha^{-1}yr^{-1}$)	S.B.W (Kg)
N_0	24.31	1987	**12.34**
N_1	23.91	1903	**12.68**
N_2	24.60	1914	**12.95**
K/Mg_0	**23.20**	1901	**12.33**
K/Mg_1	**24.87**	1952	**12.85**
K/Mg_2	**24.75**	1951	**12.80**
P_0	24.67	1975	12.58
P_1	23.88	1894	12.74
16 month old planting	**25.21**	**2121**	**11.92**
24 month old planting	**23.34**	**1748**	**13.40**
C.V (%)	9.6	10.3	5.8
$LSD_{.05}$ (N K/Mg)	1.36	115	0.42
$LSD_{.05}$ (P Age)	1.11	94	0.35

Note: In this and all subsequent tables, numbers in bold type signify a significant difference at $p<0.05$.

Table 2: Experiment 106, Production per hectare per year, Jan 86-Dec 88.

	Wt. of bunches ($t\ ha^{-1}yr^{-1}$)	No. of bunches ($ha^{-1}yr^{-1}$)	S.B.W. (Kg)
N_0	22.67	2286	**10.01**
N_1	22.83	2271	**10.16**
N_2	23.03	2249	**10.32**
K/Mg_0	**22.16**	2264	**9.87**
K/Mg_1	**23.18**	2283	**10.25**
K/Mg_2	**23.18**	2260	**10.36**
P_0	23.00	2291	10.14
P_1	22.69	2247	10.18
16 month old planting	**24.00**	**2524**	**9.53**
24 month old planting	**21.69**	**2014**	**10.79**
C.V (%)	7.8	8.2	5.4
$LSD_{.05}$ (N, K/Mg)	1.04	108	0.32
$LSD_{.05}$ (P, Age)	0.85	89	0.26

Both 1988 and cumulative 1986 to 88 data show Sulphate of Ammonia application to have caused a small but significant (1988: p=0.006, Jan86-Dec88: p=0.037) increase in single bunch weight. There are no significant effects of Sulphate of Ammonia on number of bunches produced on FFB yield, though the cumulative data shows non-significant trends of an increase in FFB yield and decrease in number of bunches produced due to the Sulphate of Ammonia treatment. Considering the last nitrogen application was made in June 1985, the lack of nitrogen treatment effect in 1988 is to be expected. Figures 1 to 3 illustrate the annual production data for years 1985 to 1988 for the nitrogen treatment main effects.

Sulphate of Ammonia applications stopped in June 1985, but the FFB yield benefit from the nitrogen application persisted into 1986 where there is a 7.4% higher FFB yield for the N_2 treatment relative to the N_0 treatment. In 1987 and 1988 no FFB yield benefit was observed for the earlier Sulphate of Ammonia treatments. The FFB yield increases due to Sulphate of Ammonia application in 1985 and 1986 are due largely to higher numbers of bunches produced. In 1987 and 1988, the numbers of bunches produced in the earlier Sulphate of Ammonia treated plots dropped below that of the N_0 control. This experiment illustrates clearly the need for continuous nitrogenous fertilizer applications. Cessation of nitrogen fertilizer applications rapidly results in the loss of any yield benefits attained from earlier applications.

Both 1988 data and 1986 to 1988 cumulative data, show Triple Superphosphate application to have had no significant effect on FFB production or yield components. Bearing in mind the very small amounts of Triple Superphosphate applied in this trial - the lack of identified phosphorus response is not surprising.

The combined Muriate of Potash (Bunch Ash in earlier applications)/Kieserite applications, in both the 1988 and the 1986 to 1988 cumulative data, produced significant (1988 $p=0.028$, 1986-88 $p=0.001$) increases in single bunch weight which are largely responsible for the significant (1988 $p=0.025$, 1986-88 $p=0.04$) increases in FFB production. As discussed in the 1987 PNGOPRA Annual Report, the FFB production response to the combined Muriate of Potash/Kieserite application is probably due to the addition of magnesium.

Figures 4 to 6 illustrate the annual production data for the years 1985 to 1988 for the Muriate of Potash/Kieserite treatment main effects. Despite the fertilizer application being stopped in June 1985, the FFB production increases due to the K/Mg treatments appear to have persisted through this period, 1985-1988, unlike the nitrogen response. The FFB production response to K/Mg application appears to be due to higher single bunch weights in the K/Mg treated plots for the whole of this period.

The use of 16 months old planting material over 24 months old planting material has produced a significant (1988 data: $p=0.001$, 1986 to 1988 data: $p<0.001$) increase in FFB production. The higher FFB production in the 16 month old planting material is due to a greater number of bunches produced, although the greater number of bunches produced has depressed the single bunch weight.

Fig.2 Experiment 106
Production per year, 1985 to 1988.

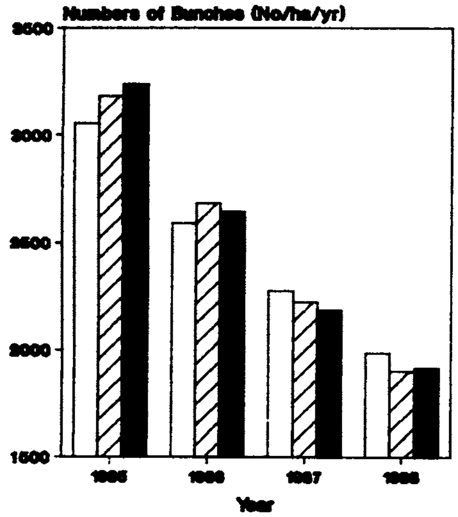


Fig. 3 Experiment 106
Production per year, 1985 to 1988.

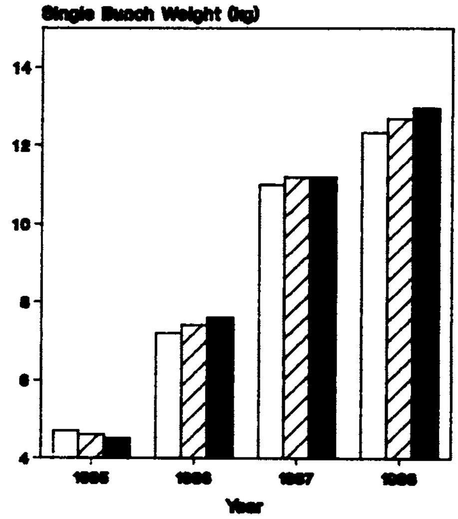


Fig. 1 Experiment 106
Production per year, 1985 to 1988.

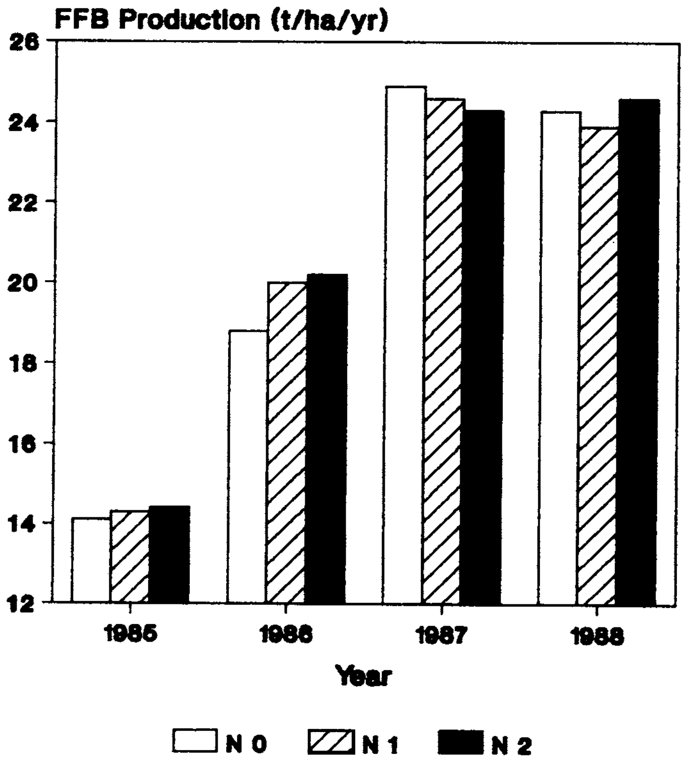


Fig. 5 Experiment 106
Production per year, 1985 to 1988.

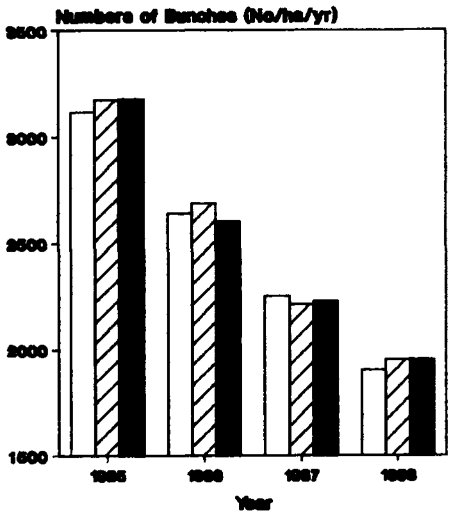


Fig. 6 Experiment 106
Production per year, 1985 to 1988.

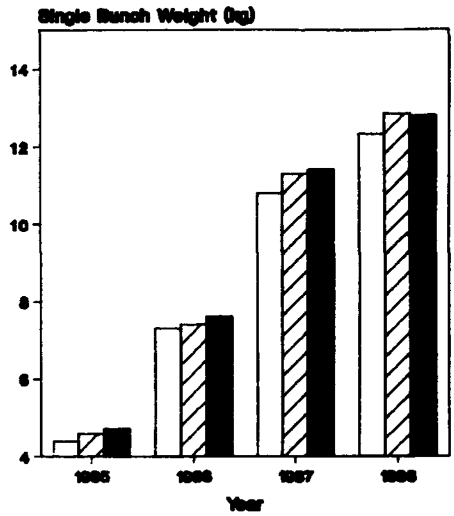


Fig.4 Experiment 106
Production per year, 1985 to 1988.

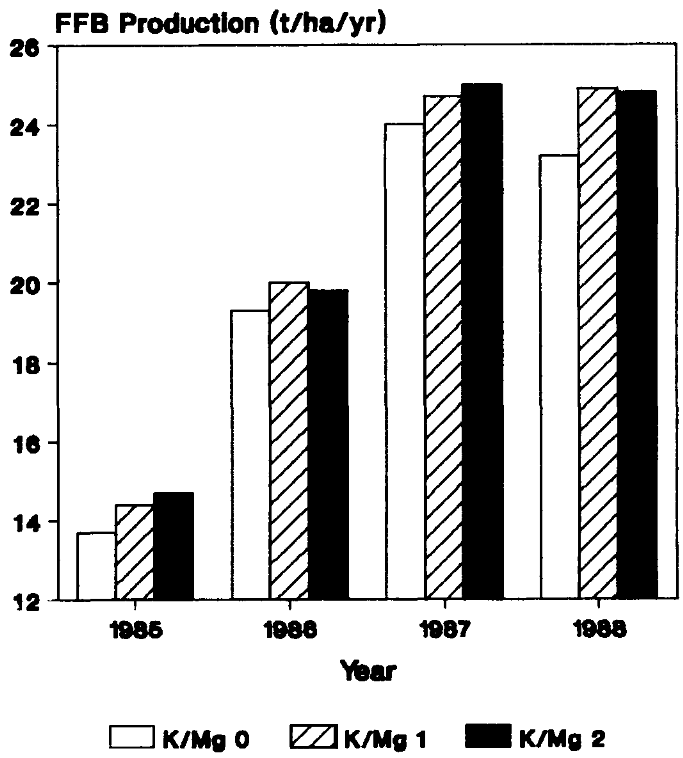


Fig. 8 Experiment 106
Production per year, 1985 to 1988.

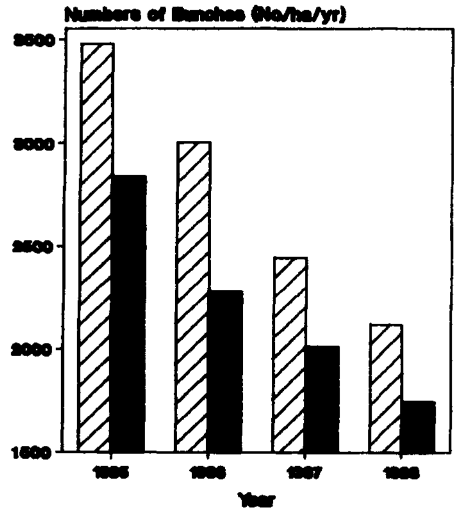


Fig. 9 Experiment 106
Production per year, 1985 to 1988.

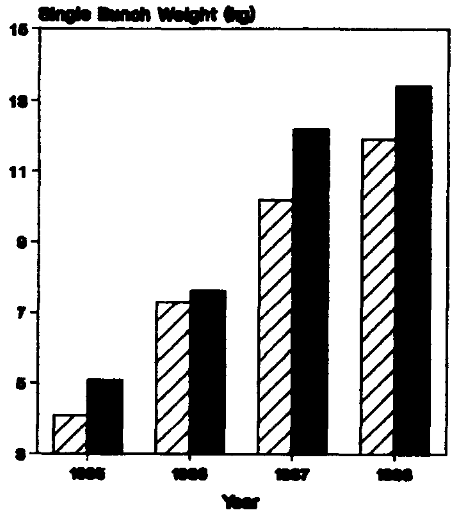
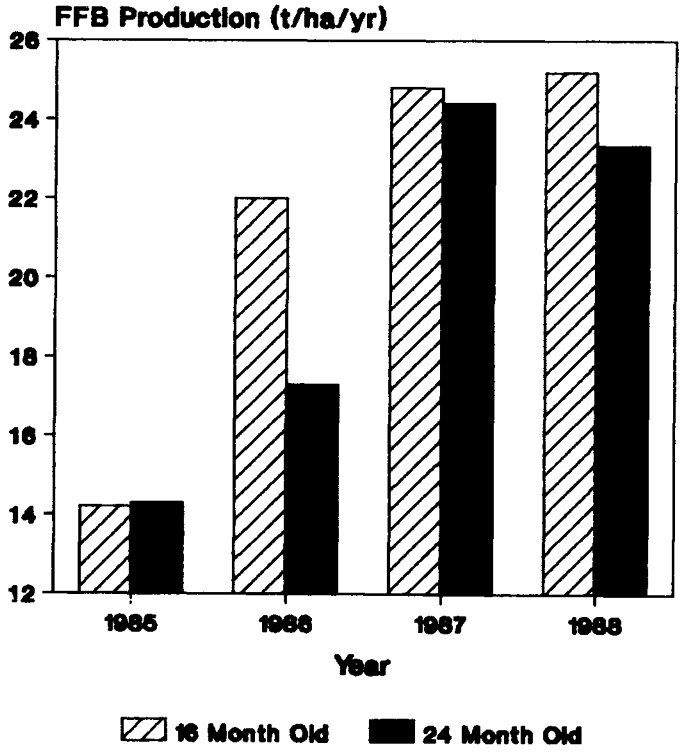


Fig. 7 Experiment 106
Production per year, 1985 to 1988.



Figures 7 to 9 illustrate the annual production data for the years 1985 to 1988 for the 16 month old and 24 month old planting material main effects. The higher number of bunches produced and slightly depressed single bunch weight of the 16 month old planting is evident throughout this period. As illustrated in Fig. 7, the 16 month old planting material reaches a peak yield of around 25t ha^{-1} yr^{-1} much more rapidly than the 24 month old planting material reaches its peak of around 24t ha^{-1} yr^{-1}

There are no significant treatment interactions affecting FFB production or yield components.

Due to the length of time since the last experimental treatment and the lack of guard rows, this experiment was discontinued at the end of 1988.

EXPERIMENT 107: Factorial fertilizer experiment on mature replanted palms, Bebere Plantation.

Site Details: The palms were planted in December 1982 and January 1983 at a planting density of 135 palms ha^{-1}. The experiment uses 2592 palms in total, 1152 palms being recorded. The experimental area is approximately 19.2ha. The site had previously been under oil palm for 14 years.

Design: This experiment consists of a mixed series $3^2 2^3$ factorial design (N,P,K,Mg and Establishment N). 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. Fertilizers are applied as two equal split doses per year. Annual fertilizer application rates are 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	-

Results and Discussion: Table 3 displays the FFB production per hectare, yield component data and petiole WxT measurement data (main effects) for the period January to December 1988. Table 4 displays the FFB production per hectare per year and yield component data (main effects) for the period January 1986 to December 1988.

Table 3: Experiment 107, Production per hectare and Petiole WxT measurement (adjusted means), Jan-Dec88.

	Wt. of bunches ($t\ ha^{-1} yr^{-1}$)	No. of bunches ($ha^{-1} yr^{-1}$)	S.B.W (Kg)	Petiole WxT June88
N_0	25.90	2431	10.66	24.59
N_1	25.88	2412	10.74	25.26
N_2	26.13	2432	10.75	25.31
P_0	25.75	2394	10.77	25.02
P_1	26.27	2467	10.66	24.90
P_2	25.90	2415	10.72	25.24
K_0	26.16	2448	10.70	25.15
K_1	25.78	2404	10.74	24.96
Mg_0	25.56	2422	10.57	24.88
Mg_1	26.38	2430	10.86	25.23
-Estn. N	26.37	**2468**	10.70	25.11
+Estn. N	25.57	**2383**	10.74	25.00
C.V (%)	7.3	7.1	4.6	5.6
$LSD_{.05}$ (N&P)	1.11	100	0.29	0.82
$LSD_{.05}$ (K,Mg & Estn.N)	0.90	81	0.24	0.67

There is a good correlation between pre-treatment petiole WxT measurements and the FFB production, yield component and post-treatment petiole WxT measurement data. Adjustment of the experimental data by the pre-treatment petiole WxT measurements using analysis of covariance (ANCOVA) greatly reduced the experimental error. ANCOVA was carried out on both 1988 and cumulative data. As with most trials on West New Britain, inclusion of blocking into the model, had little or no effect on reducing experimental error and was therefore not included in the analysis.

Although the Sulphate of Ammonia treatment shows no significant ($p<0.05$) effects on FFB production, yield components or petiole WxT measurement data, the Jan86 to Dec88 data does show non-significant increases in numbers of bunches produced and single bunch weights and these trends produce a non-significant increase in FFB production. Sulphate of Ammonia application also produces a non-significant increase in petiole WxT measurements.

Table 4: Experiment 107, Production per hectare per year, Jan86-Dec88. (Adjusted means)

	Wt. of bunches ($t\ ha^{-1} yr^{-1}$)	No. of bunches ($ha^{-1} yr^{-1}$)	S.B.W (Kg)
N_0	22.51	2541	8.86
N_1	22.78	2561	8.89
N_2	23.02	2579	8.93
P_0	22.83	2551	8.96
P_1	22.78	2584	8.81
P_2	22.71	2547	8.91
K_0	22.78	2571	8.86
K_1	22.76	2551	8.93
Mg_0	**22.11**	2528	**8.75**
Mg_1	**23.43**	2594	**9.04**
-Estn. N	23.01	2596	8.87
+Estn. N	22.53	2523	8.92
C.V (%)	6.5	6.3	4.1
$LSD_{.05}$ (N&P)	0.87	94	0.21
$LSD_{.05}$ (K,Mg+Estn. N)	0.71	77	0.17

In both the 1988 and cumulative data, Triple Superphosphate application has produced no significant effect (main effects), on FFB production, yield components or petiole WxT measurements.

The Sulphate of Potash treatments have produced no significant responses with regard to FFB production, yield components or petiole WxT measurements in both the 1988 and 1986 to 1988 data.

The Kieserite treatments have produced an increase in FFB production of 1.3t ha^{-1} $year^{-1}$ for 2kg $palm^{-1}$ $year^{-1}$ kieserite applied in the cumulative data, which is significant ($p=0.028$). The increase in FFB production is due to increases in both single bunch weight and number of bunches produced. The same effects are seen in the Jan-Dec 1988 data, although the trends are not statistically significant.

It is now about 5 years since the last establishment nitrogen treatment was applied. Although there appears to be a significant ($p=0.041$) decrease is number of bunches produced due to establishment nitrogen treatment in the Jan-Dec 1988 data, this result should be treated with caution.

The analysis of covariance of the cumulative data shows a significant (p=0.03) N * P interaction. The predicted FFB production values from a multiple linear regression model, generated on the cumulative (Jan86-Dec88) data, using a step wise method with an inclusion limit of p=0.05, are presented in Table 5.

Table 5: Experiment 107, Predicted FFB production per hectare per year Jan86-Dec88.

At Mg = 0		N_0	N_1	N_2
	P_0	23.26	21.78	22.16
	P_1	22.40	22.40	22.40
	P_2	21.53	23.02	22.64
At Mg = 2		N_0	N_1	N_2
	P_0	24.02	22.53	22.91
	P_1	23.15	23.15	23.15
	P_2	22.29	23.78	23.40

TSP fertilizer apparently depresses yield in the absence of N fertilizer.

Sampling of frond 17 leaflet tissue was carried out in June 1988.The results of the analysis are presented in Table 6.

Table 6: Experiment 107, Frond 17 Leaflet Tissue (dry matter) Analysis. June 88.

	N (%)	P (%)	K (%)	Mg (%)	Ca (%)	S (%)	Cl (%)	Fe (ppm)	Mn (ppm)	Cu (ppm)	Zn (ppm)	B (ppm)
N0	2.62	0.175	1.13	0.22	0.99	0.19	0.18	71.2	37.2	6.08	22.4	11.8
N1	2.61	0.172	1.09	0.21	0.98	0.19	0.17	63.5	42.2	6.21	22.6	11.4
N2	2.59	0.174	1.09	0.21	1.00	0.19	0.19	66.5	49.5	6.38	22.5	12.2
P0	2.66	0.174	1.14	0.22	0.98	0.19	0.17	68.1	41.6	6.13	22.2	12.0
P1	2.61	0.173	1.10	0.21	1.01	0.19	0.19	66.6	43.3	6.38	21.9	11.5
P2	2.54	0.174	1.08	0.21	0.98	0.19	0.18	66.4	44.1	6.17	23.3	11.8
K0	2.59	0.174	1.11	0.22	0.99	0.19	0.18	66.4	42.5	6.42	22.6	11.4
K1	2.62	0.173	1.10	0.21	0.99	0.19	0.18	67.6	43.5	6.03	22.4	12.1
Mg0	2.60	0.174	1.12	0.21	1.00	0.19	0.18	67.7	44.0	6.36	22.6	11.7
Mg1	2.61	0.173	1.09	0.22	0.99	0.19	0.19	66.4	41.9	6.08	22.3	11.8
-EST.N	2.63	0.174	1.11	0.21	1.00	0.19	0.18	64.2	43.6	6.25	22.6	11.6
+EST.N	2.58	0.173	1.10	0.21	0.98	0.19	0.18	69.9	42.4	6.19	22.3	12.0
C.V.(%)	7.3	-	8.1	-	7.1	-	34.6	16.5	15.6	18.4	10.7	19.6
LSD.05(N+P)	0.11	-	0.05	-	0.04	-	0.04	6.4	3.9	0.67	1.4	1.3
LSS.05(K+Mg)	0.09	-	0.04	-	0.03	-	0.03	5.3	3.2	0.55	1.1	1.1

There is little treatment effect on the elemental composition of frond 17 leaflet samples. The exceptions being a significant ($p<0.001$) increase in leaflet manganese level following Sulphate of Ammonia application, probably due to manganese mobilization following soil acidification at the site of fertilizer application. Secondly, there is a small but significant ($p=0.002$) increase in leaf Mg level due to application of kieserite.

Beginning in 1989 fertilizer treatment applications will be 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	-

The sodium chloride treatment is to be applied "orthogonally" over the establishment nitrogen treatment.

The purpose of the amendment of treatment rates is to increase the dose rates which it was felt were too low to allow satisfactory determination of rate response curves.

Secondly leaf chlorine levels are all exceptionally low, which it is believed may be limiting response to existing treatments and may also be the reason for the high incidence of leaf fungal attack (mainly fan blight) observed in this trial. Application of sodium chloride as a treatment will allow statistical analysis of any chlorine effects or interactions on yield, growth measurements, leaf nutrition levels and disease incidence.

EXPERIMENT 108: Systematic Nitrogen Fertilizer Trial, Kumbango.

Site Details: This area was planted in 1972 at a planting density 120 palms ha^{-1}. 2134 palms are used in the experiment covering an area of approximately 18 ha. This experiment was initiated in 1985 in an area of Kumbango plantation which was felt to be suffering a decline in soil fertility.

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 abutts a second set but with the direction of increase of dose in one set being opposite to the other. Two replicates of this arrangement were placed in a block mulched with 30 t ha^{-1} empty bunches in March 1985 and two replicates placed in an unmulched one. There is a total of 64 plots, each plot consisting of the two rows on either side of a harvesting path (twin row) and on average consisting of 33 palms. There are no guard rows between levels but the two sources are guarded from each other and the end rows are guarded.

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

	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

The fertilizer is applied as two split doses per year. Application commenced in July 1985.

For each level of application, both ammonium chloride and diammonium phosphate supply the same quantity of nitrogen.

Results and Discussion: FFB production, yield components and petiole WxT measurements data are presented in Tables 7 to 10, for the period Jan-Dec 1988.

Cumulative FFB production and yield component data for the period (Jan 86-Dec 88) are presented in Tables 11 to 13.

Table 7. Expt. 108, FFB production (t ha^{-1}) Jan-Dec1988.

		Ammonium chloride		**Diammonium phosphate**		**MEANS**			
		-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	AC	DAP
	0	14.92	16.44	13.40	16.04	14.16	16.24	15.68	14.72
L	1	16.18	15.76	15.67	15.56	15.93	15.66	15.97	15.62
E	2	17.72	20.41	16.52	15.87	17.12	18.14	19.06	16.19
V	3	18.76	18.08	15.32	18.68	17.04	18.38	18.42	17.00
E	4	17.19	17.88	16.17	19.67	16.68	18.78	17.54	17.92
L	5	16.49	17.69	18.03	16.03	17.26	16.86	17.09	17.03
	6	17.56	19.05	18.91	14.42	18.24	16.74	18.30	16.67
	7	17.12	18.72	15.40	16.12	16.26	17.42	17.92	15.76

Table 8. Expt. 108, Numbers of bunches (ha^{-1}) Jan-Dec 1988

		Ammonium chloride		Diammonium phosphate		MEANS			
		-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	A.C	DAP
	0	714	755	680	879	697	817	735	779
	1	765	743	750	761	758	752	754	756
L	2	748	905	808	734	778	819	827	771
E	3	799	751	714	850	757	801	775	782
V	4	722	747	669	914	696	830	735	791
E	5	762	695	824	742	793	718	729	783
L	6	753	775	812	773	783	774	764	793
	7	679	747	673	838	676	793	713	756

Table 9. Experiment 108, Single bunch weight Jan-Dec 1988.

		Ammonium chloride		Diammonium phosphate		MEANS			
		-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	A.C	DAP
	0	20.83	21.40	19.72	18.40	20.28	19.90	21.11	19.06
L	1	21.10	21.18	20.91	20.46	21.00	20.82	21.14	20.68
E	2	23.69	22.55	20.53	21.60	22.11	22.11	23.12	21.06
V	3	23.47	24.07	21.44	21.96	22.45	23.01	23.77	21.70
E	4	23.86	23.93	24.24	21.70	24.05	22.82	23.90	22.97
L	5	21.68	25.49	21.87	21.76	21.77	23.63	23.58	21.81
	6	23.29	24.74	23.45	18.68	23.37	21.71	24.02	21.07
	7	25.23	25.03	22.94	19.18	24.08	22.10	25.13	21.06

Table 10. Experiment 108, Petiole WxT (cm^2) Jan - Dec 1988.

		Ammonium chloride		Diammonium phosphate		MEANS			
		-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	A.C	DAP
	0	40.3	43.0	33.4	35.3	36.9	39.1	41.6	34.4
L	1	40.3	44.6	35.8	36.2	38.0	40.4	42.5	36.0
E	2	41.2	45.6	39.4	37.9	40.3	41.8	43.4	38.7
V	3	43.5	48.9	40.7	43.1	42.1	46.0	46.2	41.9
E	4	48.4	53.2	47.5	46.5	48.0	49.9	50.8	47.0
L	5	49.9	51.8	46.6	48.1	48.3	50.0	50.9	47.4
	6	48.7	49.4	43.5	49.2	46.1	49.3	49.1	46.3
	7	47.2	48.0	43.9	46.9	45.5	47.4	47.6	45.4

Table 11. Expt. 108, FFB production (t $ha^{-1}yr^{-1}$) Jan86-Dec88.

		Ammonium chloride		Diammonium phosphate		MEANS			
		-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	A.C	DAP
	0	15.14	17.03	13.34	15.51	14.24	16.27	16.08	14.42
L	1	16.95	17.03	16.29	16.38	16.62	16.71	16.99	16.34
E	2	19.01	19.62	17.13	18.24	18.07	18.93	19.31	17.68
V	3	20.28	19.47	18.50	19.94	19.39	19.70	19.88	19.22
E	4	19.33	21.04	18.29	22.20	18.81	21.62	20.18	20.25
L	5	20.26	20.31	20.01	20.22	20.14	20.27	20.29	20.12
	6	21.31	21.14	21.05	20.55	21.18	20.84	21.23	20.80
	7	20.51	21.39	19.54	20.04	20.02	20.71	20.95	19.79

Table 12 Experiment 108, Number of bunches produced($ha^{-1}yr^{-1}$) Jan 86-Dec 88.

		Ammonium chloride		Diammonium phosphate		MEANS			
		-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	A.C	DAP
	0	745	780	669	815	707	797	762	742
L	1	799	797	804	801	802	799	798	803
E	2	855	873	857	852	856	862	864	855
V	3	903	823	873	923	888	873	863	898
E	4	853	867	814	992	834	930	860	903
L	5	904	837	938	903	921	870	871	921
	6	939	891	968	949	954	920	915	959
	7	854	895	858	912	856	903	875	885

Table 13. Expt. 108, Single bunch weight (Kg) Jan86-Dec88.

		Ammonium chloride		Diammonium phosphate		MEANS			
		-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	A.C	DAP
	0	20.3	21.5	19.9	19.0	21.1	20.3	20.9	19.5
L	1	21.1	21.3	20.3	20.4	20.7	20.9	21.2	20.4
E	2	22.2	22.5	20.0	21.4	21.1	21.9	22.3	20.7
V	3	22.4	23.7	21.2	21.6	21.8	22.6	23.1	21.4
E	4	22.7	24.2	22.5	22.4	22.6	23.3	23.5	22.4
L	5	22.4	24.3	21.3	22.4	21.9	23.3	23.3	21.8
	6	22.7	23.7	21.8	21.7	22.2	22.7	23.2	21.7
	7	24.0	23.9	22.8	22.0	23.4	22.9	23.9	22.4

Due to the non random nature of this type of experimental design, there is a biasing towards a lower fertility on the parts of this trial site occupied by Diammonium phosphate treatments. Bearing in mind this biasing, it appear that both ammonium chloride and diammonium phosphate are equally good sources of nitrogen, excepting the much higher price of D.A.P. The similarity in the nitrogen response surfaces of ammonium chloride and diammonium phosphate also indicates that there is no specific response to chlorine or phosphorus. The FFB yield responses are due to increases in both single bunch weight and numbers of bunches produced. The ammonium chloride treatments appear to have a greater effect on single bunch weight than diammonium phosphate, conversely diammonium phosphate has a greater effect on number of bunches produced. These relative differences between the two nitrogen sources on yield components, are most marked where 30t/ha E.B. mulch was applied in March 1985.

The EFB mulching in 1985 is still affecting FFB production. The cumulative data (Jan86-Dec88) shows an overall 4.4% yield increase in FFB yield, whilst the data for Jan-Dec 1988 shows an overall 4.2% increase in FFB yield due to this E.F.B. application. The effect of the EFB mulching is most marked at lower fertilizer application rates, indicating that the effect of the mulching may be due to its influence on nitrogen nutrition. The effect of EFB mulch on nitrogen supply is probably due to the effects of the mulch on the dynamics of the soil nitrogen rather than its own fertilizer value in terms of amounts of nutrient applied in the mulch.

Nitrogen application from both sources has produced an increase in vegetative growth as indicated by the response of Petiole WxT measurements to nitrogen application. The EFB mulching has increased Petiole WxT measurements overall by 5.4%.

Figures 10 to 12, illustrate the FFB production and yield component data and best fit regression curves for the period Jan86-Dec88.

Analysis of the monthly FFB production data, starting with the first recorded harvests in this experiment, was carried out. Figure 13 illustrates the FFB yield responses per month relative to the "no nitrogen applied" control. The graph was produced as a 3 dimensional surface plot, but here has been displayed as a "side" view with the "application rate" axis hidden, so illustrating more clearly the changes in responses with time.

At between 10 and 11 months after the first fertilizer application, there was a rapid increase in FFB yield due to the nitrogen fertilizer applications. The majority of the yield benefit derived from such nitrogen applications comes as a result of peak treatment responses which usually coincide with period of normally higher yield. Work is continuing to explain

Fig. 11 Experiment 108
No of Bunches, Jan86-Dec88.

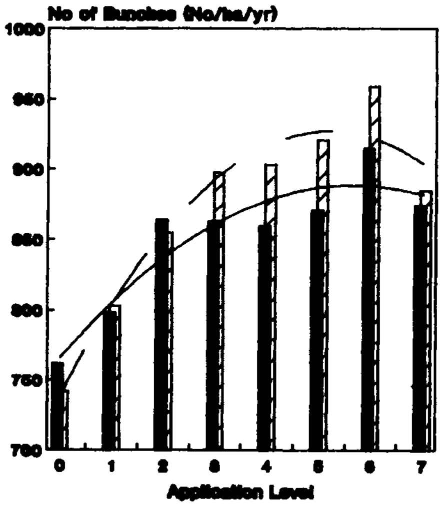


Fig. 12 Experiment 108
Single Bunch Weight, Jan86-Dec88.

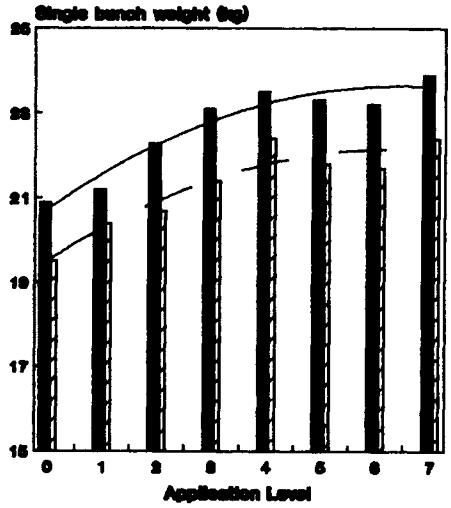
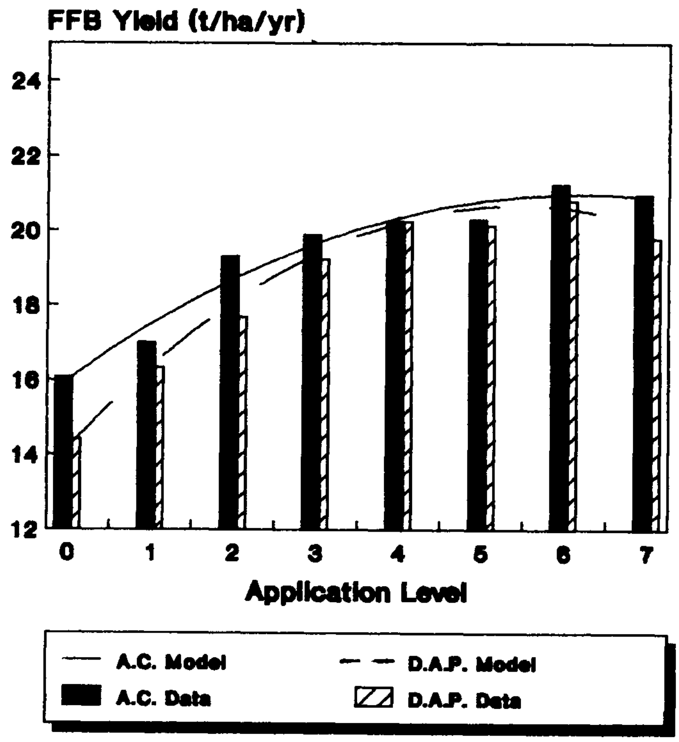
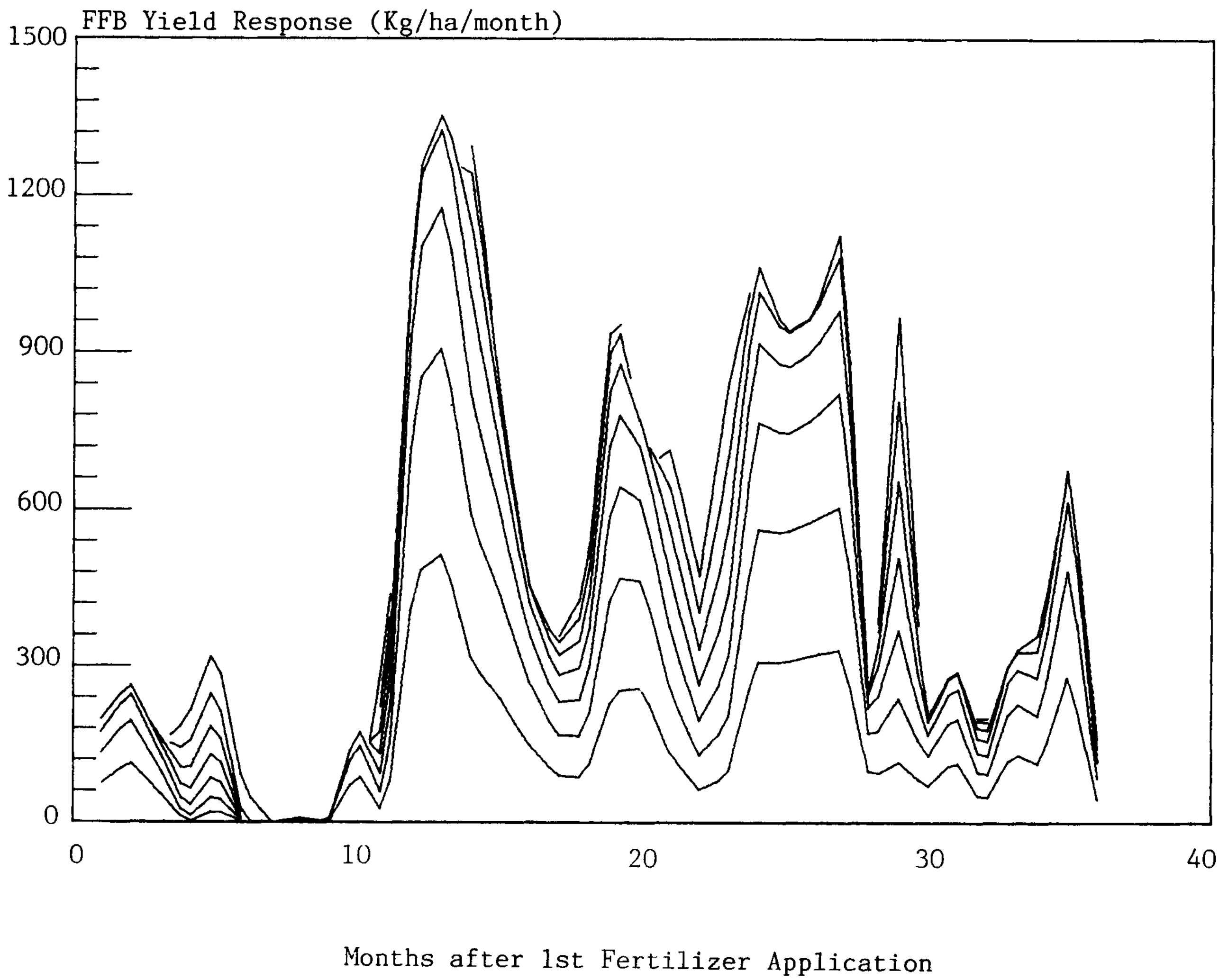


Fig. 10 Experiment 108
FFB Production, Jan86-Dec88.



the response pattern with time in terms of climatic parameters, agronomic management and palm physiology. There is an indication that the magnitude of peak responses is diminishing with time. If this is so, it would be indicative of a second factor limiting yield. Tissue analysis results and the trial results from experiments 106 and 107, indicate that the most likely limiting factor after nitrogen is that of magnesium.

Fig. 13 Experiment 108, Nitrogen Yield Response Relative to Control



From vegetative measurements largely carried out in June 1988, values for Fractional Energy Interception (f), Efficiency of Energy Conversion (e) and Bunch Index (BI) were calculated. The f,e, and BI data are summarized in Tables 14 to 16.

Table 14: Expt. 108, Fractional Energy Interception (f), 1988.

		Ammonium chloride		Diammonium phosphate		MEANS			
		- Mulch	+Mulch	-Mulch	+Mulch	-Mulch	+Mulch	A.C.	DAP
	0	0.87	0.87	0.86	0.84	0.86	0.85	0.87	0.85
L	1	0.86	0.86	0.85	0.86	0.86	0.86	0.86	0.86
E	2	0.87	0.88	0.86	0.87	0.86	0.87	0.87	0.86
V	3	0.89	0.89	0.87	0.88	0.88	0.89	0.89	0.88
E	4	0.91	0.87	0.90	0.89	0.91	0.88	0.89	0.90
L	5	0.91	0.87	0.90	0.89	0.91	0.88	0.89	0.90
	6	0.90	0.87	0.89	0.89	0.89	0.88	0.88	0.89
	7	0.90	0.84	0.88	0.87	0.89	0.86	0.87	0.87

Table 15: Expt. 108, Efficiency of Energy Conversion (e), 1988. ($g\ MJ^{-1}$)

		Ammonium chloride		Diammonium phosphate		MEANS			
		-Mulch	+Mulch	-Mulch	+Mulch	-Mulch	+Mulch	A.C.	DAP
	0	0.93	1.01	0.81	0.92	0.87	0.96	0.97	0.87
L	1	0.99	1.04	0.94	0.93	0.96	0.99	1.02	0.93
E	2	1.07	1.12	1.00	1.01	1.03	1.06	1.09	1.00
V	3	1.10	1.13	1.04	1.09	1.07	1.11	1.12	1.07
E	4	1.09	1.24	1.06	1.20	1.07	1.22	1.16	1.13
L	5	1.14	1.21	1.10	1.15	1.12	1.18	1.17	1.13
	6	1.17	1.22	1.13	1.16	1.15	1.19	1.19	1.15
	7	1.13	1.25	1.09	1.16	1.11	1.20	1.19	1.12

Table 16: Experiment 108, Bunch Index* (BI), 1988

		Ammonium chloride		Diammonium phosphate		MEANS			
		-Mulch	+Mulch	-Mulch	+Mulch	-Mulch	+Mulch	A.C.	DAP
	0	0.51	0.52	0.52	0.55	0.52	0.53	0.52	0.53
L	1	0.54	0.52	0.55	0.55	0.54	0.53	0.53	0.55
E	2	0.56	0.54	0.54	0.57	0.55	0.55	0.55	0.56
V	3	0.56	0.53	0.55	0.56	0.56	0.54	0.54	0.56
E	4	0.53	0.53	0.52	0.57	0.52	0.55	0.53	0.54
L	5	0.53	0.52	0.54	0.54	0.54	0.53	0.53	0.54
	6	0.55	0.54	0.57	0.54	0.56	0.54	0.55	0.55
	7	0.55	0.55	0.55	0.54	0.55	0.55	0.55	0.55

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

The FFB yield response to the nitrogen fertilizers, is largely due to an increase in the efficiency of energy conversion. The amount of applied nitrogen has had only a moderate effect on fractional energy interception and bunch index. The effects of the different sources of nitrogen and mulch treatments, were negligible on fractional energy interception and bunch index, but ammonium chloride appears to produce a greater efficiency of energy conversion for a given level of nitrogen applied than diammonium phosphate and the mulch treatment appears to produce a greater efficiency of energy conversion than the non-mulch treatment.

Frond 17 leaflet samples were collected in June 1988 and results of their analysis are presented in Table 17. Figures 14 to 19 illustrate the frond 17 leaflet levels of N, P, K, Mg, Ca and Cl respectively for ammonium chloride and diammonium phosphate at each level of application.

Both nitrogen sources increase frond 17 leaflet nitrogen levels. The lower fertility of the soil upon which the diammonium phosphate treatments are placed is clearly illustrated in the lower initial levels of nitrogen in the diammonium phosphate treated palms.

The diammonium phosphate treatment has increased frond 17 leaflet phosphorus level. The magnitude and slope of this response is very similar to that obtained from the 1987 tissue analyses, reported in the 1987 Annual Report. Unlike the 1987 frond 17 leaflet tissue analysis, the ammonium chloride applications do not appear to have increased the leaflet phosphorus levels.

Ammonium chloride and diammonium phosphate application appear to have had little effect on leaflet potassium levels.

Both ammonium chloride and diammonium phosphate application reduce leaflet magnesium levels. If magnesium shortage is accepted as the yield limiting factor most significant after that of nitrogen, there is a need to apply magnesium along with nitrogen in any fertilizer regime.

Ammonium chloride application as observed in many trials, increases the calcium level of frond 17 leaflets. This is probably due to mobilization of soil calcium resulting in an increase of calcium uptake into the palm. Diammonium phosphate application, particularly at high application levels, decreases the calcium level in frond 17 leaflets.

Frond 17 leaflet chlorine level shows a marked increase with application of ammonium chloride, but diammonium phosphate has no effect on leaflet chlorine levels.

Frond 17 leaflet manganese levels are markedly increased following application of ammonium chloride, whilst diammonium phosphate has little effect on leaflet manganese levels.

Table 17   Experiment 108, Frond 17 leaflet nutrient levels, June 1988

	Rate (kg/palm/yr)	Nitrogen (%D.M.)		Phosphorus (%D.M.)		Potassium (%D.M.)		Magnesium (%D.M.)		Calcium (%D.M.)		Sulphur (%D.M.)		Iron (ppm D.M.)		Manganese (ppm D.M.)		Zinc (ppm D.M.)		Copper (ppm D.M.)		Boron (ppm D.M.)		Chlorine (%D.M.)	
		-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch	+Mlch
	0.0	2.20	2.20	0.15	0.16	0.87	1.16	0.25	0.22	0.88	0.89	0.16	0.17	68.0	70.5	68.0	58.0	25.0	23.5	7.5	4.5	10.5	13.0	0.29	0.28
	0.9	2.30	2.20	0.15	0.15	0.87	0.84	0.24	0.19	0.93	0.85	0.15	0.16	70.5	68.5	71.0	59.0	22.0	24.5	6.5	4.5	12.0	12.0	0.34	0.39
	1.8	2.25	2.15	0.15	0.15	0.81	0.88	0.21	0.32	0.99	1.03	0.16	0.16	67.5	72.5	66.5	62.0	22.0	28.5	7.0	4.5	10.5	11.5	0.42	0.43
Ammonium	2.7	2.30	2.10	0.16	0.15	0.88	0.97	0.19	0.22	1.11	0.96	0.16	0.16	79.0	72.5	80.5	64.5	23.5	26.5	6.5	5.0	11.0	11.5	0.45	0.50
chloride	3.6	2.25	2.30	0.15	0.15	0.75	0.86	0.16	0.20	0.91	1.05	0.16	0.16	73.0	74.0	79.0	69.5	21.5	23.5	6.0	4.5	9.5	12.5	0.51	0.50
	4.5	2.35	2.20	0.16	0.15	0.84	0.89	0.20	0.20	1.02	0.99	0.17	0.17	78.0	71.5	95.5	74.0	21.5	24.0	7.5	4.5	11.0	12.0	0.57	0.51
	5.4	2.50	2.30	0.16	0.15	0.80	0.83	0.17	0.17	1.09	0.97	0.17	0.17	82.0	70.0	90.5	80.5	21.0	22.5	5.5	6.0	10.5	12.0	0.53	0.56
	6.3	2.45	2.35	0.16	0.16	0.88	0.97	0.20	0.18	1.00	0.97	0.16	0.16	83.0	77.0	94.0	87.0	23.5	22.5	6.5	3.5	10.0	10.0	0.59	0.53
	0.0	2.15	2.00	0.14	0.14	0.80	0.95	0.22	0.28	0.81	1.03	0.15	0.15	66.0	60.0	76.0	71.0	26.5	29.0	5.5	4.5	11.0	11.5	0.24	0.29
	1.2	2.15	2.05	0.15	0.14	0.99	0.89	0.27	0.23	0.98	0.89	0.16	0.15	67.5	58.5	74.0	67.5	28.0	29.0	7.5	5.0	12.0	11.5	0.25	0.29
	2.4	2.20	2.05	0.15	0.15	1.00	1.03	0.23	0.26	0.89	0.95	0.15	0.16	92.0	62.0	66.5	62.0	24.5	28.5	6.0	4.5	10.0	11.5	0.23	0.28
Diammonium	3.6	2.25	1.95	0.16	0.15	0.98	1.02	0.23	0.25	0.91	0.92	0.16	0.16	77.5	65.0	66.0	64.5	29.5	30.5	6.5	5.5	10.0	10.0	0.21	0.29
phosphate	4.8	2.25	2.15	0.16	0.15	0.99	0.96	0.20	0.24	0.87	1.03	0.16	0.16	97.5	64.5	65.0	74.5	22.0	28.5	8.0	5.0	11.5	11.0	0.23	0.28
	6.0	2.35	2.30	0.17	0.16	0.96	1.02	0.20	0.23	0.87	1.01	0.17	0.17	72.5	61.0	75.5	73.0	23.0	26.5	7.0	5.5	11.0	11.5	0.22	0.28
	7.2	2.35	2.40	0.16	0.16	1.01	1.04	0.20	0.20	0.92	0.89	0.16	0.17	76.0	65.5	67.5	73.0	19.5	28.0	6.5	6.0	11.5	10.5	0.20	0.26
	8.4	2.35	2.45	0.15	0.16	0.93	0.94	0.20	0.20	0.84	0.77	0.16	0.17	69.0	69.5	77.5	75.0	18.5	23.5	8.0	6.0	11.0	9.5	0.22	0.28

Fig. 14 Experiment 108
Leaf 17 Nitrogen Level, June88.

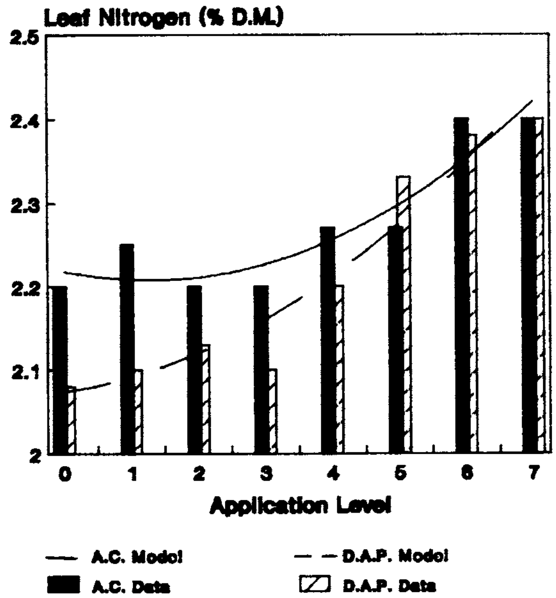


Fig. 15 Experiment 108
Leaf 17 Phosphorus Levels, June88

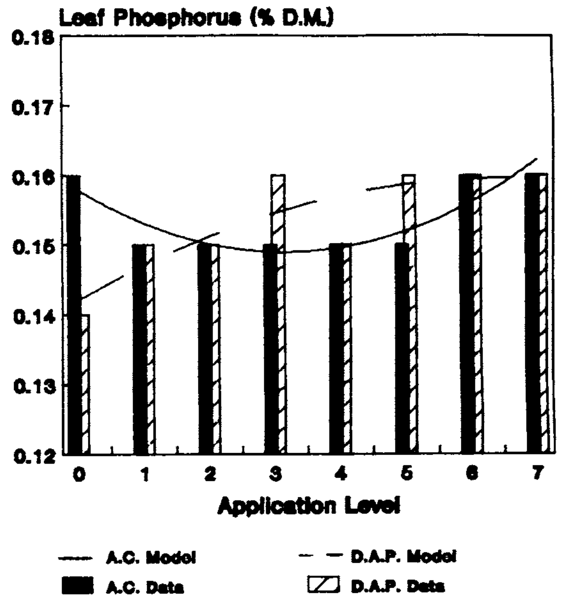


Fig. 16 Experiment 108
Leaf 17 Potassium Level, June88.

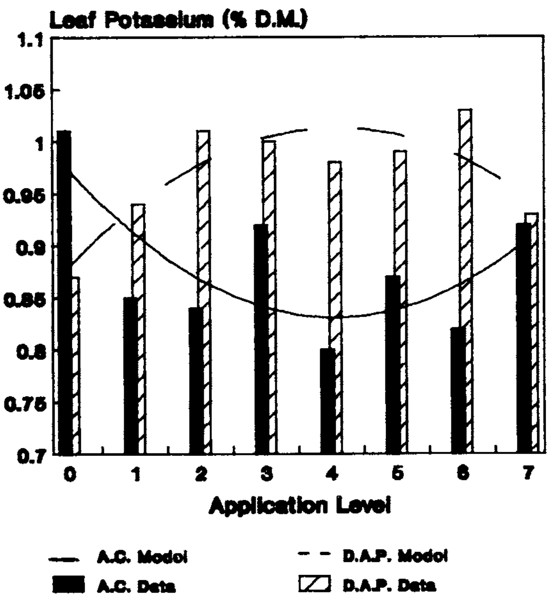


Fig. 17 Experiment 108
Leaf 17 Magnesium Level, June88.

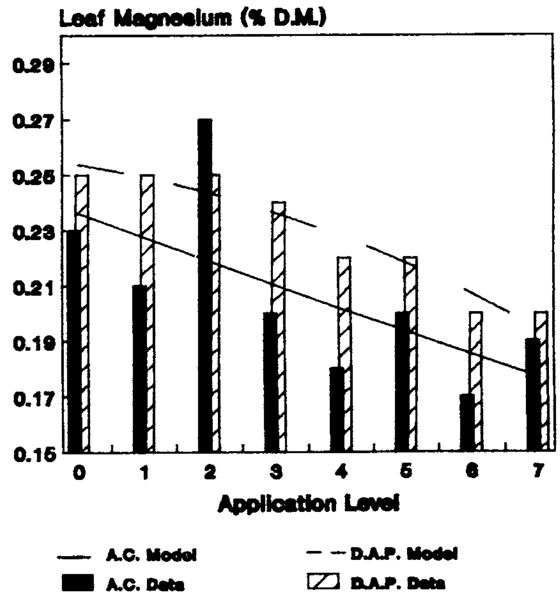


Fig. 18 Experiment 108
Leaf 17 Calcium Level, June88.

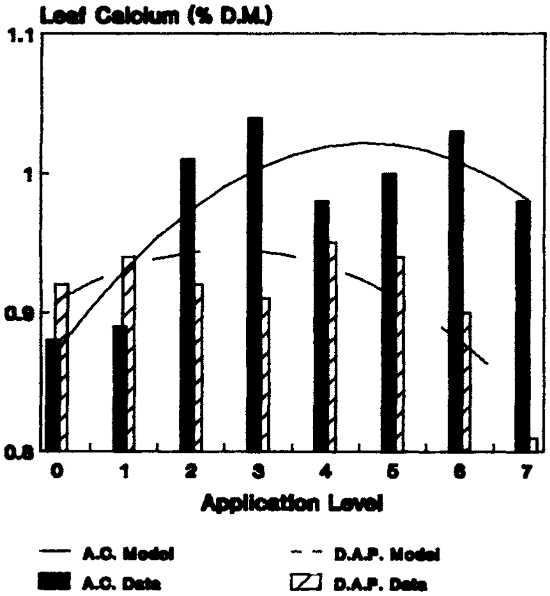
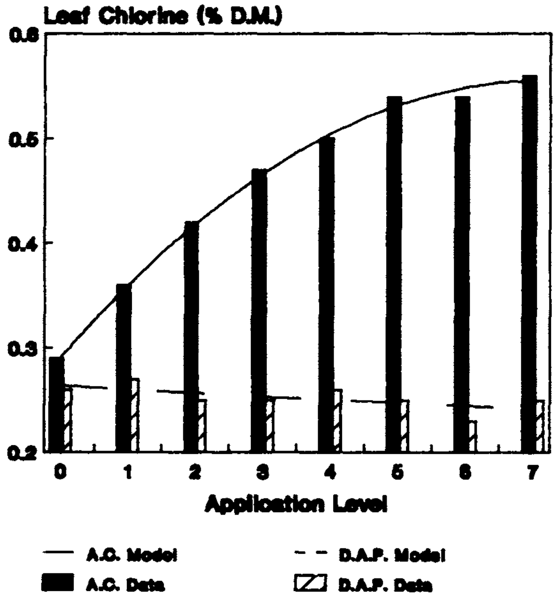


Fig. 19 Experiment 108
Leaf 17 Chlorine Level, June88,



EXPERIMENT 110: Nitrogen/anion experiment on young, replanted palms, Bebere.

Site Details: The experimental site was planted in February 1985 at a density of 135 palms/ha. The experiment uses 1152 palms, covering an area of 8.8 hectares. Plots consist of 16 palms with no guard rows.

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

Treatments: Fertilizer treatment application rates are as follows:

Treatment	Non-N Anion and Level		Non-N anion Source	Additional Ammonium Nitrate
			Kg $Palm^{-1}$	$Year^{-1}$
1	Chloride	0	0.0	1.6
2	Chloride	1	0.5	1.2
3	Chloride	2	1.0	0.8
4	Sulphate	0	0	1.6
5	Sulphate	1	1.25	0.8
6	Sulphate	2	2.50	0.0
7	Phosphate	0	0.0	1.6
8	Phosphate	1	1.4	0.8
9	Phosphate	2	2.8	0.0
10	Nil	0	0.0	0.0
11	Nil	0	0.0	0.0
12	Nil	0	0.0	0.0

(N.B. Treatment 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 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 and Discussion: FFB production and yield components data for the period Jan-Dec 1988 are presented in Table 18. Cumulative FFB production and yield component data for the period Jan87-Dec88 are presented in Table 19.

Table 18, Expt. 110, Production per hectare, Jan-Dec 1988.

Total N applied ($g\ palm^{-1}\ yr^{-1}$)	**Non-N anion &** level		**FFB Yield** ($t\ ha^{-1}\ yr^{-1}$)		**No. of bunches** ($ha^{-1}\ yr^{-1}$)		**S.B.W.** (kg)	
			+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch
580		0	25.15	**21.55**	2903	**2538**	8.73	**8.49**
580	Chloride	1	25.20	**24.58**	2908	**2781**	8.68	**8.85**
580		2	25.94	**26.51**	2832	**2966**	9.17	**8.94**
580		0	25.15	21.55	2903	2538	8.73	8.49
580	Sulphate	1	24.02	23.99	2825	2623	8.50	9.15
580		2	24.98	23.19	2873	2627	8.70	8.82
580		0	25.15	**21.55**	2903	**2538**	8.73	8.49
580	Phosphate	1	24.48	**23.42**	2672	**2677**	9.16	8.74
580		2	24.80	**25.70**	2753	**2979**	9.02	8.63
0.0	No Fert.	-	24.42	23.88	2852	2723	8.57	8.78
	MEAN		24.88	23.64	2844	2703	8.76	8.74

Table 19, Experiment 110, Production per hectare, Jan87-Dec88.

Total N applied ($g\ palm^{-1}\ yr^{-1}$)	**Non-N anion &** level		**FFB Yield** ($t\ ha^{-1}\ yr^{-1}$)		**No. of bunches** ($ha^{-1}\ yr^{-1}$)		**S.B.W.** (kg)	
			+Mlch	-Mlch	+Mlch	-Mlch	+Mlch	-Mlch
580		0	23.61	**19.67**	3227	**2770**	7.33	**7.11**
580	Chloride	1	23.91	**22.02**	3277	**2967**	7.30	**7.42**
580		2	23.71	**24.13**	3077	**3233**	7.71	**7.47**
580		0	23.61	**19.67**	3227	2770	7.33	7.11
580	Sulphate	1	22.43	**21.95**	3159	2843	7.09	7.73
580		2	23.20	**21.47**	3106	2931	7.47	7.32
580		0	23.61	**19.67**	3227	**2770**	7.33	7.11
580	Phosphate	1	22.54	**21.12**	2981	**2931**	7.57	7.20
580		2	22.85	**22.84**	3037	**3179**	7.53	7.19
0.0	No Fert.	-	22.80	21.71	3173	2934	7.19	7.40
	MEAN		23.16	21.47	3153	2933	7.35	7.32

Overall, mulching has produced a significant increase in FFB production in both the 1988 and cumulative data (Jan-Dec88: p=0.002, Jan87-Dec88 p<0.001) of 1.24 t ha^{-1} yr^{-1} (5.2%) and 1.69 t ha^{-1} yr^{-1} (7.9%) respectively. The yield response to mulching is due to an increase in the number of bunches produced.

In the presence of mulch and nitrogen application, the non-nitrogenous anion treatments produced no significant effect on FFB production, number of bunches produced or single bunch weight. In the absence of mulch with the addition of 580g N $palm^{-1}$ yr^{-1}, the chloride treatment produces significant increases in FFB production, number of bunches produced and single bunch weight (p=o.0002, p=0.0008 and p=0.035 respectively for 1988 data and p=0.0001, p=0.0001 and p=0.056 respectively for cumulative 1987 and 1988 data), the sulphate application produces a significant (p=0.046) increase in FFB production in the Jan87-Dec88 data, which is due to non-significant trends in both number of bunches produced and single bunch weight, and the phosphate treatment produced significant increases in FFB production and number of bunches produced (p=0.0016 and p=0.0023 respectively for 1988 and p=0.0041 and p=0.0015 respectively for Jan87 to Dec88 data). Unfortunately these responses only serve to raise the production from below to just above the level at the nil fertilizer treatment.

Figures 20 to 25 illustrate the FFB production data for the Jan-Dec88 and Jan87 to Dec88 period.

Frond 17 leaflet tissue sampling was carried out in September 1988, the results of the elemental analysis of these samples are summarized in Table 20.

Both sulphate and phosphate treatments appear to reduce leaflet nitrogen levels, although only the effect of phosphate in the presence of mulch is significant (p=0.035). Phosphate application also appears to reduce leaflet nitrogen level in experiment 107, though here again the trend is non-significant.

Chloride application appears to significantly reduce leaflet potassium levels in both the absence of mulch (p=0.045) and presence of mulch (p=0.0016).

In the presence of mulch, chloride application significantly (p=0.011) increases leaflet calcium level.

In both the presence and absence of mulch, chloride application dramatically increases the leaflet chloride levels (significant at p<0.0001).

Chloride, sulphate and phosphate application have all significantly increased the leaf Mn levels (p=0.0009, p=0.01 and p=0.0035 respectively in the absence of mulch, and p=0.011, p=0.056 and p=0.013 respectively in the presence of mulch).

Fig. 21 Experiment 110
Production per hectare, Jan-Dec88.

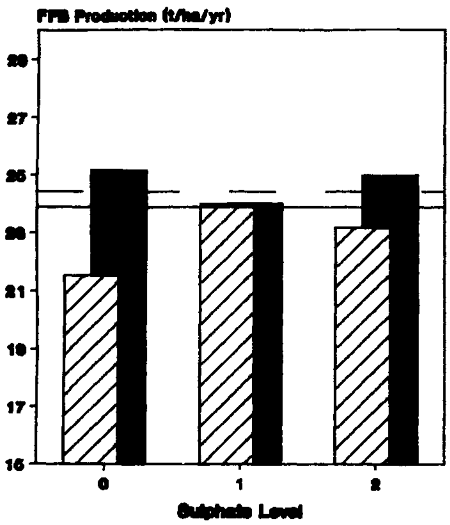


Fig. 22 Experiment 110
Production per hectare, Jan-Dec88.

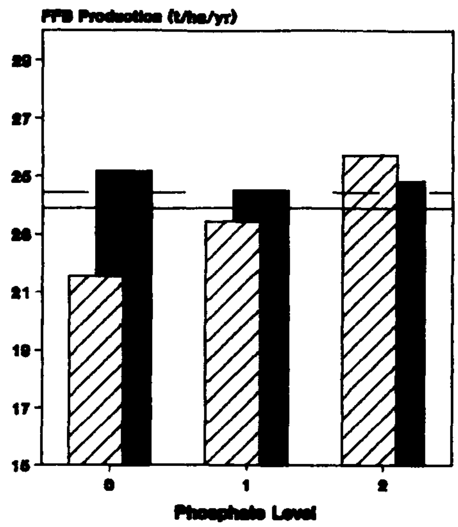


Fig. 20 Experiment 110
Production per hectare, Jan-Dec88.

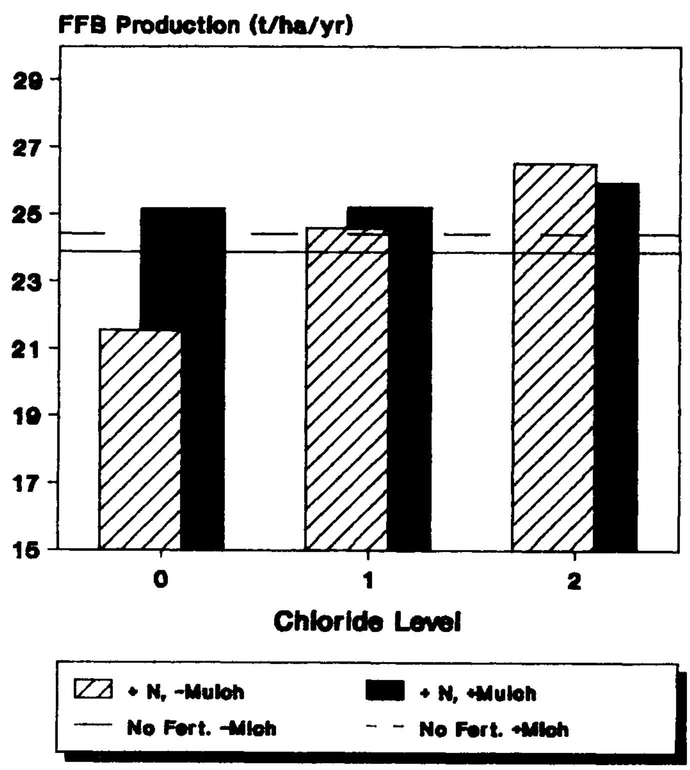


Fig. 24 Experiment 110
Production per hectare, Jan87-Dec88.

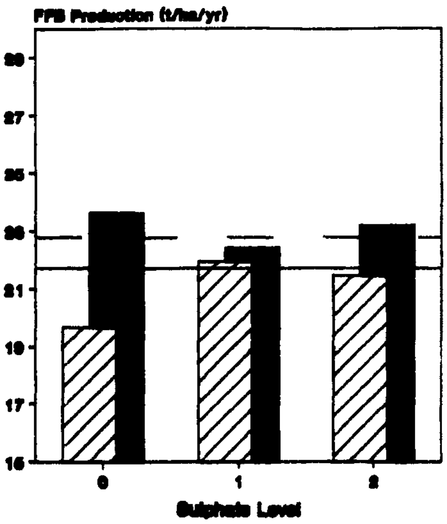


Fig. 25 Experiment 110
Production per hectare, Jan87-Dec88.

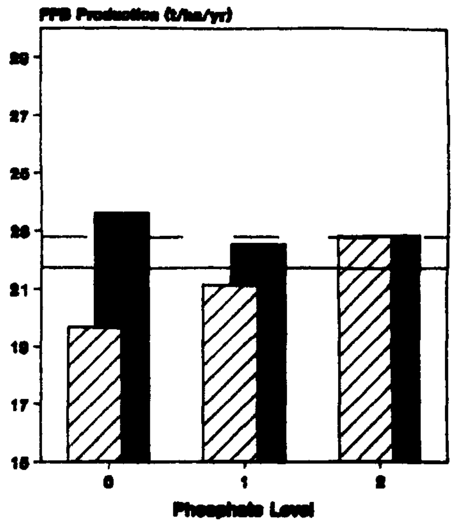


Fig. 23 Experiment 110
Production per hectare, Jan87-Dec88.

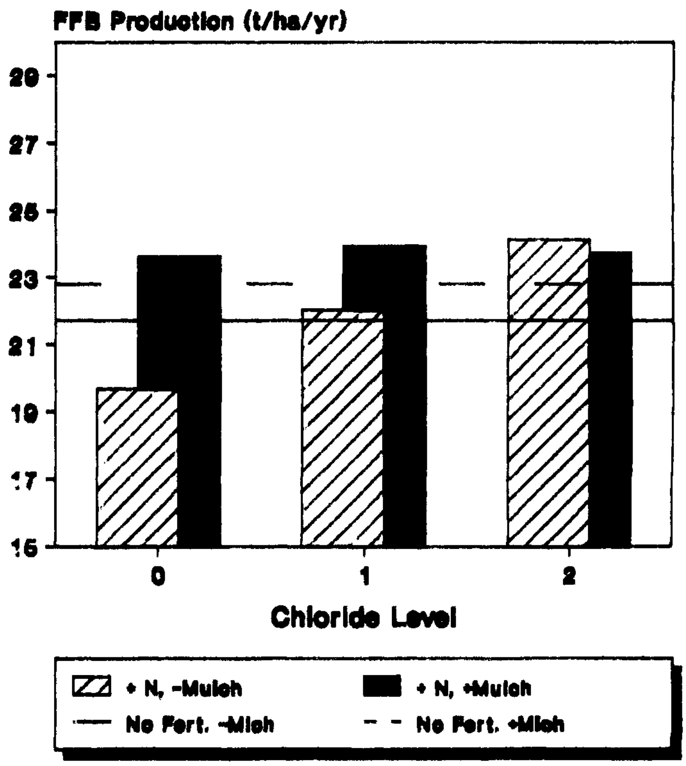


TABLE 20. EXPERIMENT 110, Effects of treatment on tissue analysis of frond 17 leaflets.

Total N applied (g palm)	Non-N anion &	level	N %DM		P %DM		K %DM		Mg %DM		Ca %DM		S %DM		Cl %DM		Fe ppmDM		Mn ppmDM		Zn ppmDM		Cu ppmDM		B ppmDM	
			+Mlch	-Mlch	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
550		0	2.65	2.60	.179	.180	1.32	1.33	.24	.24	.87	.94	.188	.184	.31	.28	59.9	68.0	52.1	52.0	21.7	22.6	6.7	7.0	10.1	11.2
550	Chloride	1	2.73	2.50	.183	.179	1.24	1.24	.25	.25	.93	.96	.190	.180	.51	.47	59.3	66.3	58.7	59.3	21.3	27.3	6.3	6.3	10.3	10.7
550		2	2.63	2.60	.180	.186	1.17	1.23	.23	.23	.99	.94	.187	.190	.51	.53	60.7	59.3	61.0	68.3	24.0	23.7	6.7	6.0	10.3	12.0
550		0	2.65	2.60	.179	.180	1.32	1.33	.24	.24	.87	.94	.188	.184	.31	.28	59.9	68.0	52.1	52.0	21.7	22.6	6.7	7.0	10.1	11.2
550	Sulphate	1	2.43	2.47	.180	.179	1.28	1.35	.24	.24	.93	.91	.183	.187	.44	.32	59.7	64.0	65.3	63.7	21.3	21.3	5.0	5.7	11.7	11.0
550		2	2.53	2.53	.178	.176	1.35	1.36	.23	.22	.94	.88	.183	.183	.31	.29	65.0	63.3	62.7	63.7	23.0	21.0	6.0	5.0	11.7	11.3
550		0	2.65	2.60	.179	.180	1.32	1.33	.24	.24	.87	.94	.188	.184	.31	.28	59.9	68.0	52.1	52.0	21.7	22.6	6.7	7.0	10.1	11.2
550	Phosphate	1	2.57	2.53	.188	.183	1.32	1.34	.24	.25	.95	.99	.187	.183	.29	.29	68.7	66.0	57.3	60.0	22.7	24.3	6.0	5.0	11.7	10.7
550		2	2.43	2.47	.185	.170	1.26	1.32	.24	.23	.88	.88	.190	.170	.29	.31	70.7	68.7	64.0	66.0	24.0	20.0	6.0	6.0	13.0	10.3
0.0	No. Fert.		2.58	2.66	.180	.181	1.32	1.28	.25	.24	.88	.90	.183	.188	.32	.32	62.1	61.5	44.6	46.0	21.6	21.7	6.1	6.2	10.2	11.4
Mean			2.59	2.57	.181	.180	1.30	1.31	.24	.24	.91	.92	.186	.184	.35	.33	62.5	64.7	54.9	56.2	22.2	22.5	6.2	6.1	10.8	11.2

EXPERIMENT 116: Systematic Nitrogen fertilizer trial, Bebere.

Site Details: This trial is situated on sections E3 and E4 of Bebere Plantation. The area was planted in 1971 at a planting density of 120 palms per hectare. The trial covers an area of approximately 15 ha.

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 abutts 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 and Discussion: Yield recording began in July 1987. FFB production and yield component data for the period Jan-Dec 1988 is presented in Table 21.

Table 21, Experiment 116 Production per hectare Jan-Dec 1988.

Fert. Application Year	87	87+88	87	87+88	87	87+88
Ammonium chloride application rate (Kg palm^{1}yr^{1})	FFB Yield (t ha^{-1})		No. of bunches (ha^{-1})		S.B.W. (kg)	
0	12.92	13.76	603	635	21.6	21.7
1.5	14.78	16.13	644	707	22.9	22.9
3.0	16.20	17.56	743	727	21.6	24.1
4.5	15.33	19.36	703	792	21.8	24.4
6.0	19.60	18.06	813	732	24.1	24.7

FFB production and yield component data for the period Jan-Dec88 are illustrated in Figures 26 to 28.

Fig. 27 Experiment 116
Number of Bunches, Jan-Dec88.

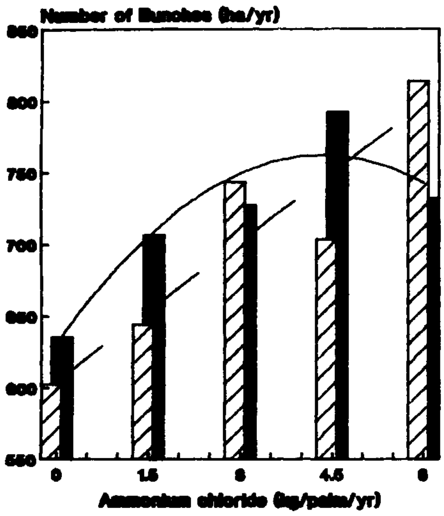


Fig. 28 Experiment 116
Single Bunch Weight, Jan-Dec88.

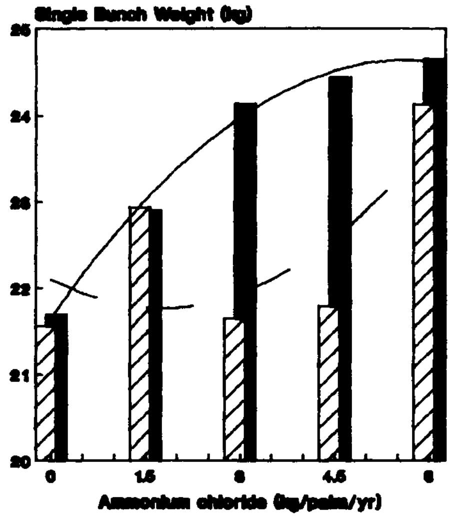
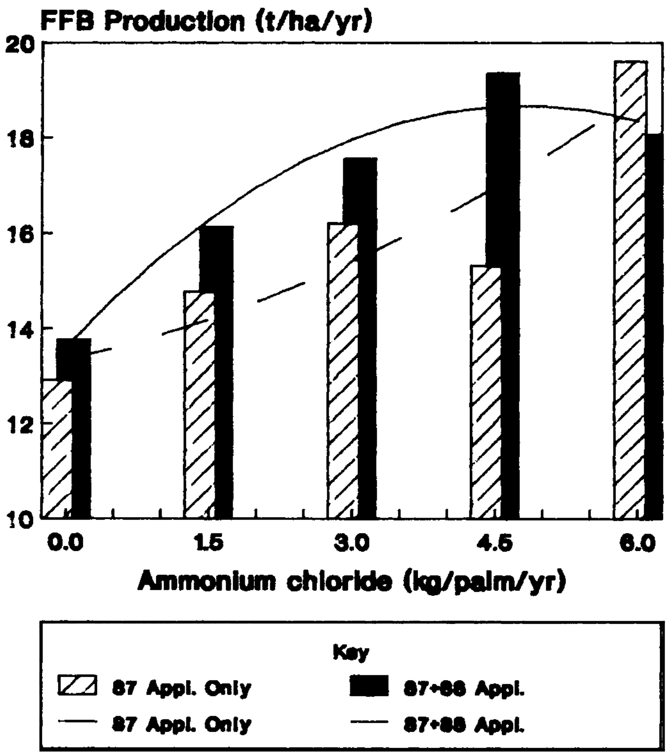


Fig. 26 Experiment 116
FFB Production per hectare, Jan-Dec88.



There is an obvious yield response to fertilizer application. Both numbers of bunches produced and single bunch weight are increased by nitrogen fertilizer application.

Comparing 1987 only and 1987+88 fertilizer application treatments, there is a rapid flattening of the yield response curve brought about by a rapid fall in single bunch weight after only one years' lack of fertilizer, following earlier applications. Oil palm growing on soil similar to those of Experiment 116 trial site, will respond rapidly to a cessation or reduction in nitrogen fertilizer application.

EXPERIMENT 117: Systematic Nitrogen Fertilizer Trial, Kumbango.

Site Details: This trial is situated in sections D8 and D9 of Kumbango Plantation. The area was planted in 1975 at a planting density of 120 palms per hectare. The trial covers an area of approximately 15 ha.

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 abutts 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 and Discussion: Yield recording began in July 1987.

FFB production and yield component data for the period Jan-Dec 1988, are presented in Table 22.

Table 22, Experiment 117, Production per hectare Jan-Dec 1988.

	FFB Yield ($t\ ha^{-1}yr^{-1}$)		No of bunches (ha^{-1})		S.B.W (Kg)	
LEVEL	A.C	Urea	A.C	Urea	A.C	Urea
0	15.33	15.33	698	697	22.1	22.2
1	15.93	17.01	692	747	23.0	22.8
2	16.95	15.73	774	748	21.9	21.1
3	18.69	16.97	777	776	24.2	21.9
4	16.97	15.23	739	708	23.0	21.5

FFB production and yield component data for the period Jan-Dec 1988, are illustrated in Figures 29 to 31.

Ammonium chloride application produces a significant rate response with regard to FFB production. This increase in FFB production is due to an increase in number of bunches produced and to a smaller extent single bunch weight. Urea produces no clear yield response. Even though urea produces a response similar to ammonium chloride with regard to numbers of bunches produced, urea application appears to reduce single bunch weight. The responses seen with urea application tend to drop back towards zero level values at higher application rates. This may be due to an increase in ammonium volatilization occurring when soil surface urea concentration rises.

EXPERIMENT 118: Systematic Nitrogen Fertilizer Trial, Kumbango

Site Details: This trial is situated in section B9 of Kumbango plantation. The area was planted in 1977 at a planting density of 120 palms per hectare. The trial covers an area of approximately 7.5 ha.

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 abutts 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.

Fig. 30 Experiment 117
No of Bunches, Jan-Dec88.

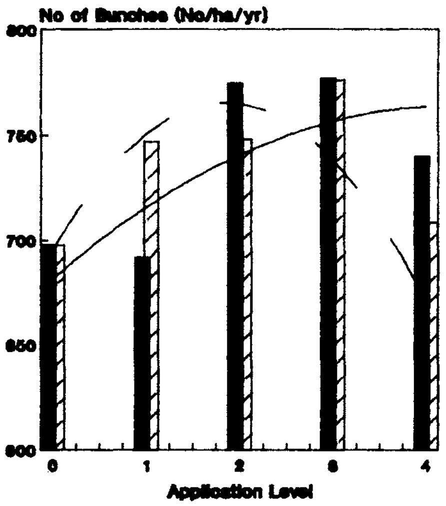


Fig. 31 Experiment 117
Single Bunch Weight, Jan-Dec88.

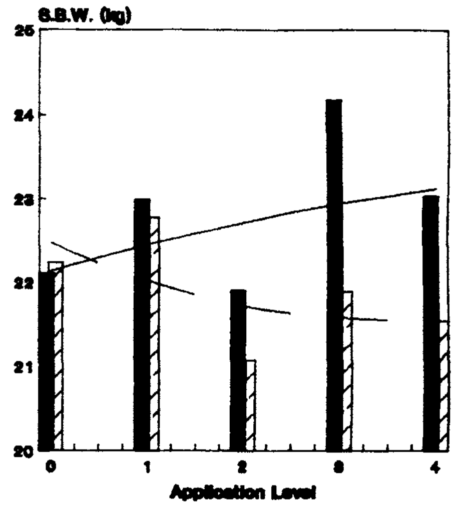
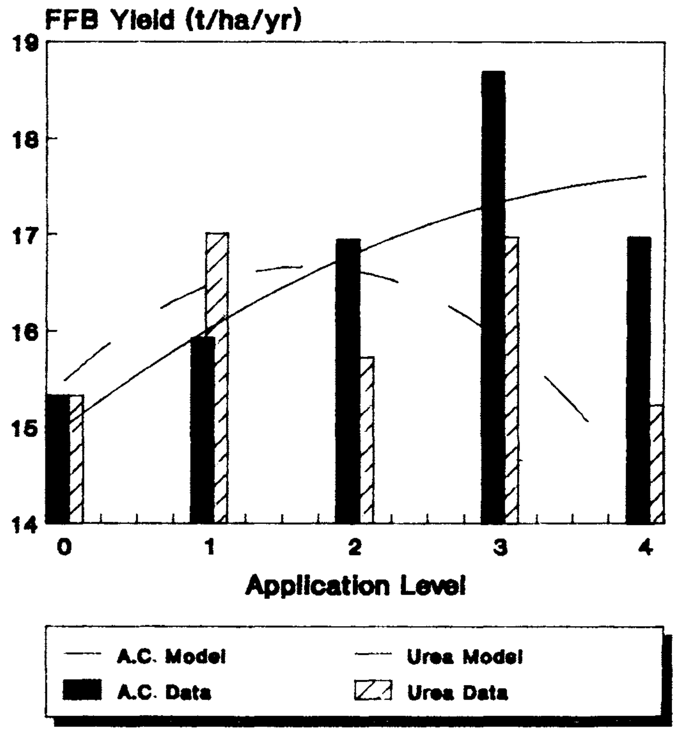


Fig. 29 Experiment 117
FFB Production, Jan-Dec88.



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 and Discussions: Yield recording began in July 1987.

FFB production and yield component data for the period Jan-Dec 1988 are presented in Table 23.

Table 23, Experiment 118, Production per hectare Jan-Dec 1988.

LEVEL	**FFB Yield** (t ha^{-1}yr^{-1})	**No. of bunches** (ha^{-1}yr^{-1})	**S.B.W.** (Kg)
0	22.16	1096	20.2
1	22.02	1080	20.4
2	23.54	1177	20.0
3	24.25	1172	20.8
4	22.14	1199	18.5

FFB production and yield component data for the period Jan-Dec 1988 are illustrated in Figures 32 to 34.

Ammonium chloride application appears to have had little effect on single bunch weight, but has produced a marked increase in the number of bunches produced. The result is a clear increase in FFB production due to ammonium chloride application. The FFB production figure for the highest ammonium chloride application rate is depressed due to an unusually low single bunch weight value.

Fig. 33 Experiment 118
Number of Bunches, Jan-Dec88.

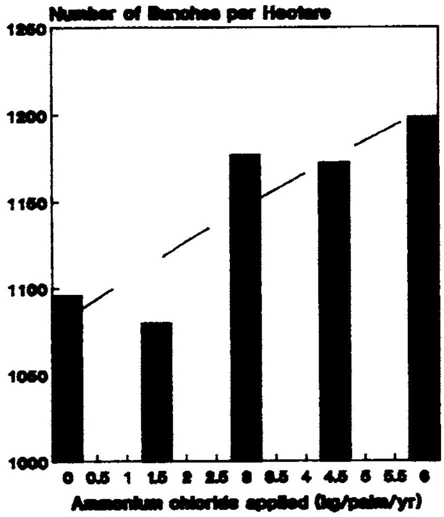


Fig. 34 Experiment 118
Single bunch weight, Jan-Dec88.

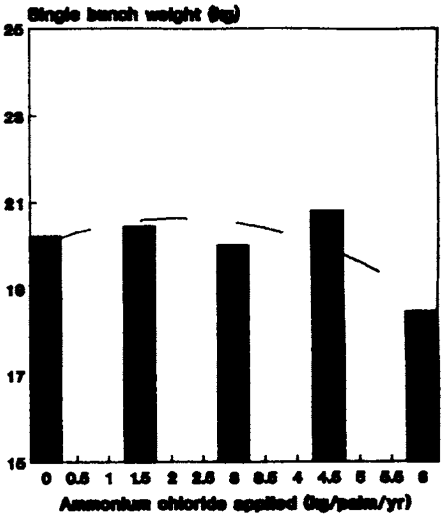
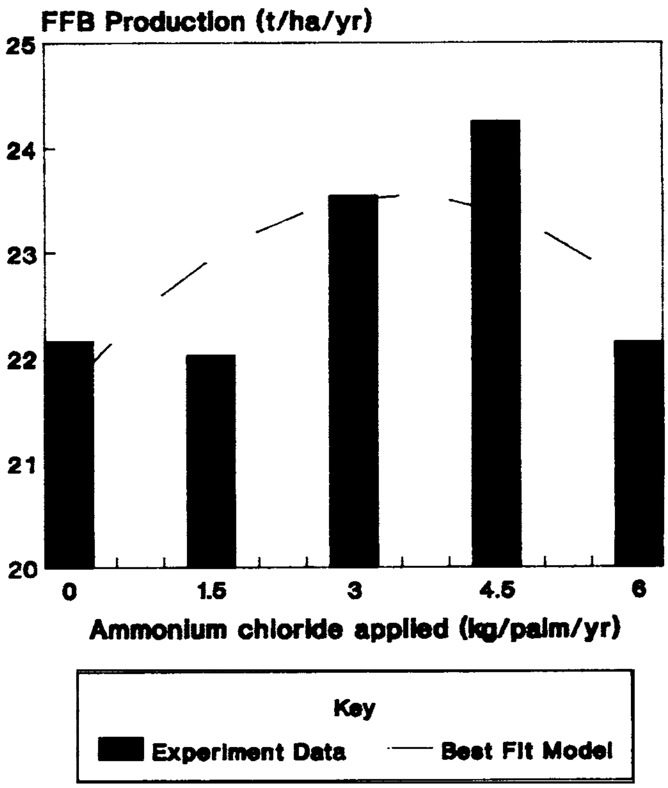


Fig. 32 Experiment 118
FFB Production per hectare, Jan-Dec88.



EXPERIMENT 201: Fertilizer Trial, Hargy.

Site Details: The palms (IRHO DxP) in the trial site were planted in 1973 at a planting density of 115 palms ha^{-1}. The trial contains 2916 palms palms in total, 1296 of these being recorded. The trial covers an area of approximately 25.4 ha.

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 and Discussion: FFB production and yield component data for the period Jan - Dec 88 are presented in Table 24.

Table 24 Experiment 201, Production per hectare, Jan-Dec 1988.

	Wt. of bunches ($t\ ha^{-1}yr^{-1}$)	No. of bunches ($ha^{-1}yr^{-1}$)	S.B.W (Kg)
N_0	18.37	913	20.2
N_1	18.20	898	20.2
N_2	18.98	955	20.0
P_0	**17.29**	**880**	**19.7**
P_1	**18.33**	**912**	**20.1**
P_2	**19.93**	**974**	**20.6**
K_0	19.03	966	19.7
K_1	17.96	871	20.6
K_2	18.56	928	20.1
Mg_0	18.72	923	20.3
Mg_1	17.64	873	20.2
Mg_2	19.19	969	19.9
C.V (%)	16.5	17.8	6.0
$LSD_{.05}$	1.77	94	0.7

Cumulative FFB production and yield component data for the period Jan 86 - Dec 88 are presented in Table 25.

Table 25, Experiment 201, Production per hectare, Jan86-Dec88.

	Wt. of bunches ($t\ ha^{-1} yr^{-1}$)	No. of bunches ($ha^{-1} yr^{-1}$)	S.B.W (Kg)
N_0	22.22	1047	21.3
N_1	22.68	1062	21.4
N_2	23.15	1106	21.0
P_0	**21.54**	**1037**	**20.8**
P_1	**22.68**	**1071**	**21.2**
P_2	**23.83**	**1107**	**21.6**
K_0	23.13	1108	20.9
K_1	22.30	1038	21.5
K_2	22.61	1069	21.2
Mg_0	22.82	1059	**21.6**
Mg_1	22.03	1042	**21.2**
Mg_2	23.2	1114	**20.9**
C.V (%)	9.1	10.4	5.4
$LSD_{.05}$	1.19	64	0.7

The only significant main effects in both the 1988 and cumulative data are those in Triple Superphosphate application. From the cumulative data, TSP application has produced significant increases in single bunch weight ($p=0.016$), numbers of bunches produced ($p=0.033$) and FFB production ($p=0.0002$).

Stepwise Multiple linear regression analysis using a $p=0.05$ selection limit was carried out on the annual and cumulative data. Analysis of annual data resulted in selection only of the linear component of the TSP treatment. Analysis of the cumulative data produced a more complex model, with nitrogen, phosphorus and magnesium being important parameters with regard to FFB production.

Table 26 presents the predicted FFB yields expected for various levels of N,P, and Mg.

Within the constraints of this trial, the highest FFB production appears to be attained at a mixture of highest rates of P and Mg with low rate of nitrogen (N_1 P_2 Mg_2). There appears to be a complex nitrogen/magnesium interaction, possibly an antagonism between the two elements.

Table 26 Experiment 201, Predicted FFB production (t ha^{-1}yr^{-1}) from data of Jan 86-Dec 88.

N_0 K_0	P_0	P_1	P_2
Mg_0	22.23	22.00	21.77
Mg_1	21.30	22.03	22.75
Mg_2	22.34	24.02	25.70

N_1 K_0	P_0	P_1	P_2
Mg_0	21.98	23.01	24.04
Mg_1	20.04	22.03	24.01
Mg_2	20.07	23.01	25.95

N_2 K_0	P_0	P_1	P_2
Mg_0	24.25	24.02	23.78
Mg_1	21.30	22.03	22.75
Mg_2	20.32	22.00	23.68

Frond 17 leaflet tissue samples were collected in July 1988. A summary of the results of the elemental analysis of these tissue samples, is presented in Table 27.

Table 27 Experiment 201, Frond 17 nutrient levels, July 1988

	N %	P %	K %	Mg %	Ca %	S %	Cl %	Fe ppm	Mn ppm	Cu ppm	Zn ppm	B ppm
N_0	2.18	0.148	0.95	0.135	0.908	0.161	0.280	65.6	66.5	5.7	23.3	14.4
N_1	2.23	0.153	0.97	0.135	0.877	0.165	0.287	61.8	67.9	5.6	22.5	14.7
N_2	2.19	0.153	0.95	0.140	0.878	0.167	0.279	58.8	67.0	5.6	22.3	13.5
P_0	**2.16**	**0.145**	0.97	**0.128**	0.888	0.162	0.288	61.5	67.3	5.8	22.1	13.4
P_1	**2.20**	**0.156**	0.96	**0.135**	0.886	0.168	0.279	64.5	68.0	5.6	23.3	14.9
P_2	**2.24**	**0.153**	0.95	**0.147**	0.889	0.162	0.279	60.1	66.1	5.5	22.6	14.2
K_0	2.22	0.150	**0.99**	0.188	0.874	0.166	**0.221**	63.2	67.1	5.6	23.1	14.4
K_1	2.19	0.151	**0.96**	0.138	0.885	0.161	**0.303**	62.0	66.7	5.7	23.0	14.2
K_2	2.20	0.152	**0.93**	0.133	0.904	0.165	**0.321**	61.0	67.5	5.6	22.0	13.9
Mg_0	2.20	0.148	0.96	**0.130**	0.907	0.168	0.277	59.5	68.1	5.6	22.7	**13.5**
Mg_1	2.16	0.153	0.96	**0.137**	0.877	0.159	0.280	60.8	67.7	5.7	23.1	**14.0**
Mg_2	2.24	0.153	0.96	**0.142**	0.878	0.166	0.288	65.8	65.6	5.6	22.2	**15.1**

Analysis of frond 17 leaflet samples shows triple superphosphate application to significantly increase levels of nitrogen, phosphorus and magnesium. The increase in leaflet nitrogen has been observed by other workers after application of phosphates, and may be due to the phosphate increasing nitrogen mineralization in these phosphorus deficient conditions. In this site both phosphorus and magnesium levels are very low. The fact that triple superphosphate application increases magnesium levels so markedly, suggests that the beneficial effect of triple superphosphate on FFB production may be in part due to the increase in magnesium in the leaflets.

Application of muriate of potash, as expected, has significantly increased the leaflet chlorine levels. The application of potash though has caused a significant reduction in leaflet potassium levels. This reduction in leaflet potassium levels due to application of fertilizer potassium has been seen before on similar soils. Frond petiole samples will be taken shortly for analysis and should give more information about this phenomenum.

Kieserite application has significantly increased leaflet magnesium and boron levels.

EXPERIMENT 109a: Mill Waste Manurial Trial on Young palms, Bebere

Site Details: The palms in the trial site were planted in 1978 at a planting density of 135 palms per hectare. The trial area contains 1080 palms in total, 480 of these being recorded. The trial covers an area of approximately 8 ha.

Design: The trial consists of a randomised block design, with 5 replicates and 6 treatments. Each plot consists of 36 palms, the central 16 palms being recorded.

Treatments: Treatments include the use of raw palm oil mill effluent (POME) and munched (chopped) bunches at the following rates:

	Treatments	**Date of Application**
1.	Nil	-
2.	Nil	-
3.	POME 500 l/palm	Oct.84, Sept.85, Nov.86
4.	POME 1000 l/palm	Oct.84, Sept.85, Nov.86
5.	Munched bunches and POME 100 t/ha	April '86
6.	Munched bunches 100 t/ha	May-July '85

POME was applied annually, the other treatments being applied once only.

Results and Discussion: FFB production and yield component data for the period Jan-Dec 1988 are presented in Table 28. FFB production and yield component data for the period Jan 86 to Dec 88 are presented in Table 29.

Table 28: Experiment 109a, Production per hectare, Jan-Dec 1988

	FFB Yield ($t\ ha^{-1}\ yr^{-1}$)	No. of Bunches ($ha^{-1}\ yr^{-1}$)	S.B.W. (kg)
Nil	21.99	1005	22.0
POME 500 l $palm^{-1}$	24.15	1063	22.8
POME 1000 l $palm^{-1}$	26.78	1170	23.0
M.B.& POME 100 t ha^{-1}	23.68	1040	22.9
M.B. 100 t ha^{-1}	25.12	1155	21.8
C.V. %	12.7	11.4	11.4
$L.S.D._{.05}$	4.96	199	4.1

Table 29: Experiment 109a, Production per hectare per year, Jan86 - Dec88

	FFB Yield ($t\ ha^{-1}\ yr^{-1}$)	No of Bunches ($ha^{-1}\ yr^{-1}$)	S.B.W. (kg)
Nil	21.80	1104	19.8
POME 500 l $palm^{-1}$	24.16	1179	20.6
POME 1000 l $palm^{-1}$	25.26	1238	20.5
M.B. & POME 100 t ha^{-1}	24.92	1208	20.7
M.B. 100 t ha^{-1}	24.92	1249	20.0
C.V. %	11.5	9.6	8.7
$L.S.D._{.05}$	4.45	184	2.9

The 1988 production data shows a significant ($p=0.028$) increase in FFB production due to application of the mill waste treatments as a whole compared with the 'Nil' treated control. The linear component of the POME rate response is significant ($p=0.016$).

The data for the period Jan 86 to Dec 88 shows a significant ($p=0.001$) increase in FFB production due to application of the mill waste treatment as a whole compared with the 'Nil' treated control. The linear component of the POME rate response is significant ($p=0.001$). The FFB production response is largely due to an increased number of bunches produced.

Conclusion

Over the three years since the application of the various mill waste treatments, cumulative F.F.B. yields have on average been raised by an impressive 9 t ha^{-1}. There is no significant difference between the effects of the treatments so there is no advantage in applying the higher rates. This trial was closed at the end of the year.

EXPERIMENT 109b: Mill waste Manurial Trial on older palms, Bebere.

Site Details: The palms in this trial were planted in 1970 at a planting density of 143 palms ha^{-1}. The palms were later thinned to 123 palms ha^{-1}. The trial is located in an area where, after 15 years of oil palm cultivation, yields were declining markedly and organic matter depletion appeared to be a problem.

Design: The trial consists of 4 replicates of 6 treatments in completely randomised blocks. Each plot consists of a row of palms either side of a harvest path (twin row) containing approximately 60 palms. One twin row was left between plots as guard rows.

Treatments:

	Treatment	Dates of Application
1.	Nil	-
2.	Nil	-
3.	POME 500 l/palm	June - Sept. 85, July 86
4.	POME 1000 l/palm	June - Sept. 85, July 86
5.	Empty bunches 50 t/ha	Sept - Oct. 85
6.	Munched bunches 50 t/ha	Oct - Nov. 85

Results : FFB production and yield component data for the period Jan-Dec 88 are presented in Table 30. FFB production and yield component data for the period Jan 86 - Dec 88 are presented in Table 31.

Table 30: Experiment 109b, Production per hectare, Jan-Dec88.

	FFB Yield ($t\ ha^{-1}\ yr^{-1}$)	No of Bunches ($ha^{-1}\ yr^{-1}$)	S.B.W. (kg)
Nil	12.26	726	16.9
POME 500 l $palm^{-1}$	11.89	727	16.5
POME 1000 l $palm^{-1}$	10.73	691	15.6
E.B. 50 t ha^{-1}	12.45	635	19.5
M.B. 50 t ha^{-1}	14.35	752	19.1
C.V. %	13.1	4.2	10.2
L.S.D. 05	3.17	59	3.5

Table 31: Experiment 109b, Production per hectare per year, Jan86-Dec88

	FFB Yield ($t\ ha^{-1}\ yr^{-1}$)	No of Bunches ($ha^{-1}\ yr^{-1}$)	S.B.W. (kg)
Nil	13.39	699	19.1
POME 500 l $palm^{-1}$	15.12	781	19.4
POME 1000 l $palm^{-1}$	13.78	713	19.3
E.B. 50 t ha^{-1}	14.67	707	20.8
M.B. 50 t ha^{-1}	15.80	769	20.5
C.V. %	6.7	4.9	3.5
L.S.D. 05	1.90	70	1.4

The 1988 production data shows no significant effect of mill waste treatments over the 'Nil' control.

The cumulative Jan 86 to Dec 88 production data, shows only the 50 t ha^{-1} munched bunch treatment to significantly ($p<0.05$) increase the FFB yield over the control.

Conclusion

Three years after the application of mill waste treatments, effects are no longer seen except for a trend of higher mean bunch weights shown by the two mulch applications. However cumulative F.F.B. yields were increased by an average of 4.3 t ha^{-1} over the first two years after application of the waste materials. This improvement might have been sustained in the third year if additional fertilizers had also been applied to this impoverished soil. This trial has now been closed .

EXPERIMENT 202: Hargy Bunch Refuse Manurial Trial.

Site Details: The palms (IRHO DxP) in this trial were planted in 1973 at a planting density of 115 palms ha^{-1}. The trial area comprises 1080 palms in total, 480 palms being recorded. The trial covers an area of approximately 9.4 ha.

Design: 5 replicates of 6 treatments in a randomised complete block design. Each plot consists of 36 palms in total, the central 16 being recorded.

Treatment: The following treatments were applied once only:

Treatment	Date Applied
1. Nil	-
2. Empty bunches 25 t/ha	-
3. Empty bunches 50 t/ha	Aug - Dec. 84
4. Empty bunches 100 t/ha	Aug - Dec. 84
5. Empty bunches 100 t/ha + 1kg S.A./palm	Aug 84 - Jan 85

Results :

FFB production and yield component data for the period Jan-Dec 1988 and for the combined period Jan86 - Dec88 are presented in Table 32.

Table 32: Experiment 202, Production per hectare, Jan-Dec88

	FFB Yield ($t\ ha^{-1}\ yr^{-1}$)	No of bunches ($ha^{-1}\ yr^{-1}$)	S.B.W. (kg)
Nil	15.13	841	18.0
EFB 25 $t\ ha^{-1}$	15.27	800	19.3
EFB 50 $t\ ha^{-1}$	13.29	721	18.4
EFB 100 $t\ ha^{-1}$	15.91	811	19.7
EFB 100 $t\ ha^{-1}$ + SOA	14.78	720	20.5
C.V. %	14.9	11.9	5.9
L.S.D. 05	3.60	153	1.8

Production per hectare per year, Jan86-Dec88

	FFB Yield ($t\ ha^{-1}\ yr^{-1}$)	No of Bunches ($ha^{-1}\ yr^{-1}$)	S.B.W. (kg)
Nil	20.09	1020	19.7
EFB 25 $t\ ha^{-1}$	20.5	932	22.1
EFB 50 $t\ ha^{-1}$	19.79	949	20.9
EFB 100 $t\ ha^{-1}$	21.88	987	22.2
EFB 100 $t\ ha^{-1}$ + SOA	20.09	883	22.6
C.V. %	8.1	6.6	3.8
L.S.D. 05	2.70	103	1.3

The 1988 production data shows that the EFB applications have had no significant effect on FFB production or number of bunches produced relative to the control, and there are no significant differences between EFB treatments. However the 100t ha^{-1} EFB and 100 t ha^{-1} EFB plus SOA treatments significantly ($p<0.05$) increased single bunch weights.

The cumulative production data for the period Jan86 to Dec88 shows no significant treatment effects on FFB production. However the EFB treatments have significantly ($p<0.001$) increased single bunch weight relative to the control and significantly ($p<0.001$) reduced number of bunches produced relative to the control.

The results of the tissue analysis of frond 17 leaflet samples taken in August 1989 are presented in Table 33.

Table 33: Experiment 202, Frond 17 tissue analysis, August'89

	N %	P %	K %	Mg %	Ca %	S %	Cl %	Mn ppm	Zn ppm	Cu ppm	B ppm
Nil	2.05	0.142	1.00	.157	.965	.163	.229	63.0	26.9	7.1	10.2
EFB 25 tha^{-1}	2.16	0.144	1.03	.144	.974	.168	.278	60.2	26.8	7.2	12.4
EFB 50 tha^{-1}	2.00	0.140	1.03	.150	.922	.158	.220	60.2	27.2	7.6	11.6
EFB100 tha^{-1}	2.04	0.143	1.01	.142	.960	.158	.246	66.2	27.2	7.0	11.8
EFB100 tha^{-1} + SOA	2.10	0.143	1.06	.142	.882	.158	.272	63.2	24.4	8.0	13.0
C.V. %	4.6	7.0	4.4	21.3	5.8	6.2	12.9	6.3	8.8	12.9	21.6
$LSD_{.05}$ Nil vs EFB	0.13	0.006	0.07	.023	.075	.009	.035	7.0	2.9	1.1	2.9
EFB vs EFB	0.15	0.007	0.08	.027	.086	.010	.041	8.1	3.4	1.3	2.6

EFB treatments have had little statistically significant effect upon frond 17 leaflet nutrient levels. In the contrast "Nil vs all EFB treatments", EFB applications significantly (p=0.032) increase leaflet boron levels and significantly (p=0.05) increase leaflet chlorine levels. There is an indication, though non-significant, that EFB application reduces leaflet magnesium levels.

Conclusion

The EFB treatments have significantly increased average bunch weights, an effect which is still seen in the fourth year after application. However probably due to the limiting effect of a factor subsequently depressed further by the mulch (e.g. supply of Mg), bunch numbers have been simultaneously depressed so that there has been no net effect on yield production. This trial was concluded at the end of the year. Future trials should test EFB applied together with additional fertilizers.

2. SMALLHOLDER TRIALS

WEST NEW BRITAIN PROVINCE

(P.N)

INTRODUCTION

At Buvussi Subdivision, West New Britain Province, small fertilizer trials were carried out during the year, on selected smallholder blocks in mature palm areas (EXPERIMENT 112), and in immature replanted areas (EXPERIMENT 113). The aim is to demonstrate and publicise the benefits of fertilizer application.

EXPERIMENT 113, which includes the intercropping trial at Kavui Subdivision and the three nitrogen fertilizer demonstrations at KAPORE, SARAKOLOK and BUVUSSI were all concluded during the year. A new series of demonstrations covering more extensive areas of West New Britain Province was initiated under EXPERIMENT 121. The emphasis is on preventing yield decline which occurs in the absence of fertilizer and demonstrating methods and rates of fertilizer application based on PNGOPRA's official fertilizer recommendation No.3. Five sites have been selected and are being characterized, based on soil collection, leaf samples, and management assessment. In this series, N will be required in nearly all areas with certain regions requiring special attention (for example, Kavugara and Buvussi Subdivisions, in the West Nakanai Oil Palm Scheme).

EXPERIMENT 112: NITROGEN AND PHOSPHATE TRIAL BUVUSSI SUBDIVISION

Planted : 1980

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

Treatment :
1. Nil
2. 1kg/palm/year TSP
3. 1kg/palm/year TSP + 1kg/palm/year A.C.

Treatment Commenced: April/May 1986

1988 is the third year since the initial treatments were carried out. As shown in Table 34 differences in yield fall into three basic categories comprised of 3 high, 3 medium and 2 low yielding blocks. The treatment results in Table 35 show a significant response to N only (ie difference between (N+P) and P plots) largely due to the increase in bunch weight. The response to N fertilizer at the different sites is shown graphically in Fig. 35. At four sites there is a response of at least 40 % with one site giving a response of 80 % , whilst at the remaining sites responses are either low or negative. There is no significant response to the application of P alone.

Table 34 EXPERIMENT 112, Yield Performance (Jan-Dec 1988)

Replicate No	FFB t/ha/yr	Bunch No per ha	Bunch Wt Kg	Black Bunch Count No/palm
5	20.80	1273	16.34	3.73
8	19.68	1303	15.05	4.19
7	19.06	1308	14.57	4.00
6	15.11	977	15.47	3.30
4	13.42	960	13.98	4.34
2	12.90	796	16.21	3.40
3	11.23	848	13.24	3.70
1	9.47	622	15.23	3.62
LSD$_{.05}$	4.44	182	2.31	
C.V (%)	16.7	17.1	8.80	

Table 36 illustrates progressive FFB production in the Buvussi problem area where the trials are sited, compared with average results for the sub-division.

In Table 37, yields and leaf nutrient levels have been summarised in three groups according to yield level. It appears that leaf nutrient levels do not explain the large differences in yield between sites, although the lowest yielding group does have the lowest leaf N levels.

Table 35: EXPERIMENT 112 BUVUSSI Production Jan-Dec 1988

SITE	FFB tonnes/ha				Bunch No				Bunch Wt. Kg			
	(-)	P	N+P	Mean	(-)	P	N+P	Mean	(-)	P	N+P	Mean
1	10.93	7.05	10.42	9.47	745	448	674	622	14.67	15.76	15.47	15.30
2	11.00	11.46	16.24	12.90	742	767	880	796	14.83	14.94	18.45	16.07
3	7.97	9.09	16.63	11.23	673	784	1088	848	11.85	11.59	15.29	12.91
4	14.08	12.63	13.56	13.42	938	1059	884	960	15.02	11.93	15.35	14.10
5	20.00	21.38	21.02	20.80	1469	1160	1189	1272	13.62	18.44	17.68	16.58
6	12.65	17.08	15.61	15.11	871	1080	980	977	14.53	15.82	15.93	15.43
7	16.09	16.17	24.93	19.06	1130	1177	1617	1308	14.24	13.73	15.42	14.46
8	18.02	21.64	19.38	19.68	1320	1452	1138	1303	13.65	14.91	17.03	15.20
MEAN	**13.84**	**14.56**	**17.22**	15.21	986	991	1056	1011	**14.05**	**14.64**	**16.33**	15.01
LSD$_{.05}$	2.72				302				1.42			
C.V.(%)	16.7				17.1				8.80			

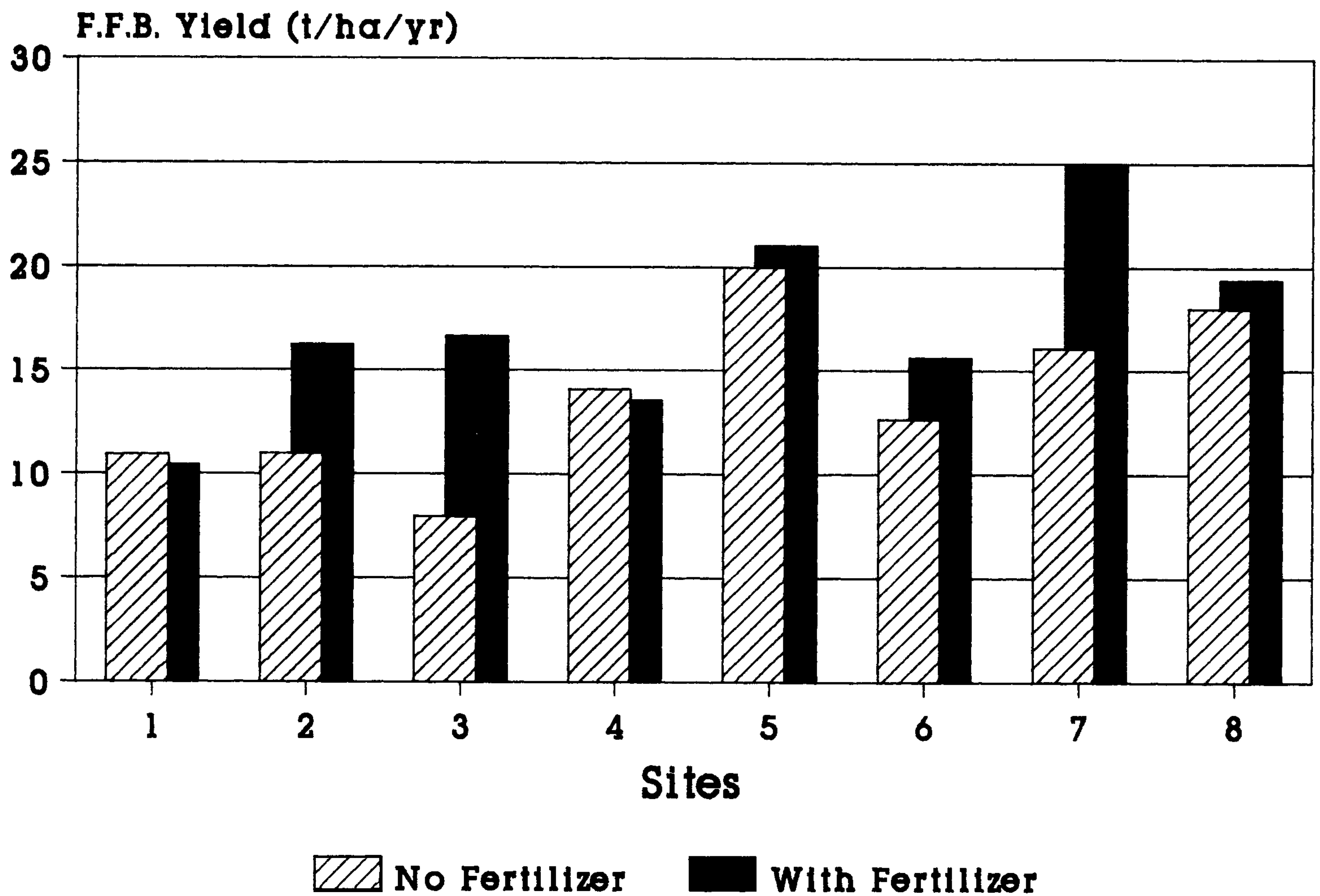


Fig. 35 Experiment 121, Response to N fertilizer at different smallholder sites at Buvussi in 1988

Table 36: Simple Comparative FFB Production of Buvussi Problem Areas.

(1) Without Fertilizer / With Fertilizer (Trial 112)

Block No	Without Fertilizer (1972 Planting) 1980 t/ha	1983 t/ha	With Fertilizer (Trial 112) (1980 Planting) 1987 t/ha	1988 t/ha
1142	13.1	-	12.09	8.74
1150	13.3	8.8	12.66	13.85
1151	12.2	8.8	13.14	12.86
1152	12.9	11.8	18.15	13.10
1193	15.4	-	15.14	21.20
1396	13.8	6.9	18.61	16.35
1397	13.6	8.2	19.36	20.55
1194	16.3	-	22.22	20.51
Mean	13.8	8.9	16.42	15.90

(2) Subdivision Average (1973 - 1988)
(without fertilizer)

Year	FFB t/ha/yr	Year	FFB t/ha/yr
1972	-	1982	13.9
1973	18.3	1983	16.8
1974	18.8	1984	15.7
1975	21.5	1985	15.6
1976	19.8	1986	13.04
1977	20.0	1987	13.41
1978	17.1	1988	N/A
1979	16.7		
1980	12.9		
1981	20.9		

Source : (1) DAL
(2) H.F.A.S. Report 15. p95

TABLE 37 EXPERIMENT 112 : Yields and leaf nutrient levels in different yielding blocks (1988).

	Low Yield	Medium Yield	High Yield
FFB t/ha/yr	10.35	13.81	19.85
Bunch No. ha/yr	735	911	1295
Bunch Wt. (kg)	14.24	15.22	15.23
Leaf 17			
% N	2.20	2.33	2.27
% P	0.165	0.165	0.166
% K	1.01	0.95	0.99
% Mg	0.21	0.23	0.22
% Ca	1.11	1.06	1.11
% Cl	0.23	0.17	0.17
% Na	0.01	0.01	0.01
% S	0.20	0.19	0.19
p.p.m. Mn	49	52	44
p.p.m. Fe	78	63	62
p.p.m. Zn	25	26	23
p.p.m. Cu	7	7	7
p.p.m. B	11	12	12

In Table 38 percentage yield responses to N fertilizer in 1988 have been tabulated for each site along with leaf nutrient levels in 1987. The results indicate an unexpected positive correlation (r=0.783) between FFB yield response to nitrogen fertilizer application and leaf nitrogen levels. Response is only obtained in the better sites, which means that some factor, possibly adverse soil physical properties or management, is limiting response. Despite this relationship, large differences in yield between sites remained unexplained. In 1988 yield varied from 9.47t/ha to 20.8t/ha. It is concluded that limiting factors are inhibiting the effect of applied nitrogen fertilizer in achieving optimum yields.

TABLE 38 EXPERIMENT 112 : 1988 % Yield Response (N+P/P) and 1987 Leaf Nutrient Levels.

	% FFB Yield Response			Leaf Nutrient Level in Control Plot						
	FFB	BNo	BWt	N	P	K	Mg	Ca	Cl	Mn
Site				%	%	%	%	%	%	ppm
1	47.8	50.4	-1.8	2.4	.15	1.0	.22	1.13	.10	37
2	41.7	14.7	23.5	2.3	.15	0.92	.22	1.28	.06	58
3	82.9	38.8	31.9	2.3	.15	0.91	.21	1.16	.06	55
4	7.4	-16.5	28.7	2.2	.15	0.97	.18	1.12	.09	50
5	-1.7	2.5	-4.1	2.2	.15	1.01	.19	1.11	.07	37
6	-8.6	-9.3	0.7	2.2	.16	0.94	.22	1.18	.08	54
7	54.2	37.4	12.3	2.3	.15	1.06	.22	1.18	.07	44
8	-10.4	-21.6	14.2	2.2	.15	1.00	.24	1.17	.07	45

Yield Assessment.

In the Buvussi trials it has previously been found that carrying out a full harvest recording every four months is a satisfactory short-cut method of estimating annual yield (PNGOPRA's 1987 Annual Report pages 55-57). To further investigate yield assessment, through estimation of bunch number, black bunch count was continued in this trial. Table 34 indicates that this observation is only very approximately related to yields, which is confirmed by a low correlation coefficient (Table 39).

During 1988 several other restricted methods of estimating annual yield values have been explored. Table 39 summarizes these findings. It is suggested that a correlation of at least 0.800 is required.

TABLE 39 : **Simple correlation of various recordings with annual FFB yield in 1987.**

	Recording	No. per year	Months	r
1	Black bunch count (BBC)	3		.560
2	Bunch number	3		.667
3	Bunch number	4		.709
4	Bunch number	12		.800
5	Mean bunch weight	12		.440
6	Mean bunch weight x BBC	12/3		.799
7	Mean bunch weight x Bunch No.	12/3		.832
8	Total bunch yield (whole month)	2	January, July	.496
9	Total bunch yield (whole month)	2	February, August	.689
10	Total bunch yield (whole month)	2	March, September	.552
11	Total bunch yield (whole month)	2	April, October	.726
12	Total bunch yield (whole month)	2	May, November	.788
13	Total bunch yield (whole month)	2	June, December	.844
14	Total bunch yield (1st half of month)	3	Feb, June, Oct.	.308
15	Total bunch yield (1st half of month)	3	Mar, Jul, Nov.	.713
16	Total bunch yield (1st half of month)	6	Jan,Mar,May,Jul,Se,No	.717
17	Total bunch yield (1st half of month)	6	Fe,Ap,Ju,Au,Oc,Dec	.569
18	Total bunch yield (2nd half of month)	6	Ja,Mr,My,Jl,Se,No	.675
19	Total bunch yield (2nd half of month)	6	Fe,Ap,Ju,Au,Oc,Dec	.860
20	Total bunch yield (whole month)	3	February,June,October	.834
21	Total bunch yield (whole month)	3	March, July, November	.869
22	Total bunch yield (whole month)	3	January, May, Sept.	.823
23	Total bunch yield (whole month)	3	April, August, Dec.	.808
24	Total bunch yield (whole month)	4	Feb, May, Aug, Nov.	.845
25	Total bunch yield (whole month)	4	Jan, Apr, Jul, Oct.	.851
26	Total bunch yield (whole month)	4	Mar, Jun, Sept, Dec.	.801
27	Total bunch yield (whole month)	6	Jan,Mar,May,Jul,Se,No	.963
28	Total bunch yield (whole month)	6	Fe,Ap,Ju,Au,Oct,Dec	.976

Comments on the results are:-

1) Methods 4 - 7 require recording every month so are not practical.
2) Methods 8 - 19, in which a limited number of harvests are recorded, give too variable results.
3) Of the remainder, recording total bunch yield 3 times a year gives satisfactory and consistent results.
4) Recording total bunch yield 4 times a year is no better.
5) Recording total bunch yield 6 times a year (ie every alternate month) is appreciably the best.

From a practical consideration, it is recommended that recording total bunch yield three times a year (i.e. every 4th month) be adopted.

EXPERIMENT 113a, FERTILIZER DEMONSTRATIONS, WEST NAKANAI SCHEME

Based on PNGOPRA's official fertilizer Advisory Leaflet No.1, fertilizer demonstrations have been carried out on three smallholdings in the West Nakanai Scheme. Table 40 gives a simple comparative yield summary of the three result demonstration sites (SARAKOLOK, KAPORE and BUVUSSI), involving the immature replanting phase. The yield obtained over the first 3-7 months of harvest, as shown in Table 40, serves to confirm the fact that by putting on fertilizer in the right way, a grower may benefit by harvesting nearly twice the amount of fruit he would have obtained without any fertilizer. The main aim was to encourage growers to 'apply' their fertilizers with emphasis on physical observations indicating nutrient deficiencies, e.g. yellowing of leaves, retarded growing features and the general appearance of the replanted palms.

TABLE 40 : Nitrogen demonstration on replanted oil palm.

Summary of yield, black bunch count and petiole measurements in first months of harvesting.

Period	Site	Recorded palms		FFB Kg/palm		Bunch No per palm		Bunch Wt Kg		Black Bunch Count per palm		WxT (cm^2)	
		(-)	N	(-)	N	(-)	N	(-)	N	(-)	N	(-)	N
Aug-Dec 1987	Sarakolok	67	128	2.03	3.46	1.1	1.7	1.89	2.06	1.79	2.41	21.3	23.2
Aug-Dec 1987	Kapore	73	172	0.61	3.54	0.3	1.8	2.10	2.00	0.40	3.19	14.1	22.5
Mar-Dec 1988	Buvussi	43	83	18.43	32.10	4.7	8.1	3.90	3.98	1.35	5.82	13.9	16.9
Mean				7.02	13.03	2.03	3.87	2.63	2.68	1.18	3.81	16.43	20.87

EXPERIMENT 113b: Intercropping and fertilizer demonstration on replanted palms, Kavui.

Design : Unreplicated demonstration plots on 2 sites.

Treatments : Intercropping for 2 years after replanting oil palms, using crops typical of three main ethnic groups among settlers of the Hoskins oil palm development, in conjuction with fertilizers as recommended in PNGOPRA Advisory Leaflet No. 1 and D.A.L. for the foodcrops where available.

Demonstration:

		Ammonium chloride/palm Kg 1987	1988	N P K /Mg 12:12:17:2 applied to
1. Covercrop alone		1.5	1.8	Nil
2. Intercropping system:	Chimbu	1.5	1.8	food crops
	Sepik	1.5	1.8	food crops
	Tolai	1.5	1.8	food crops

Cropping schedule:

	Round 1	Round 2	Round 3	Round 4
Chimbu	Sweet potato Maize Aibika Sugarcane	Peanut	Peanut	Covercrop
Sepik	Taro (Colocasia) Yam (Dioscorea) Sweet banana	Sweet banana Sweet potato	Sweet banana Sweet potato	Covercrop
Tolai	Cooking banana - Singapore (Xanthosoma)	Cooking banana	Peanut	Covercrop

Recording: Visual inspection, measurement of petiole cross section and black bunch counts.

The initial objectives were:

1) To judge the effect on oil palm of intercropping with foodcrops for up to 18 months or so. This effect may be good or bad.

2) Assuming this effect is detrimental, is this compensated for when the palms receive the recommended rate of fertilizer?

3) What benefit does the farmer obtain from the food-crops themselves?

Progressive details:

Food crops: Some records have been made especially of sweet potato, yam and bananas. No measurements had been scheduled to be made on palms at this stage. It is intended that vegetative measurement should be carried out to check if the food crops have affected palm growth perhaps after 12 months of production.

There have been numerous problems; upkeep of blocks has been the main difficulty especially when the farmer is heavily involved with off - farm activities, other social commitments, and lack of available able manpower willing to work the block.

Secondly, control of foodcrop harvest is very difficult. Especially, sugarcane (S. officinarium), bananas (musa sp) peanuts and aibika.

Foodcrop harvest on the allocated 1.0 hectare:

Crop	Weight (Kg)
Sweet potato	510.1
Yam	76.3
Xanthosoma	13.0
Bananas	44.4

EXPERIMENT 121: DEMONSTRATION OF NITROGEN FERTILIZER RECOMMENDATION.

Site Details.

The new series of Nitrogen Demonstration plots will be evenly distributed in the Hoskins Scheme. Five sites have been selected, which are located as shown in the map in Fig. 36. The identity of these sites is as follows:

1.	Tamambu village oil palm (VOP)	Block No 0020
2.	Tamba settlement	Block No 0565
3.	Galai settlement	Block No 1538
4.	Siki settlement	Block No 1066
5.	Galilo VOP	Block No 0005

On each site there will be approximately 240 palms, covering an area of 2 hectares, which will be used to show PNGOPRA's current nitrogen fertilizer recommendation (Advisory Leaflet No 3). Each will be mapped and sub-divided into 6 observation plots including one `control' which will receive no fertilizer and one `demonstration' plot which will receive the current nitrogen fertilizer recommendation.

The remaining 4 plots will be used to check on other fertilizer rates in order to provide future recommendations relevant to the area. Three of these plots will be used to test rates of Ammonium Chloride at 2kg per palm annually in the presence of triple superphosphate (TSP), potassium chloride (KCl) and kieserite (Mg) respectively. The last plot will test Ammonium Chloride only but at a higher rate (3kg/palm/yr).

All other palms within the observation area, but not included in recording work will also be fertilized to ensure that the appearance of the whole block is of a good standard. The effort will help the surrounding smallholders to realize that increased yield and consequently income is possible in this way, given time.

Initial pretreatment data shown in Table 41 indicates available background information for the sites. These are leaf area, petiole-cross-section measurements and leaf nutrient levels of December 1988. Nitrogen and chlorine levels are below optimum in all areas, but especially in Tamba, Galilo and Galai respectively. 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 trial in providing guidelines regarding nutrition and eventually yield in the various smallholder locations in the Province.

Fig. 36 Experiment 121, Distribution of smallholder demonstrations in West Nakanai oil palm scheme

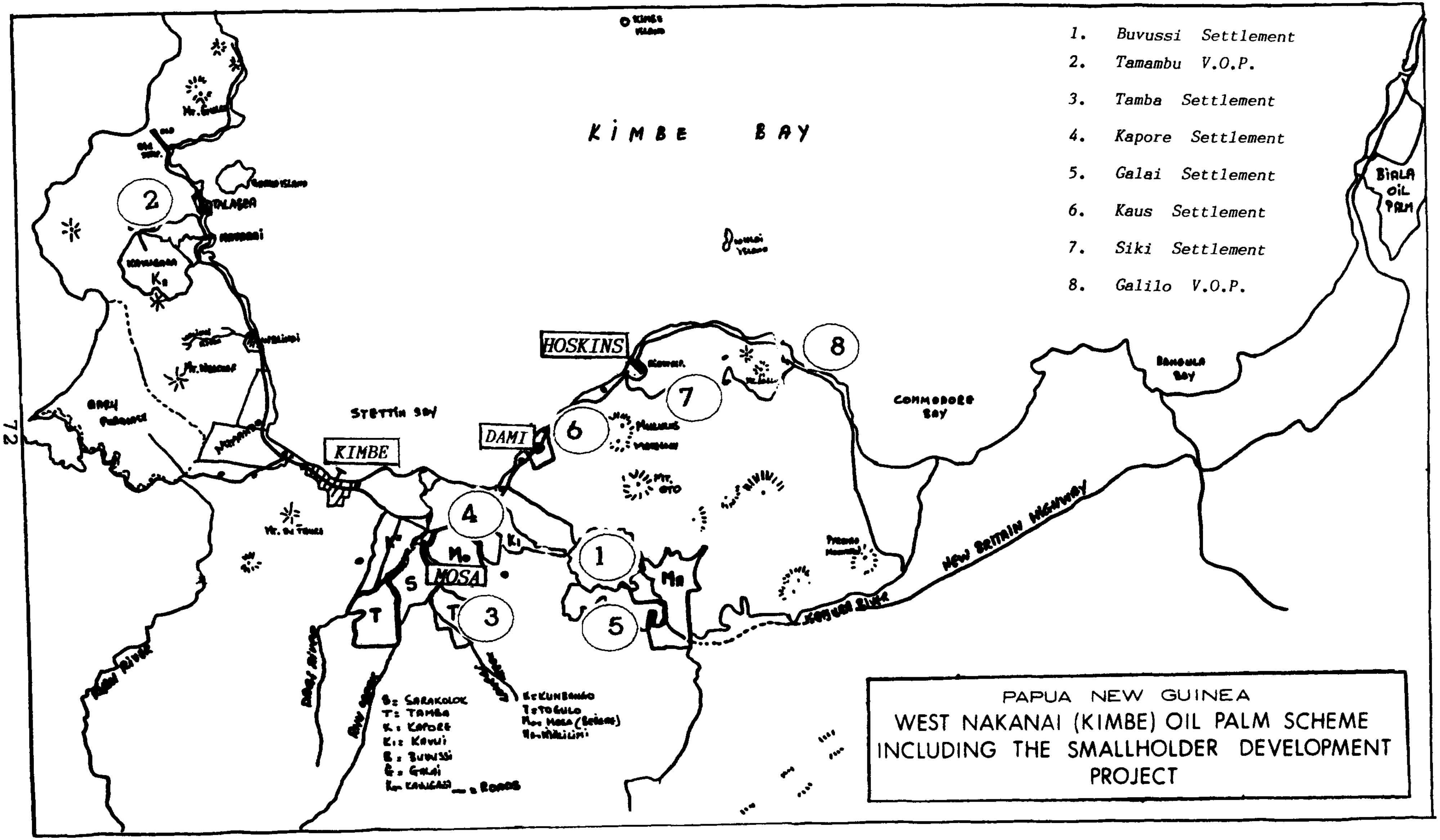


Table 41: Experiment 121 Pre-treatment data for frond measurements, and leaf nutrient levels in December 1988.

Name:	TAMAMBU	TAMBA	GALAI	SIKI	GALILO
No:	# 19/0020	# 02/0565	# 05/1538	# 10/1066	# 27/0005
Planted:	1982	1983	1984	1984	1985
Phase:	New	Replant	III	New	New
Leaf Area (m^2)	7.51	6.28	6.07	6.92	4.47
Leaf Wt. (kg)	2.86	2.77	2.21	2.65	1.81
<u>Leaf 17</u>					
% N	2.4	2.1	2.4	2.4	2.2
% P	.162	.163	.171	.171	.164
% K	1.00	1.10	1.07	1.00	0.99
% Mg	0.17	0.19	0.30	0.24	0.25
% Ca	0.95	0.90	1.09	0.99	1.22
% Cl	0.23	0.11	0.06	0.12	0.18
% S	0.16	0.17	0.18	0.17	0.17
% Na	0.01	0.01	0.01	0.01	0.01
ppm Fe	70	76	79	59	49
ppm Mn	44	54	46	51	35
ppm Zn	22	23	25	22	18
ppm Cu	10	6	7	6	7
ppm B	11	9	10	11	10

2. AGRONOMY AND SMALLHOLDER TRIALS

ORO AND MILNE BAY PROVINCES

(S.W.)

TRIAL 305, Fertilizer factorial trial, Arehe

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

Experimental details
Statistical design: Trial 305 is a randomised incomplete block factorial design, with two replicates each of 3 blocks, comprising 3x2x3x2 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 details :
Location: Arehe Estate HOPPL, block 78F.
Genetic material: Dami commercial DxP crosses.
Soils: Higaturu family, which is of volcanic ash origin,consisting of deep sandy clay loam, with good drainage and physical properties.
Planting date: 1978.
Spacing: 130 points ha.
Size: The trial comprises 72 plots: 2592 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

Treatment details :
Trial commencement: September 1981.
Trial progress: Ongoing.
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**

General yield levels have fallen during 1988, particularly on the poorest plots, which are now well below 20 t/ha.

Yield data is summarised in Table 42. To give a more reliable indication of recent trends 1988 data is also given in combination with 1987 results. Consideration of the joint values helps to avoid possible anomalous annual fluctuations.

Table 42: Experiment 305, Yield data

TRTMNT	1988 Wt of bunches t/ha	1988 No of bunches /ha	1988 s.b.w. kg	1987/8 Wt of bunches t/ha	1987/8 No of bunches /ha	1987/8 s.b.w. kg	1984-88 Wt t/ha
N 0	**19.5**	**973**	**20.0**	**22.5**	**1162**	**19.4**	**28.0**
N 1	**26.6**	**1226**	**21.9**	**28.7**	**1403**	**20.6**	**32.3**
N 2	**28.0**	**1311**	**21.4**	**30.1**	**1486**	**20.3**	**32.8**
P 0	24.9	1190	21.0	27.3	1373	19.9	31.1
P 1	24.5	1150	21.3	26.9	1328	20.3	31.0
K 0	23.6	1191	**19.0**	**25.8**	1373	**18.9**	**29.6**
K 1	24.8	1135	**21.8**	**27.6**	1330	**20.7**	**31.5**
K 2	25.7	1184	**21.6**	**27.8**	1348	**20.7**	**31.9**
Mg 0	25.2	**1210**	20.8	27.5	1376	20.0	31.3
Mg 1	24.2	**1129**	21.4	26.7	1325	20.2	30.8
lsd (N&K)	1.67	78.4	1	1.32	73.4	0.8	0.94
lsd (P&Mg	1.36	64	0.82	1.08	59.9	0.66	0.77
s.d.	2.87	135	1.72	2.28	127	1.39	1.62
c.v.	12	12	8	8	9	7	5

(In this and all following tables, significant treatment effects are indicated by bold figures)

There has been a continued major response to SOA, and a smaller response to MOP. Responses to TSP or Kieserite alone were absent, but TSP showed significant interactions with SOA and MOP.

Multiple regression was used to provide precise predicted yields. The fitted equation gave a coefficient of determination (R^2) of 74.97, correlation coefficient 0.87, mean 22.6, standard error 2.73 and coefficient of variation of 12%.

Predicted results for all N, K combinations (at zero levels of P and Mg treatments) are given in Table 43, and for maximum and minimum yields in Table 44. The actual progressive yield data for selected plots is provided in Table 48.

Table 43: Fitted F.F.B. yields in t/ha for different N and K treatment combinations in 1988

	N0	N1	N2
K0	18.7	27.3	26.5
K1	19.2	27.0	29.2
K2	20.6	29.2	28.5

Table 44: Predicted values for treatments giving highest and lowest yields - 1988

Maximum Yield Combinations					Minimum Yield Combinations				
Yield t/ha	N	P	K	Mg	Yield t/ha	N	P	K	Mg
30.0	1	1	2	0	18.0	0	0	0	1
29.8	2	1	1	0	18.7	0	0	0	0
29.8	2	2	2	1	18.9	0	1	1	1
29.6	2	0	1	1	19.1	0	1	0	0
29.3	2	1	2	0	19.2	0	0	1	0
29.2	2	0	1	0	19.2	0	1	0	1
29.2	1	0	2	0	19.5	0	0	1	1
29.0	2	1	1	1	19.5	0	1	1	1
28.5	2	0	2	0	19.7	0	1	1	0

Figure 37 gives iso-yield contours for all SOA and MOP combinations, over the period 1986-88 predicted in the absence of TSP or Kieserite. This indicates a major response to SOA with rates around 2 kg/palm providing yields of 28 t/ha for the minimum fertilizer input. At application rates of 3kg plus, SOA without MOP depressed yield. At 3 kg of SOA therefore, additional application of even 1 kg of MOP provided a flatter yield plateau, and avoided the yield depression occasioned by higher SOA applications. For absolute maximum yield (32 t/ha), 3 kg of SOA plus 3.5 kg of MOP would be necessary.

Although the major response was to SOA, selection of the correct rate was important. Application of SOA at 4 kg depressed yield compared to 3kg. The most profitable fertilizer combination under average market conditions was approximately 2.5kg SOA palm 2kg MOP per palm per year.

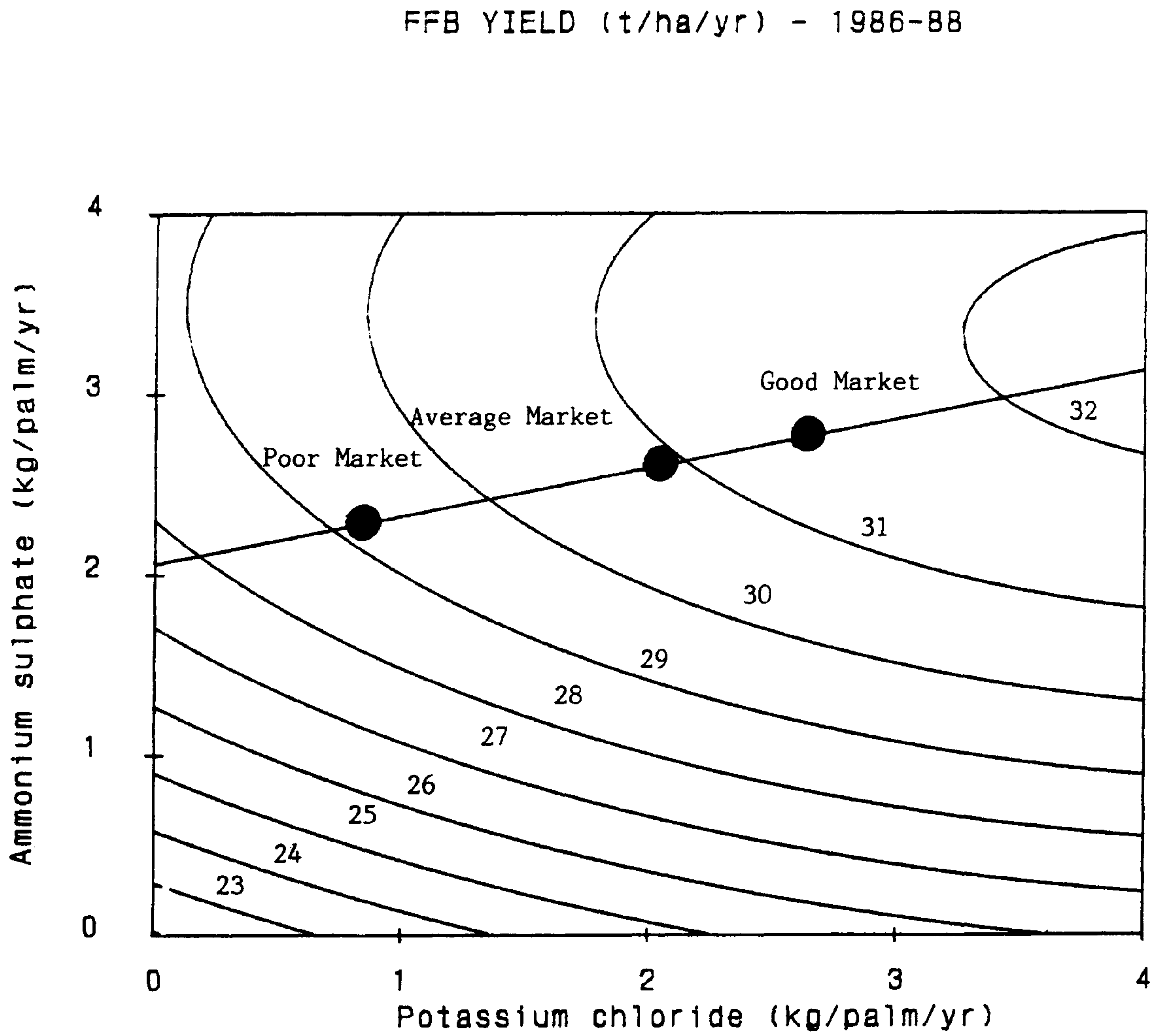


Fig. 37 Trial 305, Iso-yield contour map for period 1986-88

(Most profitable fertilizer combinations indicated for poor, average and good market conditions)

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 45.

Table 45: Trial 305 Palm Growth and Conversion Data for 1987 and 1988 (annual basis)

TRTMNT	Leaf prdn (n)	Dry Frond weight kg (FW)	Frond DM tha^{-1} (FDM)	Bunch* DM tha^{-1} (BDM)	Vegetative DM tha^{-1} (VDM)	Total* DM tha (TDM)	Bunch* Index (BI)	Leaf Area Index (LAI)	Efficiency of conversion (e)
N 0	**21.3**	**3.77**	**10.2**	**18.4**	**13.4**	**31.8**	**0.578**	**5.00**	**1.21**
N 1	**23.2**	**4.22**	**12.4**	**23.5**	**16.4**	**40.0**	**0.589**	**5.42**	**1.44**
N 2	**23.7**	**4.26**	**12.9**	**24.7**	**17.0**	**41.7**	**0.591**	**5.54**	**1.47**
P 0	22.9	4.11	12.0	22.4	15.8	38.2	0.586	5.45	1.35
P 1	22.6	4.06	11.7	22.0	15.4	37.5	0.586	5.19	1.40
K 0	22.9	**3.88**	**11.3**	**21.2**	**14.9**	**36.1**	0.586	5.23	**1.29**
K 1	22.7	**4.16**	**12.0**	**22.6**	**15.8**	**38.4**	0.587	5.25	**1.46**
K 2	22.7	**4.22**	**12.2**	**22.8**	**16.1**	**38.9**	0.585	5.49	**1.37**
Mg0	22.8	**4.06**	11.7	22.5	15.5	38	0.592	5.18	1.42
Mg1	22.7	**4.15**	12	21.9	15.7	37.6	0.58	5.46	1.33
lsd(N&K)	0.53	0.15	0.66	1.08	0.74	1.39	0.01	0.44	0.12
lsd(P&Mg)	0.43	0.12	0.54	0.88	0.61	1.13	0.01	0.36	0.1
s.d.	0.92	0.25	1.14	1.87	1.28	2.39	0.03	0.76	0.2
c.v.	4	6	10	8	8	6	5	14	15

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

There was no significant difference between bunch index values for the different fertilizer treatments. However SOA raised TDM production by about 10t/ha, and also raised the LAI, both through leaf number and leaf weight. This resulted in a major improvement in efficiency of energy conversion.

MOP also increased TDM production, by a lower amount of about 2 t/ha, and also produced a significant improvement in the efficiency of energy conversion.

3. Nutrient analysis

The latest plant analysis results are presented in Tables 46 and 47 for rachis and leaflet samples respectively.

Table 46: 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	**1.09**	1.51	**.083**	.488	**.68**	**.036**
LSD		(.03)	(.020)	(0.12)	(.008)	(.071)	(.08)	(.003)
	K0	.25	**.061**	**1.10**	**0.68**	**.398**	**.12**	.041
	K1	.25	**.106**	**1.61**	**0.78**	**.496**	**.74**	.038
	K2	.24	**.113**	**1.80**	**0.86**	**.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)

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.

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.

Table 47: Leaf analysis related to fertilizer treatments in 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
	100	**108**	**111**	100	100	100	100	102	100	100			
P%	**.149**	**.155**	**.154**	.153	.153	.153	.153	.152	**.154**	**.151**	.003	.0025	3
	100	**104**	**104**	100	100	100	101	100	**100**	**98**			
K%	.855	.875	.888	.869	.877	**.935**	**.860**	**.824**	.877	.869	.044	.036	9
	100	102	104	100	101	**100**	**92**	**88**	100	99			
Cl%	.419	.403	.368	.410	.383	**.203**	**.459**	**.528**	.394	.400	.072	.059	31
	100	96	88	100	93	**100**	**226**	**260**	100	102			
S%	**.152**	**.163**	**.163**	.160	.159	.159	.160	.160	.160	.159	.004	.003	5
	100	**107**	**107**	100	99	100	100	101	100	99			
Ca%	**.922**	**.859**	**.846**	**.889**	**.863**	**.830**	**.888**	**.910**	.883	.868	.034	.028	7
	100	**93**	**92**	**100**	**97**	**100**	**107**	**110**	100	98			
Mg%	**.218**	**.202**	**.195**	.206	.204	.209	.204	.202	.203	.207	.012	.009	10
	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	23
	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	15
	100	**84**	**80**	100	98	100	97	99	100	100			

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 in some way with the variation in K levels between the rachis and the leaf.

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.

Summary :

General yield levels have fallen during 1988, particularly on the poorest plots, which are now well below 20 t/ha.

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.

Over the period 1986-88 there has been a major response to SOA with rates around 2 kg/palm providing yields of 28 t/ha for the minimum fertilizer input. For absolute maximum yield (32 t/ha), 3 kg of SOA plus 3.5 kg of MOP would be necessary.

Table 48: Progressive changes in yield and nutrient status

N0K0		82	83	84	85	86	87	88
	Yield	28.3	28.27	30.44	30.22	23.34	19.96	17.60
	N%	2.8	-	2.45	2.6	2.4	2.2	2.0
	K%	1.2	-	0.97	1.02	0.95	0.91	0.98
	P%	0.18	-	0.17	0.17	0.16	0.15	0.14
	Cl%	0.21	-	-	0.19	0.16	0.13	0.12

N1K0		82	83	84	85	86	87	88
	Yield	28.99	33.22	34.02	34.68	29.7	32.22	25.26
	N%	2.9	-	2.55	2.65	2.5	2.65	-
	K%	1.05	-	0.94	0.94	0.89	0.96	-
	P%	0.16	-	0.15	0.17	0.16	0.16	-
	Cl%	0.17	-	-	0.14	0.11	0.07	-

N0K1		82	83	84	85	86	87	88
	Yield	26.95	32.24	36.91	34.68	28.36	25.81	21.85
	N%	2.95	-	2.6	2.6	2.45	2.2	-
	K%	1.05	-	0.86	0.93	0.9	0.85	-
	P%	0.16	-	0.16	0.18	0.16	0.15	-
	Cl%	0.27	-	-	0.46	0.48	0.44	-

N1K1		82	83	84	85	86	87	88
	Yield	28.25	31.94	36.51	38.02	33.7	32.61	29.08
	N%	2.7	-	2.65	2.7	2.55	2.55	-
	K%	1	-	0.86	0.94	0.86	0.81	-
	P%	0.16	-	0.16	0.17	0.16	0.15	-
	Cl%	0.37	-	-	0.5	0.47	0.45	-

TRIAL 306, FERTILIZER FACTORIAL TRIAL, AMBOGO

Experimental Details :

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

Statistical design: Trial 306 is a randomised incomplete block factorial design, with one replicates 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 details :

Location: Ambogo Estate HOPPL, block 79B.
Genetic material: Dami commercial DxP crosses.
Soils: Ambogo and Penderetta families - recent alluvial origin, having silty loam topsoil and sandy loam subsoil, with mottling due to seasonally high water tables.
Planting date: 1979.
Spacing: 143 points ha.
Size: The trial comprises 81 plots: 2916 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

Treatment details :

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

Treatments in Kg/palm/year:

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

Results :

1. **Yield**

The previous exceptional yields in trial 306 have fallen substantially during 1988 to the 15-26 t/ha range. Substantial responses to appropriate fertilizer combinations have been maintained. Yield data is given in Table 49, and details of significant interactions in Table 50.

Table 49: Trial 306 yield data

TRTMNT	1988 Wt of bunches t/ha	1988 No of bunche /ha	1988 s.b.w. kg	1987/8 Wt of bunches t/ha
N 0	**19.0**	**1157**	**16.5**	**21.9**
N 1	**21.8**	**1253**	**17.7**	**24.9**
N 2	**22.5**	**1296**	**17.4**	**25.7**
P 0	21.1	1238	17.0	23.9
P 1	21.2	1233	17.2	24.0
P 2	21.0	1215	17.4	24.7
K 0	**19.8**	1244	**15.9**	**22.3**
K 1	**21.8**	1226	**17.9**	**25.4**
K 2	**21.7**	1217	**17.8**	**24.9**
Mg 0	21.2	1236	17.2	23.8
Mg 1	21.6	1264	17.2	25.1
Mg 2	20.4	1187	17.2	23.8
lsd	1.3	72.3	0.68	1.28
s.d.	2.39	133	1.25	2.35
c.v.	11	11	7	10

Table 50: Fertilizer interaction tables: annualised means

NxP Yield t/ha 87/88

	P0	P1	P2
N0	20.1	22.2	23.4
N1	25.9	24.3	24.8
N2	25.8	25.5	25.9

KxP Yield t/ha 87/88

	K0	K1	K2
P0	20.5	25.5	25.8
P1	22.3	25.9	23.8
P2	24.2	24.8	25.2

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

Multiple regression was used to provide precise predicted yields. The fitted equation gave a coefficient of determination (R^2) of 64.76, correlation coefficient 0.805, mean 20.2, standard error 2.30 and coefficient of variation of 12%.

Predicted results for all SOA and MOP combinations (at zero levels of P and Mg treatments) are given in Table 51, and for maximum and minimum yields in Table 52. Actual ongoing yield for selected plots is given in Table 56.

Table 51: Fitted yields in t/ha for different N and K fertilizer combinations in 1988.

	N0	N1	N2
K0	16.1	19.2	17.9
K1	20.1	24.5	24.0
K2	20.5	24.6	25.2

Note: N and K are coded for the trial fertilizer rates of SOA and MOP, as given in the trial details at the start of this section.

Table 52: Trial 306, Predicted values for treatments giving highest and lowest yields - 1988

Maximum Yield Combinations					Minimum Yield Combinations				
Yield t/ha	N	P	K	Mg	Yield t/ha	N	P	K	Mg
26.07	2	2	2	2	15.55	0	1	2	2
26.03	2	0	2	2	16.00	0	0	0	2
25.61	2	0	1	2	16.06	0	0	0	0
25.19	2	0	2	0	17.27	0	1	0	2
25.14	1	1	1	0	17.48	1	0	0	2
24.86	1	0	2	0	17.62	0	2	1	0
24.68	2	1	1	0	17.84	0	2	1	2
24.46	1	0	1	0	17.95	2	0	0	0
24.27	2	1	2	0	18.41	0	2	0	0
24.25	2	1	1	2	18.53	0	0	2	2
24.18	2	2	2	0	18.61	1	1	2	2

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

Major responses to MOP and SOA are continuing. Little overall response to Kieserite or TSP has been identified, although there are various significant interactions, and also evidence of a minor quadratic response to Kieserite. The NxP and KxP interactions in Table 50 indicate a response to TSP in the absence of SOA or MOP, which is lost when SOA or MOP are applied.

Application of a combination of SOA and MOP is now necessary for high yield (see Tables 50 and 56). Although response to either fertilizer on its own is limited, the combination of level 1 of SOA and MOP was one of the highest yielding treatments in 1988.

Application of Kieserite or TSP in addition to MOP and SOA has a relatively minor effect, and interactions are such that this may be positive or negative. Table 52 indicates that the correct fertilizer balance is vital, and even high rates of MOP or SOA either alone or in certain combinations can result in very poor yields.

Figure 38 gives iso-yield contours for the period 1986-88 for all SOA and MOP combinations, predicted in the absence of TSP or Kieserite. This indicates that a combination approximating to 3.5kg of MOP plus 2.5kg of SOA approached the economically optimum yield. Application of both fertilizers is essential, even at low rates, to obtain an efficient response.

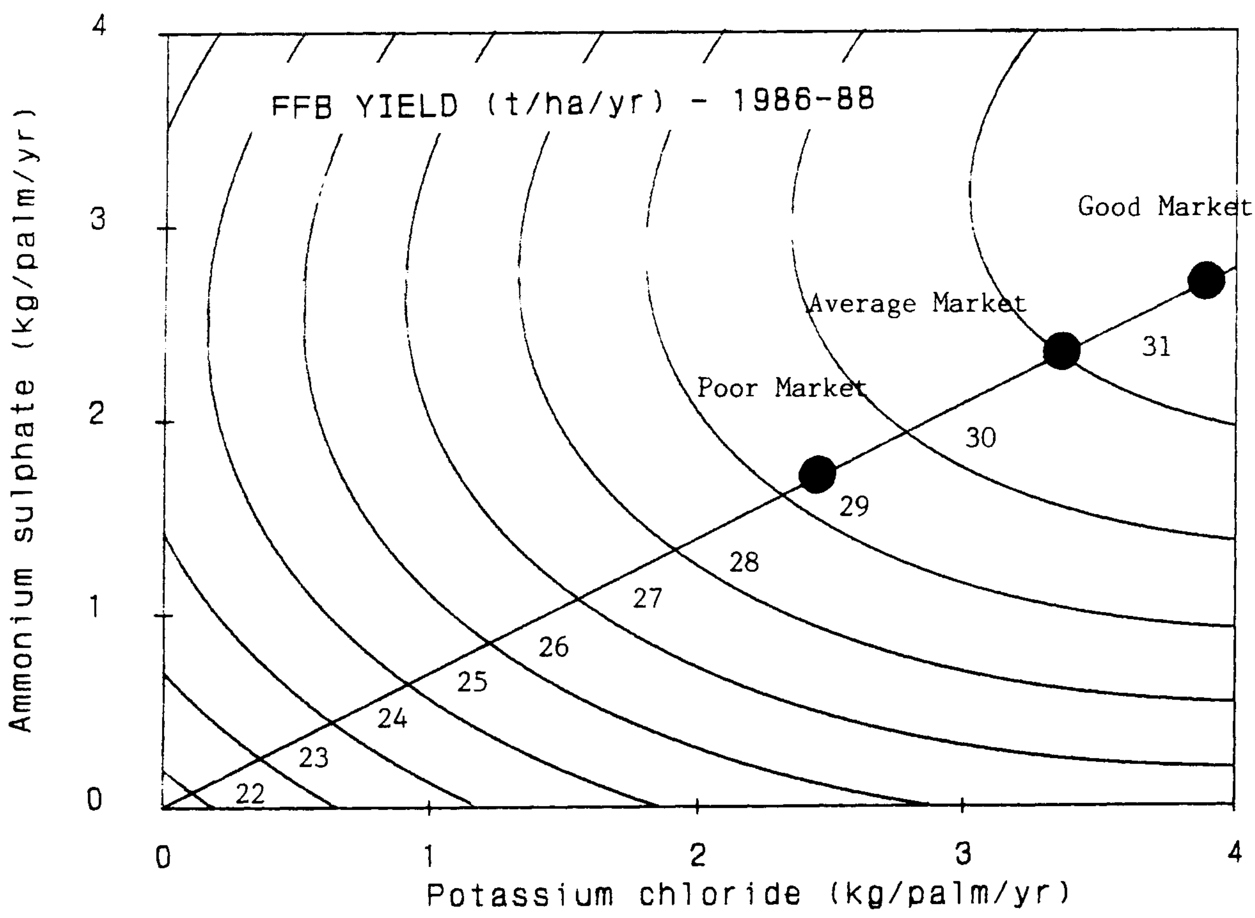


Fig.38: Trial 306, Iso-yield contour map for the period 1986-88 (Most profitable fertilizer combinations indicated for different market conditions)

2. Growth

Table 53 indicates the components of production in 305 for 1987 and 1988.

Table 53: Trial 306, Palm growth and conversion data for 1987 and 1988

TRTMNT	Height in m (1988)	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)
N 0	**3.78**	**23.5**	**3.55**	**11.9**	**18.0**	**15.3**	**33.2**	0.539
N 1	**3.98**	**24.6**	**3.86**	**13.6**	**20.5**	**17.4**	**37.9**	0.541
N 2	**4.09**	**24.8**	**3.92**	**13.9**	**21.1**	**17.8**	**38.9**	0.541
P 0	3.99	24.4	3.85	13.5	19.6	17.2	36.8	**0.531**
P 1	3.95	24.2	3.71	12.9	19.7	16.5	36.2	**0.543**
P 2	3.92	24.2	3.77	13.1	20.3	16.8	37.0	**0.547**
K 0	**3.82**	24.3	**3.64**	**12.7**	**18.3**	**16.2**	**34.5**	**0.530**
K 1	**4.01**	24.1	**3.81**	**13.2**	**20.8**	**16.9**	**37.8**	**0.551**
K 2	**4.03**	24.4	**3.88**	**13.6**	**20.4**	**17.4**	**37.8**	**0.540**
Mg 0	3.95	24.2	3.70	12.8	19.5	16.4	35.9	0.542
Mg 1	4.00	24.4	3.83	13.4	20.5	17.2	37.7	0.543
Mg 2	3.90	24.3	3.81	13.2	19.5	16.9	36.4	0.535
lsd	14.82	0.35	0.18	0.71	1.05	0.84	1.62	0.013
s.d.	27.23	0.65	0.34	1.31	1.93	1.54	2.97	0.023
c.v.	7	3	9	10	10	9	8	4

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

Palm height continues to be significantly increased by SOA, and to a leser extent MOP. SOA has also particularly raised frond dry matter production, both through increased frond production, and increased individual frond weights. In view of the spacing of 143/ha at Ambogo, it is necessary to avoid excessive N applications, which would result in undue competition and excessive height increment, to the detriment of yield.

MOP also has a minor effect on total frond dry matter, through an increase in individual frond weights.

SOA has increased total dry matter production, with proportional increases in both vegetative dm production, and bunch dm production.It has thus not affected the bunch index. MOP has particularly improved partition of assimilates to bunch production, resulting in a significant improvement in the bunch index. TSP has also improved the bunch index.

3. Nutrient analysis

The most recent plant analyses are given in Tables 54 and 55.

Table 54: Trial 306, Frond 17 Rachis Analysis: 1988

	%N	%P	%K	%Mg	%Ca	%Cl	%S
N0	**.23**	**.182**	1.54	.107	.390	.61	.032
N1	**.25**	**.133**	1.54	.100	.396	.59	.033
N2	**.26**	**.094**	1.54	.097	.391	.63	.034
P0	.24	.132	1.57	.100	.389	.61	**.036**
P1	.25	.135	1.53	.103	.407	.62	**.033**
P2	.25	.142	1.51	.101	.380	.61	**.031**
K0	.24	**.103**	**1.16**	**.090**	**.335**	**.08**	.034
K1	.25	**.151**	**1.67**	**.107**	**.418**	**.70**	.034
K2	.25	**.155**	**1.78**	**.106**	**.424**	**1.05**	.032
Mg0	.25	.129	1.48	**.096**	.379	.56	.033
Mg1	.25	.139	1.57	**.099**	.400	.67	.034
Mg2	.25	.140	1.57	**1.10**	.398	.60	.033
LSD	(.01)	(.016)	(0.13)	(.011)	(.041)	(.14)	(.005)

The recent rachis analyses give a fuller picture of nutrient uptake and levels within the palm, sometimes diametrically opposed to values in the leaflets. In particular MOP boosts rachis K, Ca, P, Mg and Cl, whilst only Cl rises in the leaflet, and Mg and K actually fall. SOA has raised leaflet P levels, whilst reducing rachis levels. Such effects may indicate reasons for the absence of response to TSP and Kieserite in the presence of MOP and SOA.

Table 55: Leaf analysis related to fertilizer treatments 1987

	N0	N1	N2	P0	P1	P2	K0	K1	K2	Mg0	Mg1	Mg2	LSD.05	C.V.(%)
N%	**2.22**	**2.32**	**2.33**	2.32	2.25	2.30	**2.23**	**2.29**	**2.35**	2.29	2.28	2.3	0.089	7
	100	105	105	100	97	99	100	103	105	100	100	100		
P%	**0.146**	**0.15**	**0.15**	0.149	0.148	0.15	0.149	0.148	0.15	0.15	0.149	0.148	0.003	4
	100	103	103	100	99	101	100	99	101	100	99	99		
K%	0.823	0.846	0.823	0.83	0.831	0.829	**0.879**	**0.805**	**0.806**	0.831	0.828	0.831	0.036	8
	100	103	100	100	100	100	100	92	92	100	100	100		
Cl%	0.339	0.34	0.357	0.334	0.342	0.35	**0.115**	**0.439**	**0.481**	**0.313**	**0.366**	**0.357**	0.044	23
	100	100	105	100	102	105	100	382	418	100	117	114		
S%	**0.167**	**0.173**	**0.177**	0.171	0.173	0.172	0.173	0.171	0.172	0.173	0.173	0.17	0.005	6
	100	104	106	100	101	101	100	99	99	100	100	98		
Ca%	0.754	0.763	0.755	0.749	0.762	0.761	0.753	0.762	0.757	0.746	0.767	0.759	0.033	8
	100	101	100	100	102	102	100	101	101	100	103	102		
Mg%	**0.275**	**0.256**	**0.259**	0.262	0.269	0.26	**0.289**	**0.254**	**0.247**	**0.259**	**0.258**	**0.274**	0.014	10
	100	93	94	100	103	99	100	88	85	100	100	106		

4. Fruitset

During 1988 the fruitset in high and low fertilizer plots was monitored. Despite marked yield differences, fruitset on both high and low fertilizer plots has been remarkably similar, following similar seasonal variations: see Figure 39.

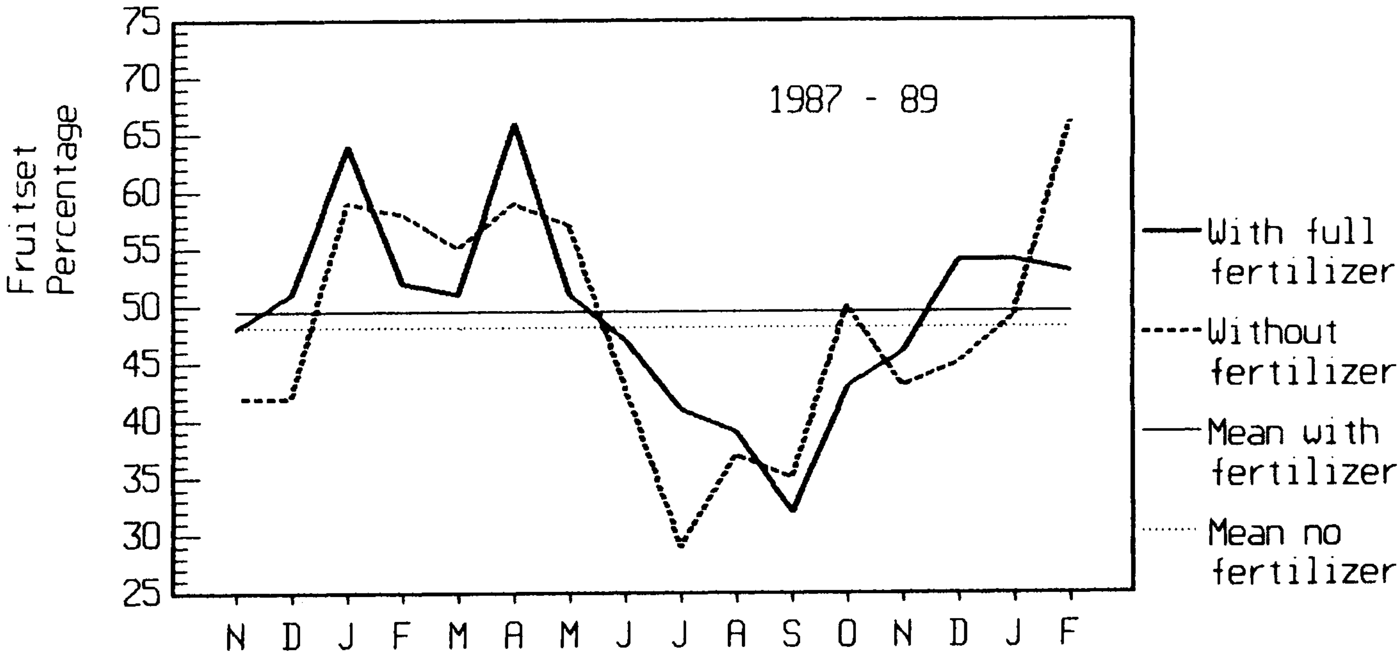


Figure 39: Fruitset related to Fertilizer Treatment

Summary :

The previous exceptional yields in trial 306 have fallen substantially during 1988 to the 15-26 t/ha range.

Application of a combination of SOA and MOP is now necessary for high yield.

Over the period 1986-88 a combination approximating to 3.5kg of MOP plus 2.5kg of SOA approached the economically optimum yield. Application of both fertilizers is essential to obtain an efficient response.

During 1988 fruitset was compared between high and low fertilizer plots on trial 306. Despite marked yield differences, fruitset in both high and low fertilizer plots was remarkably similar, indicating that a direct major nutrient influence can be discounted.

Table 56: Progressive changes in yield and nutrient status

Treatment		83	84	85	86	87	88
N0K0	Yield		26.1	30.3	23.2	14.4	15.7
	N%	2.8	2.8	2.6	2.4	2.3	
	K%	1.2	1.22	1.13	1.01	0.77	
	P%	0.18	0.18	0.17	0.15	0.14	
	Cl%	0.23	0.1	0.09	0.05	0.04	
N1K0	Yield		23.7	38.0	32.9	27.7	19.4
	N%	2.6	2.7	2.9	2.5	1.9	
	K%	1.2	1.07	1.02	1.06	0.81	
	P%	0.16	0.18	0.18	0.16	0.16	
	Cl%	0.21	0.09	0.1	0.09	0.04	
N0K1	Yield		21.4	33.7	31.4	22.5	16.7
	N%	2.7	2.8	2.7	2.6	2.2	
	K%	1.2	1.13	0.98	0.87	0.79	
	P%	0.16	0.17	0.17	0.14	0.14	
	Cl%	0.31	0.36	0.56	0.46	0.48	
N1K1	Yield		29.9	33.1	33.6	31.3	22.6
	N%	2.7	2.8	2.6	2.7	2.5	
	K%	1.1	1.05	0.97	0.89	0.78	
	P%	0.16	0.17	0.17	0.15	0.15	
	Cl%	0.32	0.47	0.47	0.47	0.44	

TRIAL 309, EMPTY BUNCH APPLICATION TRIAL, AMBOGO/ TRIAL 309 (b), SOURCES OF POTASSIUM TRIAL, AMBOGO

309 - Original Trial

Experimental Details:

Purpose: To provide an indication of the effect of EFB application, in comparison to an unfertilized control.

Statistical design: Trial 309 is a randomised complete block design, with five replicates of 5 plots, comprising 4 treatments (2 controls per replicate).

Layout: The plots consist of a core of 16 recorded palms, surrounded by a guard row, making a total of 36 palms per plot.

Trial details :

Location: Ambogo Estate HOPPL, block 80H.
Genetic material: Dami commercial DxP crosses.
Soils: Penderetta family - 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.
Spacing: 143 points ha.
Size: The trial comprises 25 plots: 900 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

Treatment details :

Trial commencement: 1984.
Trial progress: Converted to Trial 309(b) in 1988.
Treatments: A single application of empty bunches was made between September and December 1984.

Treatment codes:	1 & 2	3	4	5
Empty bunch t/ha 11/84	0	50	100	100
SOA kg/palm 11/84	0	0	0	1

309 (b) Details of changes:

Experimental Details :

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.

Statistical design: Trial 309 is a latin square design, with 5 treatments, each occuring once on each previous treatment, and once on each previous block.

Trial details : As for 309 above .

Treatment details :
Trial commencement: 1984.
Trial progress: Converted to Trial 309(b) in January 1988.
Treatment application: January 1988 and then every 6 months.

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 will raise overall yield levels.

At this stage the new treatments are not expected to be significantly influencing yields, but full analysis has been completed for both the original and the superimposed treatments. The results are reported in 2 separate sections.

2. 309 (a) :

As indicated in Table 57 yield in 309 has fallen dramatically on all plots during 1987 and 88. The 1985 mean yield was 29.5 t/ha which had declined to 9.7 t/ha in 1988. This demonstrates the susceptibility of Ambogo and Penderetta family soils to rapid declines in yield if nutritional problems occur. Examination of leaf data (Table 58) indicates that the major yield decline was occasioned when leaf N% fell below 2.5%.

With the decline in yield, error variation in the trial has increased due to the proportionally greater effects of local soil variation. In spite of this there remained a significant difference between plots with EFB application and those without during 1988.

In yield terms the advantage was a 33% increase in comparison to the control plots, bringing the cumulative yield advantage for the average EFB treatment to 17 t/ha between 1985 and 1988.

The 1984 EFB application, although still providing some benefit, is now quite inadequate for satisfactory yields without further supplementation.

Table 57: Yield data for trial 309

Treatment	S Bunch wt Mean 1988	Bunches/ha Mean 1988	Yield tonnes/ha Mean 1988	Mean 1987	Mean 1986	Mean 1985	Mean 85-88
Control	8.43	954	8.1	**16.00**	**25.45**	**27.02**	**19.1**
50 t/ha	9.67	1099	10.8	**19.37**	**29.53**	**31.30**	**22.8**
100 t/ha	9.39	1117	10.7	**20.83**	**30.11**	**30.02**	**22.9**
100 + SOA	10.02	1078	10.9	**23.42**	**32.25**	**31.92**	**24.6**
(b)							
Control	9.01	1069	9.8				
BA	9.03	992	9.1				
MOP	9.45	1074	10.3				
-SOA	9.27	1014	9.6				
+SOA	9.20	1053	9.8				
gm	9.19	1040	9.7				21.7
sd	1.47	213	3.12	2.55	2.87	3.29	2.81
lsd	1.44	210	3.07	3.42	3.85	4.41	3.66
cv	16	20	32				13

Note:
(1) Data presented exclusively for 309 (a) is based upon the original analysis of variance to facilitate comparisons

Table 58: Progressive changes in yield and nutrient status

Control		84	85	86	87	88	AVG
	Yield		27.02	25.45	16.00	8.10	19.14
	N%	2.56	2.66	2.48	1.93	1.88	2.30
	P%	0.18	0.17	0.16	0.15	0.14	0.16
	K%	0.88	0.91	0.83	0.86	0.62	0.82
	Mg%	0.33	0.29	0.32	0.36	0.34	0.33
	Ca%	0.92	0.84	0.87	0.90	0.88	0.88
	S%	0.17	0.17	0.17	0.13	0.15	0.16
	Cl%	0.34	0.22	0.20	0.19	0.20	0.23
EFB		84	85	86	87	88	AVG
	Yield		31.05	30.63	21.21	10.80	23.42
	N%	2.59	2.81	2.57	2.18	1.97	2.42
	P%	0.18	0.17	0.16	0.15	0.14	0.16
	K%	0.90	1.06	0.93	0.97	0.70	0.91
	Mg%	0.33	0.25	0.29	0.32	0.29	0.30
	Ca%	0.91	0.79	0.85	0.88	0.85	0.86
	S%	0.17	0.18	0.18	0.13	0.15	0.16
	Cl%	0.35	0.28	0.24	0.22	0.23	0.26

With the depressed yields and nutritional levels currently pertaining, it will be of interest to observe the extent to which recovery can be achieved, and the length of time taken. This will be useful in guiding policy for rehabilitation of smallholdings.

At present 309 is also proving a most valuable trial for demonstration to visiting smallholders of the dangers of inadequate fertilization, and the benefits of N and K fertilizing.

For other components of yield (see Table 59) EFB has led to significant increases in frond number and frond dry matter production. It has also led to slightly greater values for palm height and bunch index (not statistically significant in 1988).

For comparison the 1988 total dry matter production was only about 50% of that for trial 306, and the bunch index was also poorer, resulting in a ffb yield of less than half. The difference is likely to be due to shortage of N limiting dm production.

Table 59: Trial 309 Palm Growth and Conversion data for 1988

TRTMNT	Height in m (1988)	Leaf prdn (n)	Dry Frond weight kg (FW)	Frond DM tha (FDM)	Bunch* DM tha (BDM)	Veg. DM tha (VDM)	Total* DM tha (TDM)	Bunch* Index (BI)
(a)								
Control	2.10	**21.8**	**2.14**	**6.7**	**6.6**	8.1	**14.8**	.444
50t EFB	2.23	**23.0**	**2.29**	**7.5**	**8.6**	9.4	**18.2**	.480
100t EFB	2.34	**22.9**	**2.35**	**7.7**	**8.8**	9.5	**18.3**	.471
100t + N	2.28	**22.4**	**2.38**	**7.6**	**9.0**	9.5	**18.4**	.477
(b)								
Control	2.23	**21.1**	2.33	7.1	8.0	8.7	16.8	.466
MOP	2.29	**21.7**	2.32	7.2	8.3	8.9	17.2	.472
BA	2.14	**21.5**	2.23	6.9	7.5	8.5	16.0	.454
MOP+SOA	2.18	**23.7**	2.32	7.9	8.6	9.7	18.3	.465
BA+SOA	2.22	**23.9**	2.10	7.2	7.4	8.8	16.2	.457
gm	2.21	22.39	2.26	7.24	7.97	8.9	16.9	.463
lsd	0.42	1.2	0.25	1.14	3.73	1.62	5.22	.085
s.d.	0.29	0.86	0.17	0.78	2.56	1.11	3.59	.059
c.v.	13	4	8	11	32	12	21	13

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

The ongoing EFB effects in 1988 were also reflected in significantly higher leaf and rachis levels of K, and reduced leaf and rachis levels of Mg. N levels were also higher, but not at a statistically significant level.

Summary :

Yield in 309 has fallen dramatically on all plots to a mean value of 9.7 t/ha in 1988. This demonstrates the susceptibility of Ambogo and Penderetta family soils to rapid declines in yield if nutritional problems occur.

In particular the decline is likely to be due to shortage of N, limiting dm production: for comparison the 1988 total dry matter production was only about 50% of that for trial 306.

In spite of this there remained a significant yield increase of 33% on plots with EFB. The 1984 EFB application, although still providing some benefit, is now quite inadequate for satisfactory yields without further supplementation.

The ongoing EFB effects in 1988 were also reflected in significantly higher leaf and rachis levels of K, and reduced leaf and rachis levels of Mg. N levels were also higher, but not at a statistically significant level.

3. 309 (b) :

The new fertilizer treatments commenced on 20th January 1988, and the leaf and rachis samples were taken after a relatively short period on 9th May 1988 (details in Tables 60 and 61). This is insufficient time for full treatment effects to become clear in the palm. The initial changes observed were an increase in N and Slevels occasioned by SOA application, and a marginal rise in Cl levels on plots receiving MOP.

Although fertilizer treatments take some time to effect significant production responses, application of SOA did produce a significant increase in leaf production during 1988.

Careful inspection of the data will show poorer yields being achieved with bunch ash application. This is not currently a treatment effect, but the result of random allocation of poorer plots to this treatment, since factors such as bunch number which were determined prior to treatment application fully reflect the poor performance of these plots.

Table 60: Trial 309, Leaf analysis : 1988

TREATMENT:	0	BA	MOP	-SOA	+SOA		0	50t	100t	100+M	gm	lsd	sd	cv
N%	1.78	1.94	2.01	1.89	2.06		1.88	1.98	1.98	1.96	1.94	0.151	0.153	8
%	100	109	113	106	116		100	105	105	104				
P%	0.13	0.139	0.141	0.138	0.142		0.135	0.14	0.142	0.138	0.138	0.009	0.009	7
%	100	107	108	106	109		100	104	105	102				
K%	0.666	0.649	0.684	0.651	0.682		0.623	0.676	0.708	0.702	0.666	0.086	0.087	13
%	100	97	103	98	102		100	109	114	113				
Mg%	0.29	0.314	0.314	0.325	0.303		0.336	0.29	0.288	0.296	0.309	0.046	0.047	15
%	100	108	108	112	104		100	86	86	88				
Ca%	0.854	0.863	0.868	0.875	0.856	(1)	0.881	0.848	0.86	0.846	0.366	0.054	0.039	11
%	100	101	102	102	100		100	96	98	96				
S%	0.134	0.155	0.152	0.145	0.162		0.148	0.152	0.152	0.148	0.150	0.01	0.01	7
%	100	116	113	108	121		100	103	103	100				
Cl%	0.198	0.206	0.238 (*)	0.219	0.225		0.203	0.222	0.24	0.218	0.217	0.034	0.035	16
%	100	104	120	111	114		100	109	118	107				

Note:
(1) Significant interaction between N and K sources for Ca levels:

Mean	MOP	BA
-SOA	0.898	0.852
+SOA	0.838	0.874

Table 61: Rachis analysis related to fertilizer treatments:1988

	0	BA	MOP	-SOA	+SOA	0	50t	100t	100+M		gm	lsd	sd	cv
K%	0.7	0.691	0.845	0.767	0.769	0.649	0.798	0.772	0.904		0.754	0.2	0.2	26
%	100	99	121	110	110	100	123	119	139					
Mg%	0.092	0.101	0.095	0.103	0.093	0.12	0.082	0.08	0.082		0.097	0.026	0.026	27
%	100	110	103	112	101	100	68	67	68					
Ca%	0.36	0.374	0.361	0.368	0.367	0.374	0.358	0.334	0.39	(2)	0.366	0.038	0.039	11
%	100	104	100	102	102	100	96	89	104					

Summary:

SOA significantly increased leaf production in 1988.

TRIAL 310, ANION AND FERTILIZER FREQUENCY TRIAL, AMBOGO

Experimental Details :

Statistical design: 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.

Trial details :

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

Treatment details :

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

Treatment code	Fertilizer	Kg/palm/yr	Applications/yr
1	None	0.0	0
2	Sulphate source	2.0	2
3	Chloride source	1.5	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 during 1988 :

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

2. The trial area has never received any nitrogen, and supplementation to maintain reasonable yields was therefore considered necessary. An initial application of urea at 600 gm/palm was undertaken on 22/12/88 and it is intended that applications will be continued twice a year.

2. Rachis analysis has been commenced in order to more fully identify fertilizer effects upon the palms.

Results :

1. Performance:

Since the trial was only commenced in November 1986, significant yield effects cannot yet be expected. The 1988 data has been summarised in Tables 62 and 63. The general trends indicate that a response to K is developing, although it is not statistically significant at this stage.

Table 62: Trial 310 yield data

TRTMNT	1988 Wt of bunches t/ha	1988 No of bunche /ha	1988 s.b.w. kg
Control	22.5	1344	11.2
-K	21.8	1292	11.4
+K	23.3	1369	12.2
Cl	22.4	1289	11.8
S	22.8	1372	11.8
1x	23.6	1331	12.0
2x	24.8	1406	12.4
lsd K	3.03	168	1.021
lsd Cl,S	2.85	159	0.963
lsd 1,2	3.46	192	1.167
c.v.	17	16	11

(1x, 2x = Frequency of K fertilizer application - total annual amount remaining the same)

Table 63: Trial 310 Palm Growth and Conversion data for 1988

TRTMNT	Height in m	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	3.69	23.4	3.28	10.96	18.5	14.22	32.7	0.562
-K	3.63	23.7	3.34	11.33	17.9	14.6	32.5	0.548
+K	3.68	23.6	3.42	11.54	19.1	14.9	34	0.557
Cl	3.61	23.8	3.38	11.52	18.3	14.8	33.2	0.551
S	3.7	23.5	3.37	11.35	18.7	14.7	33.3	0.555
1x	3.66	23.7	3.39	11.5	19.1	14.9	34	0.560
2x	3.7	23.8	3.44	11.57	19.1	15	34	0.555
lsd K	0.205	0.462	0.139	0.494	2.48	0.735	3.09	0.026
lsd Cl,S	0.193	0.436	0.131	0.466	2.34	0.693	2.91	0.024
lsd 1,2	0.237	0.534	0.161	0.565	2.84	0.84	3.53	0.029
c.v.	7	2	5	5	17	6	12	6

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

During 1987, Mg based salts recorded higher yields than the K based salts. During 1988 the situation has been reversed, with the K fertilizers outyielding the same ions supplied by the non-K fertilizers. For almost every parameter, including bunch weight, bunch number, bunch dry matter, frond weight, vegetative dry matter production and bunch index, the K source fertilizers have an advantage of up to 7%.

The K effect is further substantiated by a constant trend for marginally higher yields with the twice a year application of potassium fertilizers than the once a year application.

In comparing results for the sulphate and chloride anions, there is at present no clear trend emerging, and results for both are virtually identical.

The present K effect in this trial (see Table 63) has a similar impact on palm development to that of MOP application in trial 306, indicating that there are grounds for attributing at least a part of the MOP effect on 306 to K rather than Cl.

2. Plant Analysis.

Rachis analysis commenced during 1988 and results of samples collected in March are shown in Table 64.

Table 64: Trial 310, Rachis analysis related to fertilizer treatments: March 1988

	Control	-K	+K	S	Cl	lsd K	lsd S,Cl	sd	cv
K%	0.9	0.928	1.002	0.963	0.968	0.091	0.086	0.12	12
%	100	103	111	107	108				
Ca%	0.31	0.396	0.397	0.372	0.421	0.042	0.04	0.053	14
%	100	128	128	120	136				
Mg	.05	.069	.067	.061	.075	0.0091	0.0086	.0114	18
%	100	138	134	122	150				

Leaf data shown in Table 65 indicates a depression of K levels through MOP application, which is opposite to the effect in the rachis (Table 64). Overrall MOP would appear to raise plant K levels.

Table 65: Trial 310, Leaf analysis related to fertilizer treatments: March 1988

	Control	-K	+K	S	Cl	lsd K	lsd S,Cl	sd	cv
N%	2.3	2.34	2.34	2.4	2.28	0.086	0.081	0.108	5
%	100	102	102	104	99				
P%	0.15	0.155	0.154	0.155	0.154	0.005	0.004	0.006	4
%	100	103	103	103	103				
K%	**0.844**	**0.803**	**0.796**	**0.818**	**0.781**	0.033	0.031	0.041	5
%	**100**	**95**	**94**	**97**	**93**				
Ca%	0.85	0.859	0.858	0.849	0.868	0.05	0.047	0.063	7
%	100	101	101	100	102				
Mg%	0.25	0.263	0.256	0.259	0.261	0.02	0.019	0.025	10
%	100	105	102	104	104				
S%	0.164	0.165	0.169	**0.172**	**0.162**	0.006	0.006	0.008	5
%	100	101	103	**105**	**99**				
Cl%	**0.148**	**0.246**	**0.278**	**0.165**	**0.359**	0.017	0.016	0.022	9
%	**100**	**166**	**188**	**111**	**243**				

In summary, the K component raised rachis K levels, to the point where levels are actually higher than in the leaf, but had only a minor effect on other cations in the rachis, which are at 30-50% of the leaf levels. Leaf nutrient levels were unaffected by K.

Anion application resulted in substantially raised cation levels in the rachis, with increases in Mg (50%), Ca (36%) and K (8%). The increase with sulphate was generally half that found with chloride.

Chloride application lead to a general and substantial increase (of several hundred percent) in chloride levels, but depressed the K content of the leaf (by 7%). Sulphate application resulted in an increase in the leaf S levels (by 5%) and a depression of K content approximately half that occasioned by chloride.

Summary :

Initial indications point to a response to K, which is correlated with rachis K levels, rather than leaf K levels.

Table 66: Trial 310, Progressive changes in yield and nutrient status

		87	88	AVG
Control		87	88	AVG
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

Experimental Details:

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.

Statistical details: 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 details :

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

Treatment details :

Trial commencement: April 1988.
Trial progress: Ongoing.
Treatments in kg/palm/year:

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

2) EFB

EFB0 receives no EFB.
EFB 1 receives EFB.

The EFB was applied by hand between 5th and 24th November 1988 at a rate of 333 kg (fresh ex-mill weight) per treated palm, as a mulch between palm circles. It is intended to repeat applications at 16 month intervals, to achieve an effective rate of 250 kg/palm/year. At 130 palms/ha, this equates to 32.5 t/ha/yr.

Modifications during 1988 :

1. Originally the trial was set up with N and K fertilizers only, with a dummy treatment incorporated. With increasing interest in EFB application, and requirement for an EFB trial, EFB treatment was incorporated in order to identify fertilizer interactions with EFB, so as to provide more accurate recommendations in the future.

Results :

Composite 0-20 cm soil samples and frond 17 leaf samples were collected from each plot and average results for the two blocks are shown in Table 67.

Table 67: Summary of 0-20 cm soil status at commencement of trial - Block means 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

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

Experimental Details

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.

Statistical details: 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 details :

Location: Ambogo Estate HOPPL, block 80.E.2.
Genetic material: Dami commercial DxP crosses.
Soils: Ambogo family, which is of recent alluvially reworked volcanic origin, with silty loam topsoil and sandy loam sub soil, with seasonally high water tables.
Planting dated: 1980.
Spacing: 143 points ha.
Size: The trial comprises 32 plots: 1150 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

Treatment details :

Trial commencement: April 1988.
Trial progress: Ongoing.
Treatments in kg/palm/year

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

2) EFB

EFB0 receives no EFB.
EFB 1 receives EFB.

The EFB was applied by hand between 29th November and 15th December 1988 at a rate of 333 kg (fresh ex-mill weight) per treated palm, as a mulch between palm circles. It is intended to repeat applications at 16 month intervals, to achieve an effective rate of 250 kg/palm/year. At 143 palms/ha, this equates to 35.75 t/ha/yr.

Modifications during 1988 :

1. Originally the trial was set up with N and K fertilizers only, with a dummy treatment incorporated. With increasing interest in EFB application, and requirement for an EFB trial, EFB treatment was incorporated in order to identify fertilizer interactions with EFB, so as to provide more accurate recommenedations in the future.

Results :

Table 68 indicates the background data for the site at the commencement of the trial.

Table 68: Summary of status at commencement of trial 312 - Block means 1988

	LEAF							RACHIS	April 88	
	N%	P%	K%	S%	Ca%	Mg%	Cl%	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

TRIAL 313, MISSING NUTRIENT SOIL POT TRIAL SERIES

In order to assess potential major and minor nutrient deficiencies on largely unassessed soils from areas of supporting estates, either currently planted to oil palm, or with future planting potential, implementation of missing nutrient pot trials was recommended at the 1987 Scientific Advisory Board Meeting.

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

Soil origin details:

1. Sagarai oil palm nursery area. 0 - 15 cms.
2. Gili Gili (corranous area). 0 - 15 cms.
3. Gili Gili (corranous area). 15 - 30 cms.
4. West Waigani, ex forest. 0 - 15 cms.
5. West Waigani, ex plantation. 0 - 15 cms.
6. Mamba lower terrace. 0 - 15 cms.
7. Mamba upper terrace. 0 - 15 cms.
8. Mamba river terrace. 0 - 15 cms.

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 69, and details for each individual trial are reported separately.

Table 69: 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

Experimental 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.

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.

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 shown (Table b).

Table 70: 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 71: 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

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.

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.

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 shown (Table 72).

Table 72: 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 73: 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

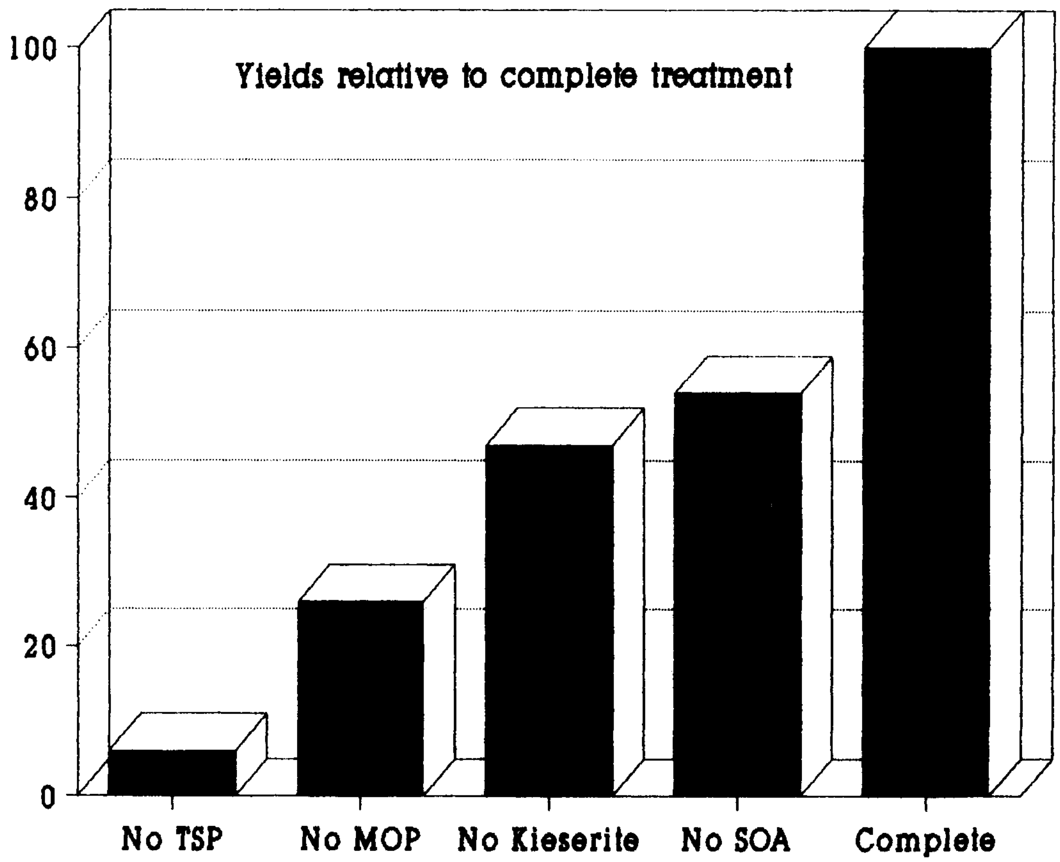


Figure 40: Relative Yields for Trial 313(b)

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.

<u>Trial 313 (c) Oil Palm Trace Element Trial</u>

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.

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.

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 74).

Table 74: 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 :

Table 75: First leaf count for Oil Palm with TE nutrient Applications

TABLE OF MEANS: leaves/plant

		FERTILIZER TREATMENTS							
		A	B	C	D	E	F	G	Average
SOILS	6	5.71	6.00	5.57	5.71	6.14	6.14	6.00	5.90
	7	5.86	5.71	6.00	6.00	5.71	5.86	5.57	5.82
	8	6.14	5.86	5.57	5.86	6.43	6.57	5.86	6.04
Average:		5.90	5.86	5.71	5.86	6.10	6.19	5.81	5.92

COMPARISONS

	sd	cv	lsd
Soil<>Soil	0.699	12	0.311
Fert <> Fert	0.756	13	0.466
Fert <> Fert (1 soil)			0.808
Fert <> Fert (2 soils)			0.800
Soil<>Soil (1 or 2 ferts)			0.800

The initial results are based on the first leaf count taken on 21/12/88. Although the oil palm is far slower to express nutrient effects than maize, the initial results do indicate certain trends, and are particularly valuable in indicating the extent to which the maize results can legitimately be extrapolated to oil palm.

In general the results obtained on the maize do appear to be borne out, but oil palm had not responded so markedly to soil differences, and in some cases has indicated a different ranking for the soils.

In considering soil differences it should also be borne in mind that the water holding capacity of the soil may unduly influence results in a pot trial, where water stress may develop rapidly. This might not be extrapolated to field conditions, where a free draining soil might actually be beneficial rather than harmful.

At this stage the oil palm on the 3 Mamba soils have not developed any overall significant differences, and there is no identification of any overall difference between the 3 Mamba soils.

Examination of the results in detail does generally confirm the TE results obtained with maize. On the LT and RT soils omission of Mn appeared beneficial for both maize and oil palm (indicating excessive Mn availability from the soil). Opposing results however arose for Zn, which appeared beneficial on maize but harmful on oil palm. However, with the relatively higher rates applied to the oil palm due to the longer duration of the trial it is possible that deficiency may easily have shifted to toxicity, which could explain apparently contradictory effects.

For the UT soil omission of Cu gave higher production with both maize and oil palm.

Thus the results from maize indicating potential Mn toxicity (LT & RT) and Cu toxicity (UT) are confirmed, but the Zn situation is unclear.

Trial 313 (d) Oil Palm Major Nutrient Trial

Experimental Design :

Statistical design: Trial 313(d) 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.

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 comprises 392 experimental plants plus guard rows around the trial.

Treatment details :

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

SOA, TSP, MOP, Kieserite and commercial TE mix were applied in various combinations at fortnightly intervals, with treatment structure as shown (Table 76).

Table 76: 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 :

Table 77: First leaf count for Oil Palm with Major Nutrient Application

TABLE OF MEANS: leaves/plant

		FERTILIZER TREATMENTS							
		A	B	C	D	E	F	G	Average
SOILS	1	6.14	4.43	5.86	6.29	5.71	5.86	5.14	**5.63**
	2	4.57	4.29	6.00	5.00	5.00	4.86	5.29	**5.00**
	3	5.00	4.29	5.29	4.57	4.29	4.14	4.00	**4.51**
	4	6.00	5.43	4.86	5.71	5.86	6.43	4.71	**5.57**
	5	6.43	5.29	5.00	5.57	4.86	5.57	4.86	**5.37**
	6	6.00	5.14	5.29	5.86	6.29	5.14	4.71	**5.49**
	7	5.43	5.00	5.00	4.43	4.43	5.14	4.57	**4.86**
	8	5.43	5.00	4.57	5.00	5.14	4.86	4.71	**4.96**
Average		**5.63**	**4.86**	**5.23**	**5.30**	**5.20**	**5.25**	**4.75**	5.17

COMPARISONS

	sd	cv	lsd
Soil<>Soil	1.26	24	0.509
Fert <> Fert	1.08	21	0.409
Fert <> Fert (1 soil)			1.156
Fert <> Fert (2 soils)			1.185
Soil<>Soil (1 or 2 ferts)			1.185

Initial results are based on the first leaf count taken on 21/12/88. Although the oil palm is far slower to express nutrient effects than maize, the initial results confirm the emergence of highly significant differences, both for soils and fertilizers. These show that the maize results can by and large be extrapolated to the oil palm.

Although there is general agreement between the parallel trials, the oil palm have not responded so markedly to soil differences, and in some cases have indicated a different ranking for the soils. For nutrients also, although there is general confirmation of results, the extent of response has differed in some cases between the 2 crops.

At this stage the soil ranking based upon the oil palm results indicates superior growth on the Sagarai, Waigani ex-forest, Waigani ex-coconut and Mamba LT soils (Sagarai and Waigani ex-forest were also superior for maize growth). The corranous sub-soil (as with maize) produced the poorest growth. Difference between the best and poorest soil at this stage is only 31%, compared with 359% in maize trial 313(a).

Overall the main nutrient effect to be expressed is SOA, with the TE plus all nutrients superior, and the control and SOA omission treatments particularly poor.

For Milne Bay soils, at Sagarai omission of MOP was not harmful, but omission of SOA was. This corresponds with soil analysis indicating the highest extractable K level for any of the Milne Bay soils at Sagarai.

On the corranous soils SOA was necessary, but TSP was not. In addition the corranous sub-soil also indicated particular benefit from Kieserite application and TE inclusion (also confirmed in the maize TE trial).

The ex-forest soil gave poor results without TSP.

For Mamba LT and RT soils omission of TSP was harmful. On the LT soil yield was also depressed in the absence of SOA and of TE. Yield on the UT soil was depressed by treatments omitting MOP or Kieserite.

These preliminary results should be treated with some caution, but in so far as they confirm the maize results they are particularly valuable, and overall indicate several potential nutritional problems for the various soils involved.

Trial 313 (e) Cocoa Major Nutrient Trial

Experimental Design :

Statistical design: Trial 313(e) 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.

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 comprises 147 experimental plants plus guard plants at the edge of the trial.

Treatment details :

Trial commencement: August 1988
First fertilizer application: 26/10/88
Trial progress: Ongoing
Treatments:

SOA, TSP, MOP, Kieserite and commercial TE mix were applied in various combinations at fortnightly intervals, with treatment structure as shown (Table 78).

Table 78: 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:

Not yet available.

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 (e.g. soil, leaf and yield) in order to improve understanding of the basic agronomy for all smallholder areas.

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

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 these 4 plots also receive TSP, and 2 do not.

Layout: 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.

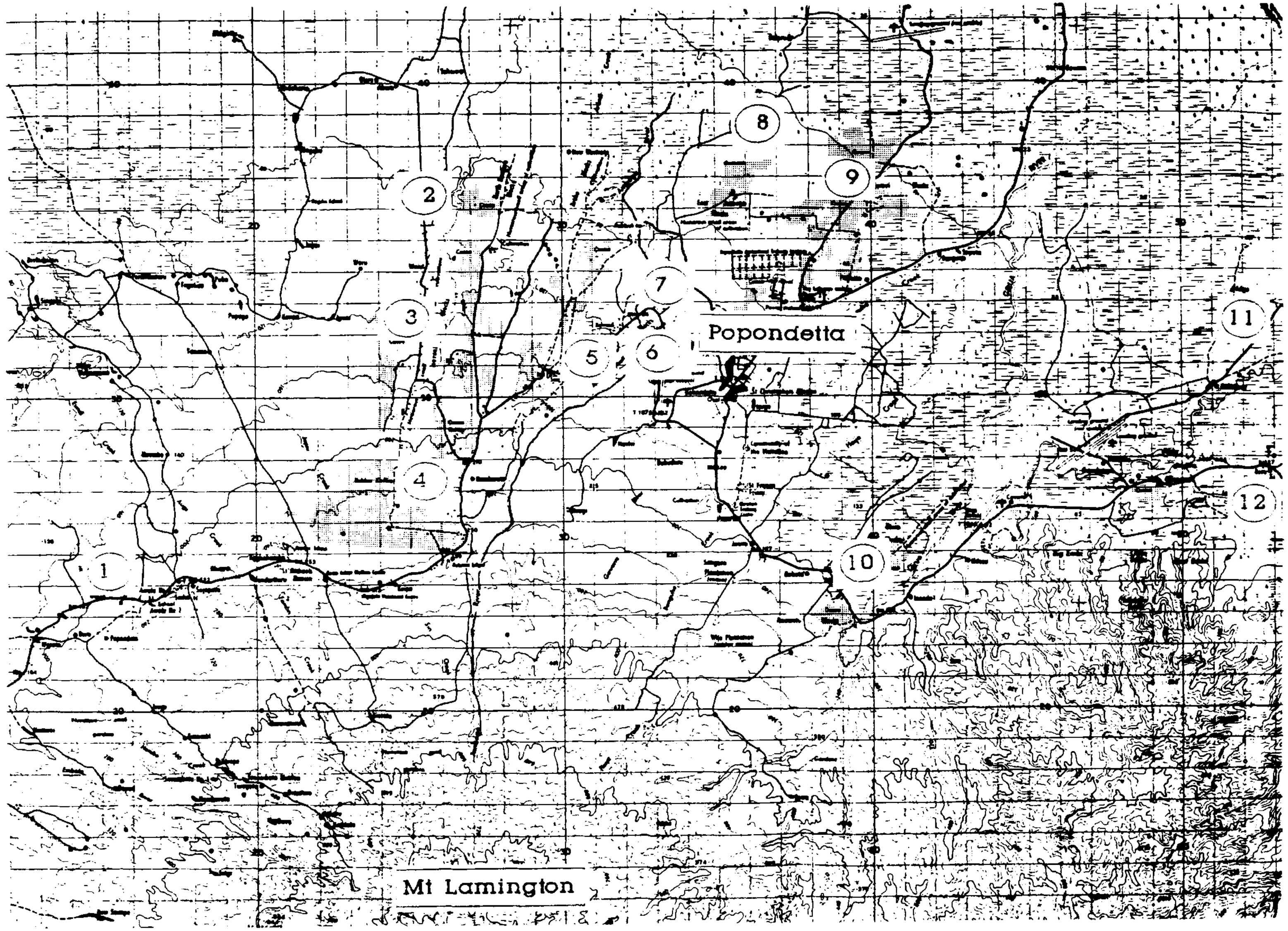
Trial details :

Location: Currently at 14 sites up to 60km apart and throughout the major smallholder oil palm areas of Oro Province. Locations are listed in Table 79 and marked on the map in Fig. 41.

Table 79: Key to smallholder areas map

Location	Area	Block	Map Number
West	Waseta	300029	1
West	Waru	520003	2
West	Isavene	101179	3
West	Igora	111578	4
West	Igora	111611	4
West	E Sangara	050157	5
East	Dobuduru	260002	6
East	E Ambogo	030309	7
East	Ahora	230003	8
East	Sorovi	040232	9
East	Sorovi	121763	9
East	Awowota	220010	10
East	Soputa	250041	11
East	Embi	881111	12

Fig. 41 Location of smallholder demonstrations



Genetic material: Dami commercial DxP crosses.

Soils: Soils generally approximate to those described for the estate trials, with the major divide occuring at the Ambogo river. Further variation may occur, particularly inland, and characterisation has not been completed.

Planting dates: Various.

Spacing: 120 points ha.

Size: The trial presently comprises 14 sites: 13 of 4 ha and 1 of 2 ha - total 54 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.

Trial naming: The trials have been divided into 2 projects:

1) Trial 314 being "Smallholder Demonstration Blocks" i.e. 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.

Treatment details :

Trial commencement: June to December 1988.

Trial progress: Ongoing.

Treatments:

1. The "control" plot receives no fertilizer whatsoever.
2. The "demonstration" plot receives whatever fertilizer is considered most appropriate for the block. This may vary from time to time.

Table 80: Fertilizer rates for demonstration plots: kg/palm 1988

		Location	
		West	East
Fertilizer			
N	SOA	2.5	2.5
K	MOP	1	2

Table 81: Systematic component rates in kg/palm/year

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

Modifications during 1988 :

1. Several modifications have been undertaken at the commencement of the trial, as experience was gained, to ensure that treatments and results are applicable and comparable at all sites.

Application frequency for K fertilizers was originally once a year.This has now been converted to twice a year.

Originally bunch ash was used as the K source. In view of various practical considerations the source has been changed to MOP.

The original systematic application rates were to vary between trials 314 and 315. They have now been unified, at the rates given.

Since the demonstration plot and the perimeter palms at each site receive fertilizer according to the current recommendation for the specific site, rather than any overall fixed rate, flexibility is built into the trial.

Results :

Initial yield and petiole cross-section data is shown in Table 82, whilst initial leaf nutrient and soil data for the different sites are shown in Tables 83 and 84 respectively. The tables indicate available background data for the sites at the commencement of the trial. Samples for the remaining sites are still under analysis.

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.

The initial records confirm the primary division between locations to the west and east of the Ambogo river.

For these 2 areas, soil data confirms lower K supplies to the east, which corresponds with the Ambogo soil where the major response to MOP has been found in the OPRA trials. Throughout both areas leaf N levels vary, and low N levels correspond with low yields.

Greatest site variation occured in the western sector. Both sites in the Waru/Isavene area had low pH (5 - 5.7) high organic matter levels (13.5 - 16.6%) and relatively lower soil Mg, making their conditions different from the rest. Waseta and Waru also had particularly high P retention (77 - 96%).

Table 82: Comparative Smallholder Baseline Performance Yield and petiole cross-section Data 1988

Location	Area	Block	First harvest	Previous fertilizer	Yield	Petiole c.s. D	Petiole c.s. C
West	Waseta	300029	19/7/82	?	17.4	21.94	17
West	Waru	520003	11/9/80	1 kg MOP 1988	7.5	34.66	29.95
West	Isavene	101179	6/5/81	None	12.1	26.14	27.21
West	Igora	111578	21/5/82	?	15.8		
West	Igora	111611	26/2/82	BA 2.5 kg 10/87	18.2	20.9	23.7
West	E Sangara	050157	12/10/82	1 kg SOA 10/88	18.6	24.9	27.44
East	Dobuduru	260002	10/9/82	?	11.1	20.19	19.1
East	E Ambogo	030309	2/9/80	0.5 kg SOA 1988	12	24.52	29.4
East	Ahora	230003	8/7/81	MOP 1kg 4/88	12.5	27.04	
East	Sorovi	040232	30/1/81	BA 2 kg 11/87	7.9	33.44	37.49
East	Sorovi	121763	2/9/82	None	21.8	31.64	31.62
East	Awowota	220010	21/8/81	?	16	30.9	23.12
East	Soputa	250041	3/1/88	SOA 0.4 kg 8/85 MOP 0.8 kg 9/86	7.3 (young)	16.34	10.02
East	Embi	881111	27/8/82	1kg MOP 1987 2 kg SOA 1988	7.3	30.83	25.56

Consideration of Table 82 indicates yields. The majority of the blocks are harvested regularly, so most low yields directly reflect low production. Very few blocks had received any fertilizer prior to 1988, and many of the sites have never been fertilized since bearing commenced.

1988 yields varied from 7.3 t/ha to 21.8 t/ha. Examination of the data indicates that the reason for low production is normally exhaustion of soil nutrients by cropping.

In combination with the information available from other OPRA trials, this indicates a poor outlook for smallholder production in 1989. Depletion of nutrients at many sites, through absence of fertilizer has instituted a decline in yield, ultimately to levels below 8 t/ha. The delayed nature of response to fertilizer by the oil palm means that even if fertilized in 1988, little improvement can be expected before 1990. For older areas with seriously depressed production, replanting would be an effective alternative to rehabilitation.

Table 83: Smallholder Baseline Leaf Data 1988

Location	Area	Block	Plot	Previous fertilizer	Yield	N%	P%	K%	Ca%	Mg%	S%	Cl%
West	Waseta	300029	C	None	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	?	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	Isavene	101179	C	None	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	111611	C	?	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
East	Dobuduru	260002	C	None	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	Ahora	230003	C	MOP 1kg/plm 4/88	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 c 1 kg c 1/88	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	121763	C	None	21.8	2.4	0.141	0.87	0.72	0.23	0.15	0.11
			D			2.6	0.152	0.91	0.76	0.33	0.16	0.17
East	Awovota	220010	C	?	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	Soputa	250041	C	SOA 0.4 kg 8/85	7.3	2.7	0.164	0.88	0.92	0.41	0.17	0.57
			D	MOP 0.8 kg 9/86	(young)	2.8	0.181	0.91	0.97	0.35	0.2	0.41

Summary :

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

Low leaf N levels corresponded with low yields.

There was a distinction between areas west and east of the Ambogo river: soil data confirms lower K supplies to the east, which corresponds with the Ambogo soil where the major response to MOP has been found in the OPRA trials.

With yields as low as 7.3 t/ha there is a poor outlook for smallholder production unless fertilizing is improved.

Table 84: Smallholder Baseline 0-20 cm Soil Data 1988

Location	Area	Block	Plot	Past fertilizer (kg/palm)	Yield	pH	P ppm	Extractable cations m.e./100g K	Ca	Mg	Na	CEC	CEC Percentage Saturation K%	Ca%	Mg%	Na%	O.M. %	P retn. %	Tot. N %
West	Waseta	300029	C	None	17.4	6.0	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	?	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	Isavene	101179	C	None	12.1	5.0	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	0.5	13.5		0.42
West	Igora	111611	C	?	18.2	6.3	3	0.25	7.3	1.3	0.04	13	2.0	58	10.2	0.3	2.9	28	0.20
			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
East	Dobuduru	260002	C	None	11.1	6.2	10	0.07	5.2	0.65	0.03	9	0.7	55	6.9	0.3	4.3	37	0.20
			D			6.4	7	0.07	5.8	0.83	0.05	10	0.7	56	8.0	0.5	4.3	34	0.24
East	Ahora	230003	C	MOP 1kg:4/88	12.5	6.4	29	0.40	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	40232	C	BA 1kg:1/88	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	121763	C	None	21.8	6.2	11	0.09	4.4	0.85	0.03	8	1.1	56	10.9	0.4	2.1	12	0.16
			D			6.4	15	0.13	9.2	2.23	0.05	15	0.9	63	15.2	0.4	3.0	22	0.20
East	Avovota	220010	C	?	16.0	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	Soputa	250041	C	SOA 0.4kg:8/85	7.3	5.9	7	0.19	3.9	0.99	0.05	13	1.5	30	7.6	0.4	6.1	54	0.29
			D	MOP 0.8kg:9/86	(young)	5.9	7	0.21	5.3	1.59	0.07	15	1.4	35	10.5	0.5	7.1	50	0.91

INVESTIGATION 316, Cover Crop and Nitrogen Evaluation

This investigation was undertaken to obtain preliminary data on nitrogen fixation by leguminous cover crops. Two lines of research have been undertaken.

1. Three areas were identified , one on each estate, where there were uniform stands of oil palm with patches of leguminous cover crop interspersed with areas virtually without leguminous cover. On Arehe and Ambogo the cover selected was Calopogonium caerulium, under mature oil palm, whilst at Isavene it was Pueraria under young palms.

In each case measurements and samples were taken at 60 points (each separated by at least 1 intermediate palm) in each area: 30 with and 30 without leguminous cover. For the palms, frond 17 was used for petiole wxt measurement and for leaf sampling. A soil sample, and leaf and root samples of the cover crop were also taken.

2. During the annual estate leaf sampling round a detailed survey of ground cover conditions adjacent to the sampled palms was undertaken on Ambogo and Arehe estates, in an attempt to identify possible relationships with the leaf N levels.

Results

Table 85 indicates the relative N percentages within the cover crop on the 3 estates, in both leaves and roots, when the covers were categorised according to the number of nodules observed on the roots. In comparison to published data (Watson, 1960; Tan et al, 1960) all these results are very high, and indicate that all the covers sampled, irrespective of observed nodulation details, were fixing nitrogen effectively. This confirms the visual observation of vigorous green growth of most leguminous species on these soils, including areas with low nutrient status.

Table 85: Percentage Nitrogen in Leguminous Cover Crop Samples

		Nodule Frequency			
		High	Med	Low	Mean
Leaf:	Arehe	4.0	4.2	4.1	4.10
	Ambogo	4.5	4.4	4.4	4.43
	Isavene	4.4	4.2	4.4	4.33
	Mean	4.30	4.27	4.30	4.29
Root:	Arehe	2.4	2.2	2.2	2.27
	Ambogo	2.7	2.3	2.3	2.43
	Isavene	2.6	2.3	2.3	2.40
	Mean	2.57	2.27	2.27	2.37

Table 86 indicates that the leguminous covers also had similar high nitrogen contents both in areas of prolific established growth, and also in areas of sparse or new growth. This would indicate that there is neither a problem in commencing fixation in new areas, nor with exhaustion in established areas, and further confirms that the high N levels are due to fixation rather than extraction.

Table 86: Percentage Nitrogen in Leguminous Cover Crop Samples

	Cover Crop Density		
Leaf:	High	Low	Mean
Arehe	4.2	4.1	4.15
Ambogo	4.4	4.3	4.35
Isavene	4.3	4.3	4.3
Mean	4.30	4.23	4.27
Root:			
Arehe	3.1	2.2	2.65
Ambogo	2.2	2.3	2.25
Isavene	1.6	2.6	2.10
Mean	2.30	2.37	2.33

Table 87 summarises the oil palm leaf data and the soil data from the 3 sites. There were no major differences observable exceptfor N. In the case of N level in oil palm leaves, the major increase was in the young palms at Isavene (from 2.4% to 2.9%). This might be expected, since energy for fixation is supplied by sunlight, so that under open conditions, more vigorous growth, fixation and N turnover is possible. With younger palms the total N uptake may also be less (smaller leaves) allowing a proportionately greater effect.

For soil organic matter and nitrogen measurements, the areas with cover crop have overall higher values in each case. The largest benefits were recorded at Arehe, with Isavene not having any improvement in soil N and organic matter levels due to cover crop - possibly due to the shorter period of establishment.

Table 87: Nitrogen Levels in Oil Palm Leaves and Soil Samples

Leaf: N%	Cover Crop Incidence High	Low	Mean
Arehe	2.5	2.3	2.40
Ambogo	2.6	2.7	2.65
Isavene	2.9	2.4	2.65
Mean	2.67	2.47	2.57
Soil: Percentage Organic Matter			
Arehe	2.9	2.7	2.80
Ambogo	3.4	3.2	3.30
Isavene	2.9	2.9	2.90
Mean	3.07	2.93	3.00
Soil: Available N kg/ha			
Arehe	136	108	122
Ambogo	119	107	113
Isavene	113	130	121
Mean	122.6	115.0	118.8
Soil: Total N as percent			
Arehe	0.17	0.12	0.15
Ambogo	0.19	0.20	0.20
Isavene	0.20	0.20	0.20
Mean	0.19	0.17	0.18

Table 88 indicates the petiole wxt measurements. Surprisingly, these appear to contradict the previous data, since the palms growing amongst vigorous cover crop have rather lower petiole wxt values in each case. Thus, although there is a clear indication of nitrogen fixation by the covers, the question of their ultimate benefit to the oil palm is left open.

Table 88: Oil Palm Petiole wxt Measurements mm

	Cover Crop Incidence High	Low	Mean
Arehe	3444	3530	3487
Ambogo	3936	4230	4083
Isavene	1610	1830	1720
Mean	2997	3197	3096.
Percentages:			
Arehe	100	102	101
Ambogo	100	107	103.5
Isavene	100	113	106.5
Mean	100	107.3	103.6

It is possible that if other nutrient/s are in short supply there is a competition effect, due to the vigorous cover crop growth, though in the long term no nutrients are permanently removed by the leguminous covers. On the other hand, some form of ground cover is essential to avoid soil loss, which would lead to a far more serious and permanent loss of nutrients.

For the ground cover surveys, examination of the data from Ambogo did not identify any relationships between vegetation and leaf N content, possibly due to other factors giving rise to overall variation, and the lack of variation in cover crop percentages between samples.

General overall analysis of the Arehe data also failed to identify any clear relationship between ground cover and leaf N levels in the oil palm. However, one multiple regression was identified involving soil type, palm age and leguminous cover crop percentage, which gave a positive and statistically significant regression between the cover crop and palm leaf N levels.

However, since the overall effects are not clear, identification of a single expression giving statistically significant results should not necessarily be interpreted as a direct cause and effect.

Generally the large scale surveys have yielded disappointingly little in terms of increased understanding of the role of the ground cover in relation to oil palm leaf N levels.

Conclusions

1. The initial data indicates that existing leguminous cover crops at HOPPL are fixing nitrogen.

2. For young palms the fixation by leguminous covers resulted in a relatively higher value for leaf N within the palm. Surprisingly, the same palms also had a reduced rachis cross-section.

3. Under closed canopy conditions there is no evidence of any substantial effect upon leaf N by the leguminous covers. Under these conditions, the potential for fixation, which relies upon sunlight, will be limited, and consequently any effect upon yield is likely to be relatively minor.

4. Slightly reduced rachis cross-section measurements were found on the palms growing leguminous cover. This association should be treated with caution, since it has not been proven that it is caused by the leguminous cover, or even that it necessarily indicates any yield reduction. However, some degree of yield reduction or decreased growth due to leguminous cover cannot be ruled out.

5. Since the leguminous covers are fixing nitrogen, if they do have any harmful effect, this is likely to be due to competition (for nutrients or water).

6. The present data has not given any clear indication of factors which might possibly be involved in competition. If details were established then the effect could be overcome by supplementing any items for which there was competition. For example, if P were limiting, then application of TSP would overcome the consequent competition effect.

7. The value of leguminous covers in terms of influence on oil palm production is unproven by the present data, so that no recommendation for choice of cover can be made on agronomic grounds.

8. Some form of ground cover is essential to avoid soil loss, which would lead to a far more serious reduction in yield than any choice between ground covers.

9. Since no substantial effect of leguminous cover has been demonstrated, appropriate ground cover can be selected on the basis of management criteria.

References

G A Watson Cover plants and the soil nutrient cycle in Hevea Cultivation Proc. Nat. Rub. Res. Conf. 1960

Tan H T et al Psophocarpus palustris, an ideal ground cover for oil palm and rubber. Proc. Nat. Rub. Res. Conf. 1960

TRIAL 316, COVER CROP INVESTIGATION SERIES
COMPETITION COMPONENT

Competition from the cover crop has been investigated by David Coomes, an undergraduate student from Cambridge, UK.

Experimental Design :

Statistical details: Randomised block design, with 7 replicates, 10 plots per block and 2 treatments.

Layout: Blocking was for time of day, and there was one palm per plot.

Trial details :

Location: Isavene Estate HOPPL: young planting between Lejo and 78D.
Genetic material: Commercial Dami DxP crosses.
Age: c. 3 years.
Size: The trial comprised 10 experimental plants.

Treatment details :

Trial date: 20th September 1988.
Trial progress: Completed.

Method : Stomatal conductance was assessed by application of different concentrations of iso-propanol mixed with water, and observation of leaf appearance. Due to surface tension characteristics, the more dilute the alcohol solution which can enter the stomata (producing a temporary white flecking) the wider open the stomata are (Wormer and Ochs, 1959).

Testing was conducted on 5 palms surrounded on all sides by vigorous Pueraria (as detailed in the previous report) and 5 palms surrounded on all sides by vigorous Momordica charantia growth.

Results : The mean alcohol concentration which entered the palms surrounded by Momordica was 54% whilst the mean value for palms amongst Pueraria was 63%. This difference was highly significant ($p < 0.1\%$) indicating increased water stress on the palms amongst Pueraria, despite a heavy shower interrupting the measurements, and 217 mm of rain during the preceding 30 days.

Conclusions :

Leguminous cover increased water stress on the oil palm significantly.

Since competition is occurring for water which is relatively plentiful, it is possible that there may also be competition for nutrients, which can be in restricted supply.

Reference :

Wormer M & Ochs R, Humidite du Sol, Ouverture des Stomates et Transpiration du Palmier a Huile et de l'Arachide Oleagineux V.14, No. 10. October 1959 pp 571-580

TRIAL 501, PRELIMINARY FERTILIZER TRIAL, HAGITA.

Purpose: To assess initial nutrient responses at Milne Bay.

Statistical details: 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 as a modification to the original design, and in consequence many plots are only guarded on 2 of the 4 edges.

Trial details :
Location: Hagita Estate MBE.
Genetic material: Dami commercial DxP crosses.
Soils: Plantation family, which is of recent alluvial origin, with (sandy) clay loam soils and a seasonally high water table.
Planting date: April 1986.
Spacing: 127 points ha.
Size: The trial comprises 1397 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

Treatment details :
Trial commencement: July 1986.
Trial progress: Ongoing.
Treatments:

Table 89: Treatments 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		0.3	0.6		0.5		0.25	0.5		
12	4/87		0.6	1.2		0.5		0.5	1.0		
18	10/87		0.6	1.2		0.5	0.5	1.5	2.5		0.05
24	4/88		0.9	1.8		0.5	0.5	1.5	2.5		
36	10/88		0.9	1.8		0.5	0.25	1.25	2.25		0.05

Modifications during 1988 :

1. Originally no guard rows were included in the trial, but all plots had at least 2 sides not adjoining other plots. Wherever possible guard rows have now been introduced.

2. It has been agreed to extend the life of this trial until results from trial 502 (at present still at the design stage) make it redundant. Fertilizer rates are intended to be those indicated at 36 months.

Results :

As shown by the growth data in Table 90, the major MOP effect has continued in 1988, and a lesser benefit from SOA applications has also emerged. The extent of the response to MOP is under-estimated in the results given, as the K0 rate also receives MOP to avoid the severe impairment occasioned by complete absence of K.

Table 90: Trial 501 Palm Growth and data for 1988

TRTMNT	Petiole cross section (mm)	Maximum Height m	Bunch count
N 0	**10.2**	3.09	10.3
N 1	**10.7**	3.22	11.3
N 2	**10.9**	3.31	11.4
P 0	10.6	3.22	10.8
P 1	10.6	3.2	11.2
K 0	**9.4**	**3.06**	**9.7**
K 1	**11.0**	**3.23**	**11.4**
K 2	**11.3**	**3.34**	**11.9**
B 0	10.57	3.29	10.33
B 1	10.74	3.27	9.81
B 0 (1)	10.5	3.24	10.78
B 1 (1)	11.0	3.27	10.07
lsd (N&K)	0.525	0.221	1.39
lsd (P&Mg)	0.429	0.181	1.14
lsd (B)	0.349	0.0832	0.803
lsd (B-1)	0.689	0.109	0.996
s.d.	0.78	0.328	2.07
c.v.	7	10	19

Note:

(1) Borate values based on 4 palms only, ie excluding palms adjacent to those with a different borate treatment.

The first borate applications were made in October 1987, and measurements nearly 1 year later give no evidence of any benefit: some indicate a marginal decrease in production and others a slight improvement. No differences are statistically significant.

The leaf results in Table 91 indicate the levels corresponding to the various fertilizer rates.

Table 91: 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				

Table 92 provides interesting information on individual NK treatment effects. In all cases the major initial response was provided by the K1 rate (2.5 kg MOP): addition of N at the K1 rate did not provide any benefit.

Table 92: Trial 501, Mean values for the NK treatments

1. Relative % Petiole cross section

K0N0 = 8.945 cm2

	K0	K1	K2
N0	100	120	120
N1	105	123	131
N2	110	126	129

2. Relative % Vertical Height

K0N0 = 2.865 m

	K0	K1	K2
N0	100	112	112
N1	110	107	121
N2	110	120	116

3. Relative % of Bunch Count

K0N0 = 8.533 bunches/palm

	K0	K1	K2
N0	100	133	130
N1	113	133	150
N2	126	134	139

Considerable further response compared to K1 or K1N1 was obtained by increasing the fertilizer rates to K2N1 (4.5 kg MOP plus 1.8 kg SOA) which combination provided the best performance in every case. The alternative rates of K2, K1N2 or K2N2 were all poorer, and generally similar in performance to the K1 rate.

This confirms a particularly high K requirement, especially where other fertilizers are also applied.

Summary:

The major MOP effect has continued, and a lesser benefit from SOA applications has also emerged.

There was no evidence of any benefit from borate.

The major response was provided by the K1 application (2.5 kg MOP) and considerable further response was obtained by increasing the fertilizer rates to K2N1 (4.5 kg MOP plus 1.8 kg SOA) which combination provided the best performance in every case. This confirms the particularly high K requirement.

EXPERIMENT 503, Nursery fertilizer trial, Hagita, MBE

Planted:	May 1987
Design:	A single Latin Square, with 7 nutrient treatments, on plots of 4 polybags.
Treatments commenced:	August 1987.
Original details:	7th Annual Report (1987)

Treatments: Nutrient allocation:

Treatment code	N (SOA)	P (TSP)	K (MOP)	Trace E.
1	0	0	0	0
2	1	1	1	0
3	1	1	0	1
4	1	0	1	1
5	0	1	1	1
6	1	1	1	1
7	0.5	0.5	0.5	0.5

Total weight applied on each treatment in grms/month/seedling:

Trt code:	1	2	3	4	5	6	7
Month: 1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	6.0	4.0	4.0	4.0	6.0	3.0
3	0.0	6.0	4.0	4.0	4.0	6.0	3.0
4	0.0	12.0	8.0	8.0	8.0	12.0	6.0
5	0.0	18.0	12.0	12.0	12.0	18.0	9.0
6	0.0	30.0	20.0	20.0	20.0	30.0	15.0
7	0.0	30.0	20.0	20.0	20.0	30.0	15.0
8	0.0	30.0	20.0	20.0	20.0	30.0	15.0
9	0.0	30.0	20.0	20.0	20.0	30.0	15.0
10	0.0	30.0	20.0	20.0	20.0	30.0	15.0

Although this was a simple trial, it has produced clear results. Reference to the final results taken in May (Table 93) indicates firstly that N was essential for good growth in the nursery polybags. TSP and Trace Elements were not of any particular benefit. MOP was of relatively minor benefit.

Extrapolation of these results to field application is fraught with danger, particularly as the nursery soil used is not representative of field soils. However, certain of the findings do agree with field trial results.

Firstly both trials confirm the requirement for K, although this is far more major in the field than suggested by the nursery trial. Possibly the use of MOP may also have some drawbacks through the osmotic effect of chloride in the confined soil volume of polybags.

The lack of P response is common to both the pot and field trials (in spite of soil data suggesting a P requirement).

Nitrogen response in pot trials is almost inevitable, since growth for a year, with N leaching through watering, would almost invariably lead to a nitrogen deficiency. On the field scale, the greater volumes of soil exploited can delay response to nitrogen, although it is very rare that a soil can support high production for extended periods without eventually developing a requirement for fertilizer nitrogen supplementation. In the initial stage of the establishment trial at Milne Bay, no significant response has yet been identified to nitrogen.

In interpreting the results, it should further be borne in mind that although they suggest that growth was almost as good when fertilizer was halved, this probably reflects inadequacies in the mix used, such as possible excess anion concentrations. The estate nursery which received a different fertilizer formulation, resulting in higher nutrient inputs, produced seedlings which were visibly superior to the trial seedlings over the same growth period.

Table 93: Trial 503, Nursery Results, May 1988

Treatments	Leaf Index Mean	Rachis cross sn Mean	Av Height Mean	Lf No Mean
F: NPK +TE	**6972**	**148**	**147**	**11.7**
D: N K +TE	**6765**	**156**	**143**	**10.8**
B: NPK	**6648**	**147**	**145**	**11.3**
G: 1/2NPKT	**6443**	**144**	**139**	**11.1**
C: NP +TE	**6113**	**139**	**141**	**11.0**
A: Control	**3205**	**94**	**100**	**8.5**
E: PK +TE	**3165**	**90**	**97**	**8.7**
lsd	596	13	7.5	0.59
sd	546	12.3	6.8	0.54
gm	5616	131	130	10.43
cv	9.7	9.4	5.2	5.2

Note: Leaf Index (L.I.) is the product of leaf number and rachis cross-section.

TRIAL 505, TRACE ELEMENT AND POTASSIUM TRIAL, MILNE BAY

Purpose:

1. To investigate whether trace element application improves the growth of poor palms at MBE.

2. To compare the possible TE effect with the K effect.

Statistical details: Trial 505 is a randomised complete block trial, of 10 replicates, each comprising 6 different treatments.

Layout: The plots consist of a core of 2 recorded palms.

Trial details :
Location: Waigani Estate MBE.
Genetic material: Dami commercial DxP crosses.
Soils: Plantation family, which is of recent alluvial origin, with (sandy) clay loam soils and a seasonally high water table.
Planting date: 1986
Spacing: 127 points ha.
Size: The trial comprises 120 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

Treatment details :
Trial commencement: 11/2/88.
Trial progress: Terminated 16/11/88.
Treatments:

Table 94: Treatments for Trial 505

Treatment:	Mixed TE	Bunch Ash	MOP	Comment
A	0	0	0	Control
B	+	0	0	TE
C	0	+	0	Bunch ash
D	+	+	0	TE + Bunch Ash
E	+	0	+	TE + MOP
F	0	0	+	MOP

Rates: 6 monthly applications of

TE - 2 g/palm in 1 litre of water.
MOP - 1 kg/palm.
Bunch ash - approx. 2 kg/palm (adjusted to equivalent K content to MOP).

Materials: The TE mix was Fetrilon-Combi red, supplying Fe, Zn, Mn, Cu, B, Mo, MgO and S.

Other: The entire area was accidentally fertilized by the Estate with 750g/palm of MOP and 250 g/palm of TSP in May.

Results :

The trial comprised 2 sources of trace elements (foliar TE mix and bunch ash) and 2 sources of K (bunch ash and MOP). Unfortunately the trial had to be terminated before sufficient time had elapsed for proper assessment, so that the maximum interval between initial trial fertilizing and final trial measurement was 9 months: too short by any count.

Even under these particularly adverse conditions, initial differences of a statistically significant proportion did develop, at the $p<0.1$ and $p<0.05$ levels.

The results shown in Table 95 show that although both bunch ash and MOP increased growth, bunch ash was inferior to MOP. This may have been due to the levels of calcium and magnesium in the bunch ash, which would both counter-act the K effect, and also immobilise some trace elements.

Table 95: Trial 505, Palm Growth Measurements

TREATMENT	Petiole cross section (cm^2)	Increase in PCS (cm)	Leaves 11/88 (n)	Increase in FDM (t/ha)
Control	6.18	2.00	9.8	0.854
-TE	5.98	2.17	10.3	0.943
+TE	6.46	2.25	10.0	0.960
BA	6.08	2.07	10.0	0.899
MOP	5.94	2.36	10.3	1.000
lsd	0.648	0.378	0.754	0.142
s.d.	0.724	0.497	0.991	0.187
c.v.	12	23	10	20

Interestingly, there was also a consistent trend for somewhat higher yields with TE application. This indicates a possibility of TE response at Milne Bay, although it was relatively minor compared to the potassium response. Unfortunately the duration of the trial was too short to obtain a clear picture of this aspect.

Conclusions :

1. At Milne Bay there is a yield response both to bunch ash and MOP.

2. For equivalent K content, the response to MOP is greater than to bunch ash.

3. There is an indication of a trace element response in addition to the K response.

4. GENERAL INVESTIGATIONS

EXPERIMENT 102a : DENSITY AND FERTILIZER TRIAL AT DAMI (P.T.)

Planted : October/November 1970

Design (Current) : Split-plot with four replicates of two planting densities (main-plots) and four levels of ammonium chloride (sub-plots).

Treatments : Commencing in November 1986 the trial has been re-randomized for 4 levels of ammonium chloride. In 1988 the two extreme densities (which had no fertilizer treatments) were dropped and only the two medium densities (110 palms/ha and 148 palms/ha) are now considered.

Density (palms/ha)	Ammonium Chloride(kg/palm/yr) Level			
	0	1	2	3
110	0	2	4	6
148	0	2	4	6

Current Recording Commenced : 1987

Current Details : 1987 Annual Report, page 91 and 1st and 2nd Quarterly Progress Report, 1988.

Table 96 shows the 1988 production results. Differences in total bunch weight per hectare were significant for density at p=0.058 in the first half of the year and differences due to fertilizer were significant at p=0.060 in the second half of the year. The effect of fertilizer on total number of bunches per ha in the second half of the year was significant at p=0.060. However over the whole year the effect of fertilizer was significant (at p=0.057) only at the lower density for single bunch weight.

The calculated optimum density for yield per hectare for the current year was 113 palms per hectare as compared to 118 palms/ha for 1987 and 136 palms/ha for the period since planting 15 years ago. In 1988 optimum responses to fertilizer could only be obtained at the low density.

Table 96 Experiment 102, Yield Production 1988

Density (palms/ha)	Ammonium Chloride (Kg/palm/year)	January 1988 - June 1988 No. of bunches/ha	January 1988 - June 1988 Wt. of bunches/ha (tonnes)	July 1988 - December 1988 No. of bunches/ha	July 1988 - December 1988 Wt. of bunches/ha (tonnes)	January 1988 - December 1988 No. of bunches/ha	January 1988 - December 1988 Wt. of bunches/ha (tonnes)	S.B.W (Kg)
	0	476.0	10.97	441.7	10.18	917.7	21.15	**23.05**
110	2	347.5	8.62	440.5	11.06	788.0	19.68	**25.17**
	4	437.3	10.04	518.7	13.28	956.5	23.32	**24.28**
	6	418.5	11.27	521.2	13.57	939.7	24.83	**26.74**
	0	349.5	7.29	**603.2**	**13.68**	952.7	20.97	22.06
148	2	493.0	9.99	**414.2**	**9.78**	907.2	19.76	21.41
	4	381.0	8.76	**491.2**	**11.19**	872.2	19.94	22.94
	6	280.7	5.86	**625.0**	**14.29**	905.7	20.15	22.29
	$LSD_{0.05}$*	138.64	3.103	144.63	3.48	258.1	5.96	2.38
	C.V (%)	21.77	21.32	17.83	17.95	17.83	17.56	6.33
110	Mean	419.83	**10.23**	480.53	12.02	900.48	22.25	24.81
148	Mean	376.05	**7.98**	533.4	12.24	909.45	20.21	22.18
	$LSD_{0.05}$	146.56	1.703	249.50	4.99	219.28	4.529	2.79
	C.V.(%)	32.73	23.41	43.76	36.57	14.16	18.96	10.56

* LSD compares means within densities.

The leaf analysis results of frond 17 (Table 97) showed significant differences in the levels of N, K and Mg between the two densities. Presumably due to increased competition, the N and K levels fell at the high density, which allowed Mg to rise. These leaf nutrient differences with density are exactly the same as those recorded in the thinning Experiments 104 and 105 at Bebere (PNGOPRA Annual Report 1984, p.35). In particular K levels in the leaflets of all the experiments were depressed in the high N plots at the higher density. This suggests that the lack of response to N fertilizer at the higher density in the present trial may be due to induced K deficiency.

Conclusion.

Since the palms in this trial were in their late stages of production there was an intensive competition for light and nutrients at the higher density. This resulted in the single bunch weight response being significant for N fertilizer only at the lower density where the competition effects were less. The high competition effect at the higher density also saw the leaf levels of N and K falling, with a consequent increase in the levels of Mg in the leaves. Thus if nutrition is a limiting factor at the higher density it is most likely to be due to K deficiency.

Table 97 Experiment 102, Nutrient Levels in Frond 17 December 1988

Density (palms/ha)	Ammonium Chloride (Kg/palm/year)	N (%)	P (%)	K (%)	S (%)	Ca (%)	Mg (%)	Na (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)	B (ppm)	Cl (ppm)
	0	2.225	0.149	0.808	0.158	1.002	0.165	0.01	74.00	60.00	25.25	7.25	9.25	0.488
110	2	2.250	0.149	0.850	0.158	0.918	0.188	0.01	64.75	52.00	21.50	8.50	9.00	0.503
	4	2.250	0.151	0.800	0.153	0.985	0.180	0.01	70.50	55.75	24.25	8.75	9.50	0.525
	6	2.200	0.146	0.823	0.153	0.890	0.175	0.01	71.75	58.75	20.75	7.50	9.75	0.488
	0	2.150	0.148	0.810	0.158	0.977	0.208	0.01	63.25	52.00	20.75	9.75	12.00	0.475
148	2	2.225	0.149	0.753	0.150	1.015	0.190	0.01	65.25	69.25	23.00	9.50	10.00	0.538
	4	2.175	0.146	0.783	0.153	0.990	0.188	0.01	68.00	64.00	18.75	9.00	9.00	0.490
	6	2.125	0.146	0.745	0.153	0.985	0.220	0.01	65.25	63.00	20.25	8.75	9.75	0.528
	$LSD_{0.05}$*	0.139	0.014	0.098	0.008	0.142	0.033	0	8.65	13.56	8.06	3.42	2.60	0.08
	C.V. (%)	3.95	2.71	7.7	3.26	9.12	11.04	0	7.96	14.29	23.10	24.82	16.62	10.26
110	Mean	**2.231**	0.149	**0.820**	0.156	0.949	**0.177**	0.01	70.25	56.63	22.94	8.00	9.38	0.501
148	Mean	**2.181**	0.148	**0.773**	0.154	0.992	**0.202**	0.01	65.44	62.06	20.69	9.25	10.04	0.508
	$LSD_{0.05}$	0.039	0.006	0.034	0.012	0.102	0.008	0	6.94	9.05	4.58	2.41	3.55	0.047
	C.V. (%)	2.41	3.9	3.8	7.10	9.38	3.85	0	9.1	13.36	18.66	24.82	32.25	8.3

* LSD compares means within densities.

EXPERIMENT 102b : POT TEST EXPERIMENTS (P.T.)

Test Plant : Maize (Zea mays)

Planted : Trial 1 30th September 1988
Trial 2 9th September 1988

Harvested : Trial 1 21st November 1988
Trial 2 19th October 1988

Objective : To evaluate fertility of top soil in Expt. 102 at Dami.

Design : There were two trials. One testing NPK and Mg and the other testing trace elements, Cu, Fe, Mn and Zn. Both were 3^4 factorial trials without replication and arranged randomly in polythene bags in the field.

Treatments : There were three levels in each trial.

Fertilizer rates and their levels were as follows:-

Trial 1:

	Level (Fertilizer grams/pot)		
	0	1	2
N (Urea)	0	1.00	2.00
P (TSP)	0	0.84	1.70
K (K_2SO_4)	0	0.45	0.90
Mg (Kieserite)	0	1.70	3.40

Trial 2:

	Level (Fertilizer grams/pot)		
	0	1	2
Cu (EDTA)	0	1.00	2.00
Fe (EDDHA)	0	4.85	8.70
Mn (EDTA)	0	0.45	0.90
Zn (EDTA)	0	1.00	2.00

In Trial 2 each pot received an additional fixed rate of NPK and Mg, which were the same rates as in level 2 of Trial 1.

Soil samples were taken at the site of Expt. 102, away from the ring weeded and fertilizer areas at a depth of 9-12cm. Soil was filled in medium large polythene bags (Volume, 17 litres) and fertilizer mixed into the top 10-12cm. Sowed with two maize seeds per pot and thinned to one after germination in the field. Plants were sampled before tasseling after 7 weeks in Trial 2 and after 5 weeks in Trial 1. Samples were dried in the oven at 75°C and dry weight results were analysed.

<u>Trial 1 Results</u>:

While there was no significant effect for K and Mg the effects of N and P were very highly significant ($P<0.001$). Table 98 gives the NxP effect on mean dry weights, which shows a significant linear improvement with the increase in the level of N and P. These results show that for maize this soil is deficient in N and P, but appears to contain adequate K and Mg.

<u>Table 98</u> Expt.102. Mean dry weights (grams) for NxP effects

		P (Level)			
		0	1	2	Mean
N (Level)	0	6.86	15.82	21.81	**14.83**
	1	9.48	29.31	44.22	**27.67**
	2	13.84	33.79	61.79	**36.47**
	Mean	**10.06**	**26.31**	**42.61**	

L.S.D. for table = 6.75
L.S.D. for means = 3.90

<u>Trial 2 Results</u>:

In the trace element test there was no main effect significant at 5% level. However, when the components of these effects were further compared and examined, a significant linear depression due to managanese was noted, which was corrected by the middle but not high rate of Fe. It is concluded that since there was no positive effect of individual trace elements these soils have no major trace element deficiency.

<u>Conclusion</u>.

These pot test experiments suggest that only N and P are deficient in the soil of Experiment 102. K, Mg and trace elements all appear to be adequate. This agrees with the response of oil palm (at the lower density) to ammonium chloride. Furthermore most trials even on soils low in extractable P have indicated little response of oil palm to P fertilizer. Thus it is concluded that N is probably the only nutrient required by oil palm on this soil.

EXPERIMENT 115: Frond Placement Trial - Kumbango Estate (P.N.)

Planted : 1976

Site : Kumbango Field D11 - 13

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

Design : 12 replicates of two paired treatments 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.

Treatments commenced : February 1987

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

Results:

Table 99 indicates the palm performance during the second year (1988) after treatments started. As yet, there are no significant differences between the two methods of frond application. However, any effect would be expected to take some time to build up, and these observations are scheduled to continue.

Table 99 EXPERIMENT 115, Assessment of Palm Performance, 24 months after initial treatment.

	3/88 - 7/88		8/88 - 12/88		3/88 - 7/88		8/88 - 12/88	
	SPREAD	STACKED	SPREAD	STACKED	SPREAD	STACKED	SPREAD	STACKED
Replicate	Single Bunch Weight				Black Bunch Count			
1	20.0	19.3	18.4	23.4	2.46	2.80	3.32	2.64
2	18.9	19.2	24.2	25.3	2.92	2.66	2.64	2.10
3	18.4	19.5	22.8	24.2	1.98	2.46	2.58	2.62
4	20.2	20.3	24.1	22.3	3.28	2.42	2.34	2.26
5	18.1	17.4	22.8	22.6	1.84	3.06	2.30	1.88
6	19.3	21.2	22.8	25.8	2.42	2.32	2.84	2.32
7	20.7	18.6	19.8	18.2	3.12	3.98	2.62	3.00
8	23.1	19.0	23.8	21.4	2.38	2.54	2.00	2.26
9	20.9	21.6	19.2	27.6	3.28	3.06	3.54	2.32
10	25.0	19.8	23.5	26.2	2.86	3.12	1.78	3.18
11	18.2	19.5	20.1	20.3	2.52	2.70	3.28	2.84
12	18.9	19.4	25.5	22.3	3.28	2.98	2.94	2.98
Mean	20.14	19.57	22.25	23.30	2.695	2.842	2.598	2.533
$LSD_{.05}$	1.39		2.1		2.8		0.4	
C.V. (%)	7.8		10.4		14.2		15.7	

TRIAL 705, CLONAL OBSERVATION BLOCK, AREHE (S.W.)

Experimental Design :
Statistical background: The trial now effectively comprises randomised complete blocks for 4 clones, with 2 replicates remaining.

Layout: The plots consist of a core of 9 recorded palms, guarded on 2 sides only.

Trial details :
Location: Arehe Estate HOPPL, adjacent to the nursery.
Genetic material: Unifield clones.
Soils: Generally Higaturu family, but affected through previous use as a nursery.
Planting date: December 1985.
Spacing: 130 points ha.
Size: The trial now comprises 8 plots: 63 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.
Trial progress: Ongoing.

Modifications :

As agreed at the 1987 SCAB meeting, this trial has been reduced in size during 1988, and most of the palms removed for expansion of a new nursery area. The density component of the original trial has been abandoned, particularly since the clones within the trial have not grown normally, and are unlikely to be representative of possible performance of clones which will be available in the future.

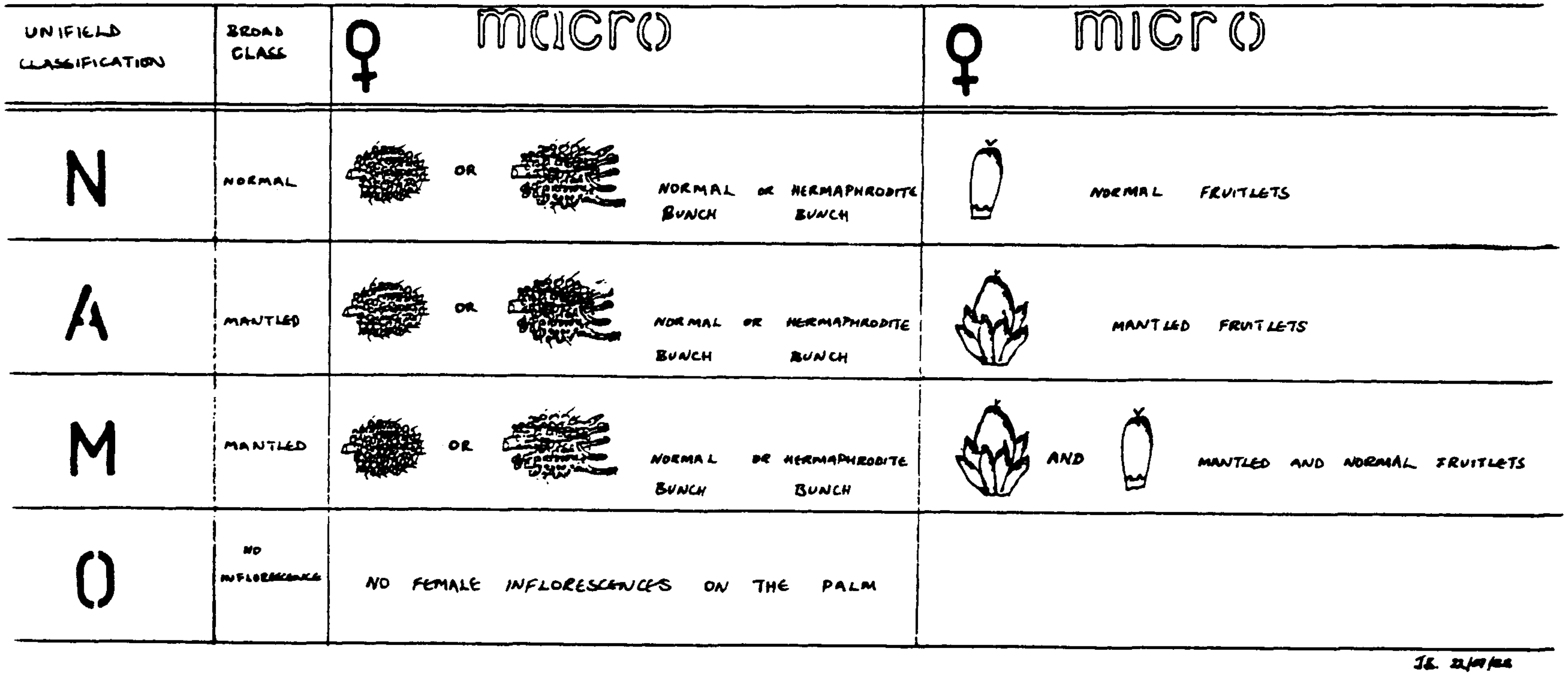
However, 2 plots of 9 palms each have been retained for continued observation of the performance and development of each of the 4 original clones.

Results :

Of the clones included, UF12 and UF15 are now producing normal male and female inflorescences, UF18 is producing normal male flowers, but abnormal female inflorescences (mantled fruitlets), and UF6 is producing both abnormal male flowers (androgynous mantled) and abnormal female inflorescences (mantled fruitlets). UF6 has produced a preponderance of male inflorescences, but for the other clones the sex ratio is balanced. Little sterility or abortion was observed.

Table 100 gives the most recent results, and Figures 42 and 43 indicate the floral morphology guidelines provided through Unifield, as the basis for the assessment.

Fig. 42 Key for assessment of female inflorescence type



Key:

N - Normal
A - Abnormal
M - Mixed
O - No Inflorescence

Fig. 43 Key for assessment of male inflorescence type

UNIFIELD CLASSIFICATION	BROAD CLASS	♂ macro	♂ micro
N	NORMAL	 NORMAL MALE FLOWER	 NORMAL MALE FLORETS
NA	ANDROGYNOUS	 ANDROGYNOUS MALE FLOWER	 NORMAL FEMALE FRUITLETS
AA	ANDROGYNOUS	 ANDROGYNOUS MALE FLOWER	 MANTLED FRUITLETS
M	ANDROGYNOUS	 POSSIBLY WITH A FEW  ANDROGYNOUS FLOWER AND POSSIBLY SOME NORMAL MALE SPIKES	 AND  AND POSSIBLY A FEW  MANTLED AND NORMAL FRUITLETS WITH POSSIBLY A FEW NORMAL MALE FLORETS IF SPIKES PRESENT
O	NO INFLORESCENCE	NO MALE FLOWERS ON THE PALM	

JB. 22/07/88

Key:

N - Normal
NA - Normal Androgynous
AA - Abnormal Androgynous
M - Mixed
O - No Inflorescence

Table 100: Floral Characteristics of the clones at HOPPL

Mean values of inflorescences per palm, counted 3/2/89

	Male		Female			Bunch
Clone	N	AA	N	M	A	Development
UF6	0.71	6.28	-	-	1.89	-
UF12	7.11	-	3.67			100% normal
UF15	7.05	-	4.56	-	-	100% normal
UF18	6.11	-	0.17	0.06	4.5	-

Summary:

UF12 and UF15 are now producing normal male and female inflorescences, UF18 is producing normal male flowers, but abnormal female inflorescences, and UF6 is producing both abnormal male flowers and abnormal female inflorescences.

INVESTIGATION 708: Continuous variation of leaf nutrient levels. (H.L.F.)

Leaf nutrient levels have been monitored monthly at two sites in Oro Province **(Trials 305** and **306)** over a period of three years.

Objectives of this investigation included a better understanding of seasonal fluctuations and time trends, both of which cause problems in foliar diagnosis.

<u>Results</u>

Seasonal fluctuations in rainfall, FFB yield and solar radiation for Trial **306** averaged over three years (1985-87) are shown in **Fig. 44.** Rainfall generally exceeds 200mm in 6 months of the year, but from March to October conditions are usually much drier, with very little rain being received in July in particular. FFB yields follow a similar trend due almost entirely to variation in bunch numbers which are most reduced from July to September.

The corresponding leaf nutrient levels are shown in **Figs. 45** and **46.** Multiple regression analysis was carried out to detect any significant and consistent effects on leaf nutrient levels due to rainfall, yield, solar radiation and fertilizer application during the six month periods prior to leaf sampling.

Fig. 44 Average monthly rainfall, solar radiation and F.F.B. yields in N2K2 plots of Trial 306 at Ambogo.

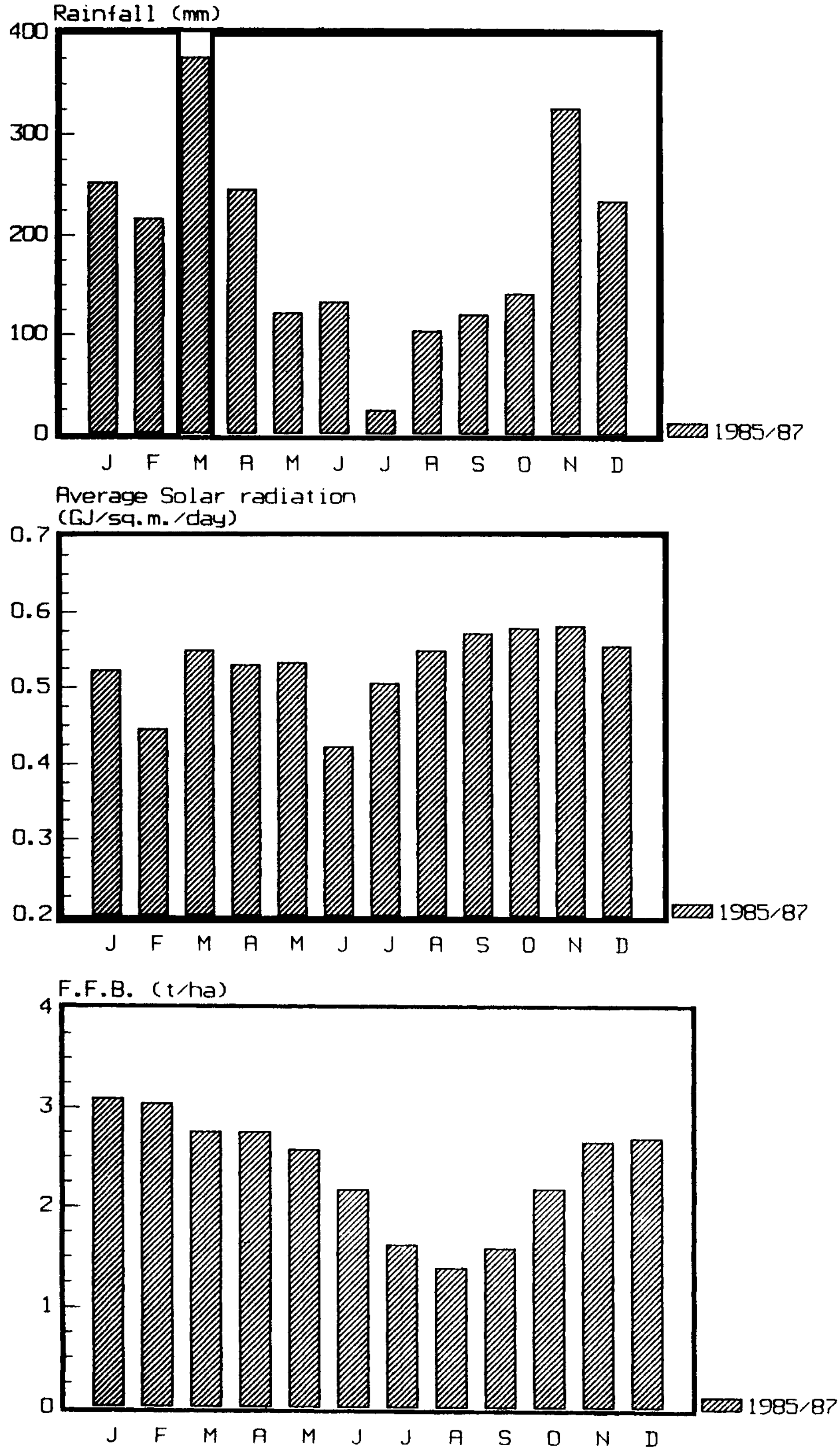


Fig. 45 Average leaf N, P and K levels in N2K2 plots in Trial 306 in different months (the solid line indicates fitted time trend and broken lines the standard error of the means).

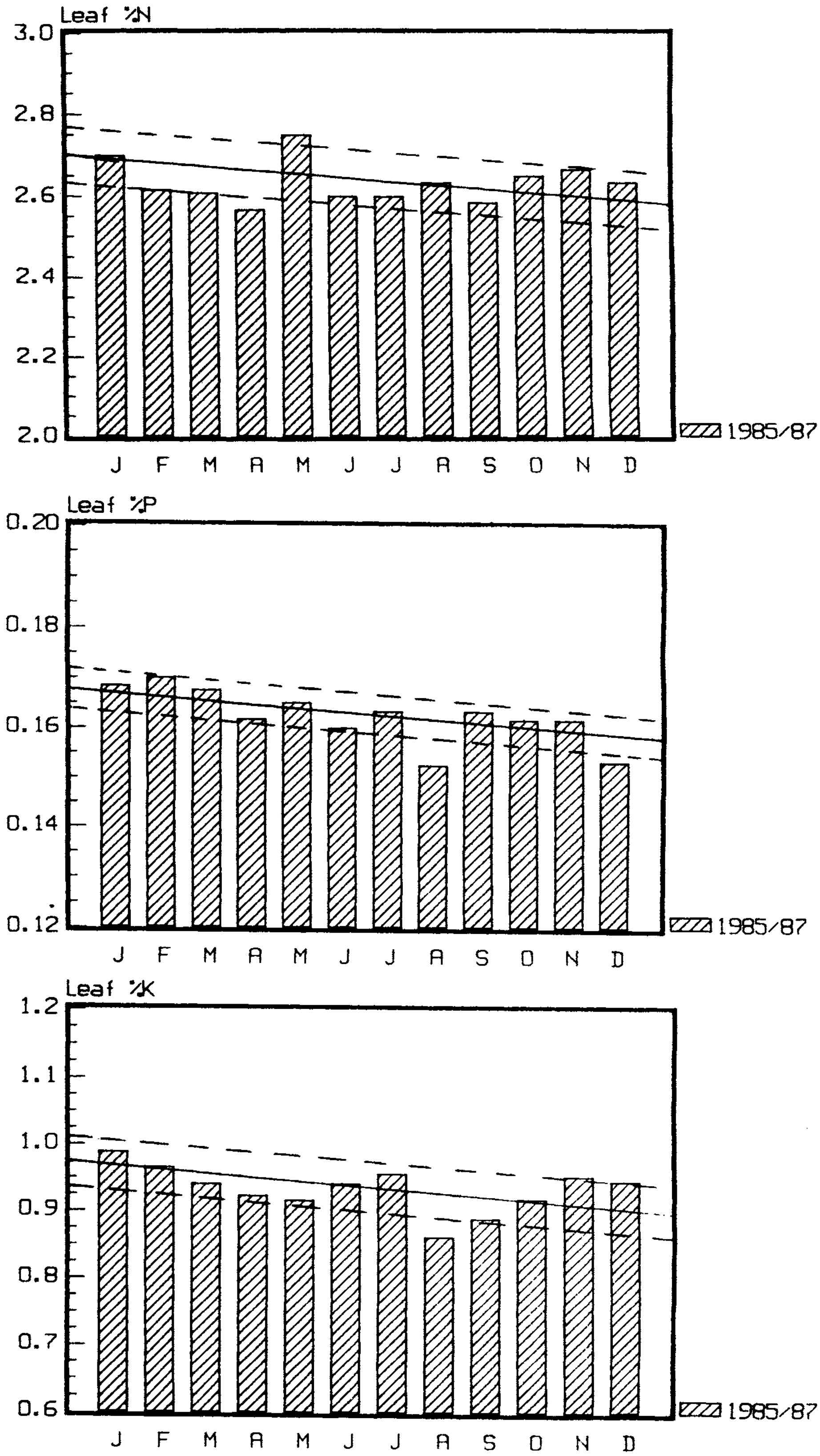
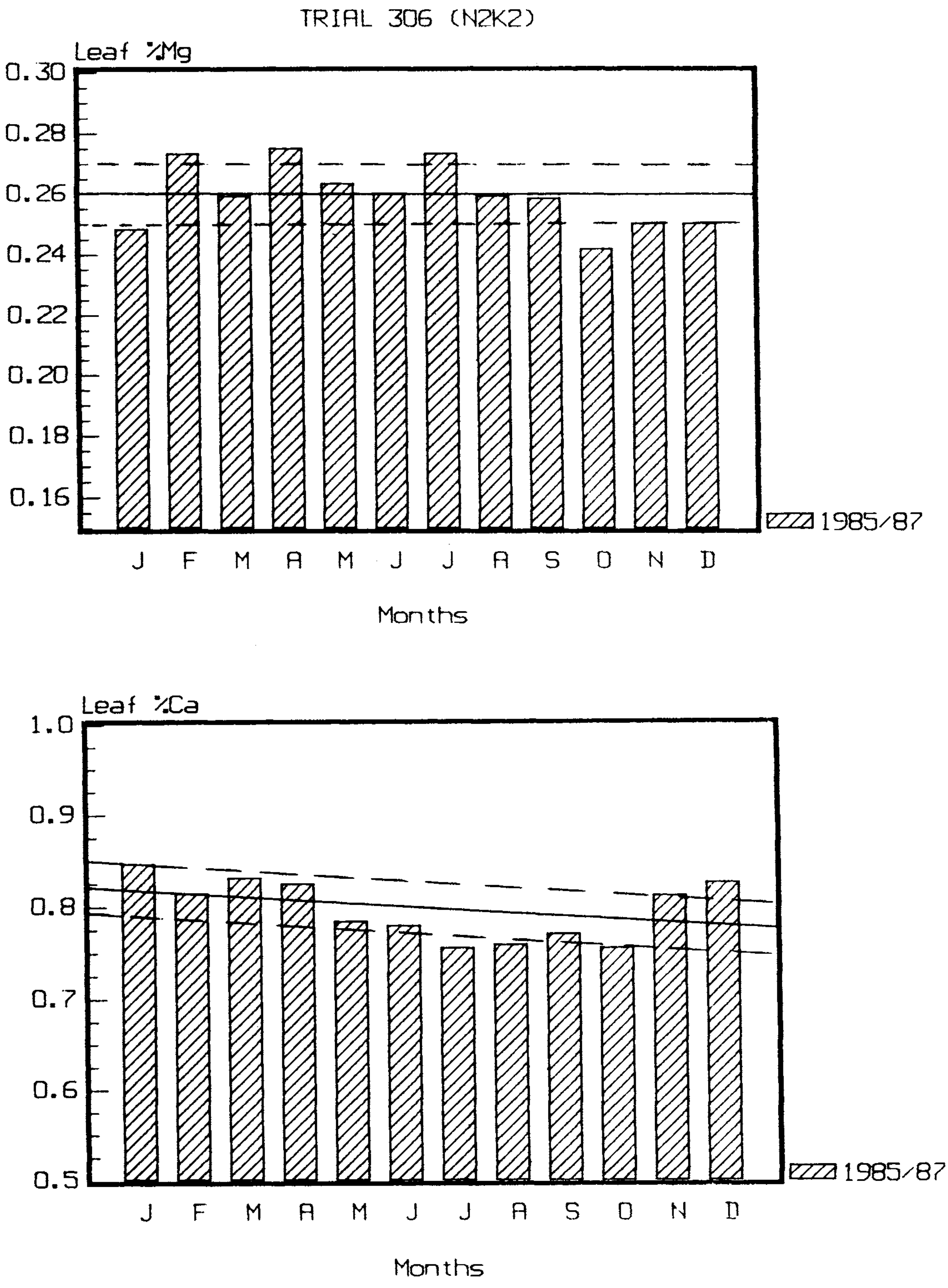


Fig. 46 Average leaf Mg and Ca levels in N2K2 plots in Trial 306 in different months (solid line indicates fitted time trend and the broken lines the standard error of the means).



Whilst highly significant multiple correlations were found with the levels of all the nutrients, none of these correlations were consistent from year to year or with similar correlations calculated for Trial 305 (which showed similar seasonal variation) - except for the time trend. The average change in leaf nutrient levels with time in **Trial 306** is shown in Table 101 for both fertilized and unfertilized plots. On average the annual decline in leaf N,P, K and Ca ranged from 5-7%; fertilizer appreciably reducing the decline in N, S and Ca.

The fitted time trends for the major leaf nutrients are shown in **Figs. 45** and **46**, and can be compared with the average observed monthly values. The standard errors of the latter are indicated by the broken lines in the figures. It may be noted that observed monthly means deviate from their standard errors in the following cases:

1) N: Low in April (last month of wet season)
   High in May (first month of drier period)

2) P: Low in August (month after driest month)

3) K: Low in August (month after driest month)

4) Mg: Low in October

5) Ca: Low in July (driest month)

These results generally agree with those obtained in Trial 305. Thus it is recommended that leaf sampling in the Popondetta area should definitely be avoided in August when particularly low levels of P, K and Ca tend to be recorded, presumably due to the dry conditions. Similarly April and May should be avoided if possible, as N tends to fluctuate markedly over this period.

Table 101: Change in leaf nutrient levels with time in Experiment 306 (1984-87)

	N0 K0 Fertilizer			N2 K2 Fertilizer		
Nutrient	Mean	Change/year (%)	t	Mean	Change/year (%)	t
N	2.50	- 0.200 (8.0)	-7.4***	2.63	- 0.126 (4.8)	-4.9***
P	0.16	- 0.012 (7.7)	-8.5***	0.16	- 0.009 (5.9)	-7.2***
K	1.02	- 0.082 (8.0)	-5.3***	0.93	- 0.061 (6.6)	-5.2***
S	0.17	- 0.011 (6.5)	-6.0***	0.18	- 0.008 (4.3)	-4.3***
Mg	0.29	(n.s.)		0.26	- 0.009 (3.3)	-2.3*
Ca	0.72	- 0.053 (7.4)	-7.0***	0.80	- 0.042 (5.3)	-5.0***
Cl	0.12	+ .029 (24.1)	3.4**	0.52	- 0.021 (4.9)	-2.2*

TRIAL 709, PROGENY TRIAL, AREHE (S.W.)

Experimental Design :

Purpose: The initial HOPPL agronomy planting was recovered by OPRA, primarily for assessment of the possible influence upon fruitset of genetic variations and inflorescence characteristics.

Statistical background: Trial 709 is a latin square design, with two replicates each of 4 treatments.

Layout: The plots consist of 12 recorded palms, which are unguarded.

Trial details :

Location: Arehe Estate HOPPL, adjacent to the office complex.
Genetic material: 4 selections have been included. From Dami there are HBN (high bunch number) and MSR (medium sex ratio) selections, whilst from the Cameroons are 2 selections coded CF1 and CO1, also exhibiting high bunch number and medium sex ratio characteristics respectively.
Soils: Higaturu family, which is of volcanic ash origin, consisting of deep sandy clay loam, with good drainage and physical properties.
Planting date: 1980.
Spacing: 130 points ha.
Size: The trial comprises 32 plots: 384 experimental points, and is surrounded by additional areas of buffer palms, separating it from estate areas.

Treatment details :

Trial commencement: January 1987.
Trial progress: Yield recording of this trial was undertaken from January 1987 to December 1988, and fruitset studies commenced in November 1987 and are ongoing.

Results :

1. Yield

The yield data shown in Table 102 indicates that in terms of tonnes of F.F.B., CF1 is continuing to give superior performance to CO1, and that there is no significant difference currently between the CF1, MSR and HBN selections, although HBN continues to have the highest yield.

CF1 has the highest bunch weight and the lowest bunch numbers. CO1 has the lowest bunch weight but the highest bunch numbers. HBN and MSR material is very similar for bunch weight, but the HBN material has borne 7% more bunches.

The Cameroon material is more variable than the Dami material, with a substantial proportion of poor palms, but also some excellent material.

Table 102: Yield per hectare for Trial 709: 1987 and 1988 (annual basis)

Treatment	Wt of bunches t/ha	No of bunches ha	s.b.w. kg
HBN	26.74	2061	13.0
MSR	24.80	1928	12.9
CF1	24.14	1837	13.2
CO1	22.84	2495	9.1
lsd	2.46	143	0.888
sd	2.4	140	0.866
cv	10	7	7

2. Growth

For growth and conversion data in Table 103, the Cameroon material is distinctly shorter in height, which puts it at a disadvantage in an unguarded trial of this nature. Interestingly, the highest bunch producing progeny CO1 also had the lowest height.

Table 103: Trial 709 Palm Growth and Conversion data for 1987 and 1988 (annual basis)

TRTMNT	Height 1988 m	Leaf prdn (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 of conversion (e)
HBN	2.73	21.8	2.92	8.11	21.9	11.4	33.4	0.661	4.53	0.846
MSR	2.6	22.5	2.88	8.23	20.3	11.4	31.7	0.639	4.66	0.851
CF1	2.4	22.0	2.65	7.39	19.8	10.4	30.2	0.654	4.30	0.830
CO1	2.17	19.8	2.67	6.72	18.7	9.5	28.3	0.661	4.31	0.831
lsd	0.215	0.979	0.161	0.428	2.02	0.601	2.473	0.017	0.388	0.025
s.d.	0.209	0.955	0.157	0.417	1.97	0.587	2.413	0.017	0.379	0.025
c.v.	8	4	6	5	10	5	8	3	9	3

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

The Cameroon material also had a lower vegetative dry matter production. With a similar bunch index and efficiency values the Cameroon material's yield appears to be limited, particularly for CO1, by lower vegetative dry matter production due mainly to smaller leaf area indices. In the case of MSR the bunch index was slightly poorer, so that bunch dry matter yields were similar for MSR and CF1, although the CF1 had a significantly lower vegetative dm production. For commercial use of Cameroon type material, a denser planting might therefore be advantageous.

3. Fruitset

During 1988 two methods of fruitset assessment were undertaken. In addition to ongoing assessment of every bunch from a number of selected palms, assessment was also undertaken on a more representative basis, by selecting successive plots for each progeny in every month, allowing assessment based on every plot within the trial.

It has been argued that the palms receiving continuous monitoring may achieve higher than normal fruitset, due to increased exposure of inflorescences by bending down of the fronds during inspection and marking of the crown. Comparison of the 2 methods of assessment provides an indication of whether or not this effect is significant (see Figures 47 and 48).

In general assessment by both methods was in vary close agreement. However, with the continuously monitored palms the MSR material achieved substantially superior fruitset to the HBN material, whereas on the representative samples the fruitset for both Dami progenies was very similar.

Under both assessments the CO1 progeny had distinctly poorer fruitset than other progenies. This is not due to problems of access by the weevils, since the Cameroon material is well suited to insect pollination, with good bunch exposure.

There is marked seasonal variation from a high of 74% (mean) in April, down to a trough of 50% in July. Variation of this extent is not matched by any particular variation in weevil pollination or inflorescence accessibility. Rather it would appear to be a physiological effect, mirroring as it does the annual cycling of bunch production, with lowest fruitset occuring on the bunches pollinated during higher production periods (see Figure 49).

Thus high yielding material which generally cycles between extremely high production alternating with rest periods, would also inevitably be particularly subject to fruitset variation.

Whilst the mechanism of reduction of fruitset is not yet known, it appears to be physiologically controlled by the palm, which would account for the marked variations found in similar material according to age, location and season. Amelioration of the situation would therefore partly be by genetic means, although any high yielding material must risk susceptibility to poor fruitset.

In addition any measures which can reduce stress to the palm should also improve fruitset.

Figure 47: Monthly Fruitset values for overall sampling

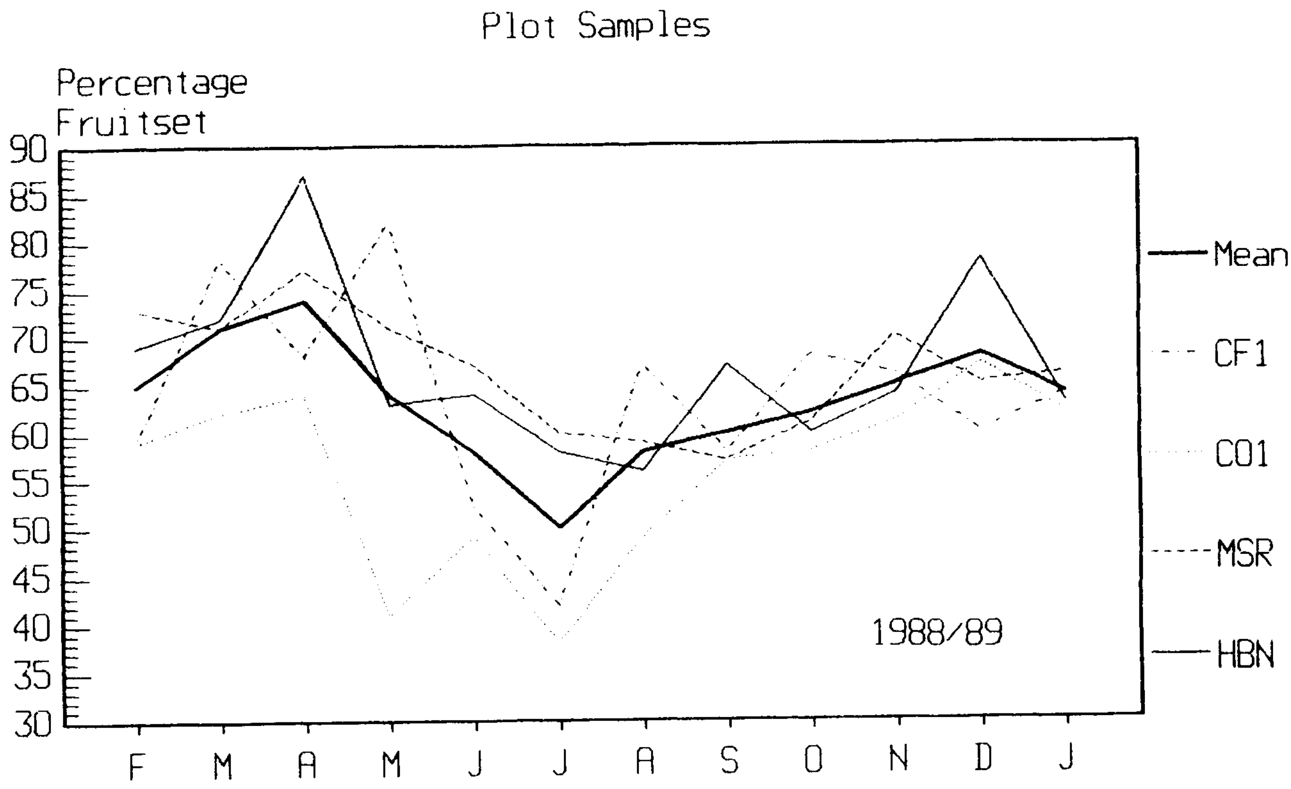


Figure 48: Monthly Fruitset values for Selected Palm sampling

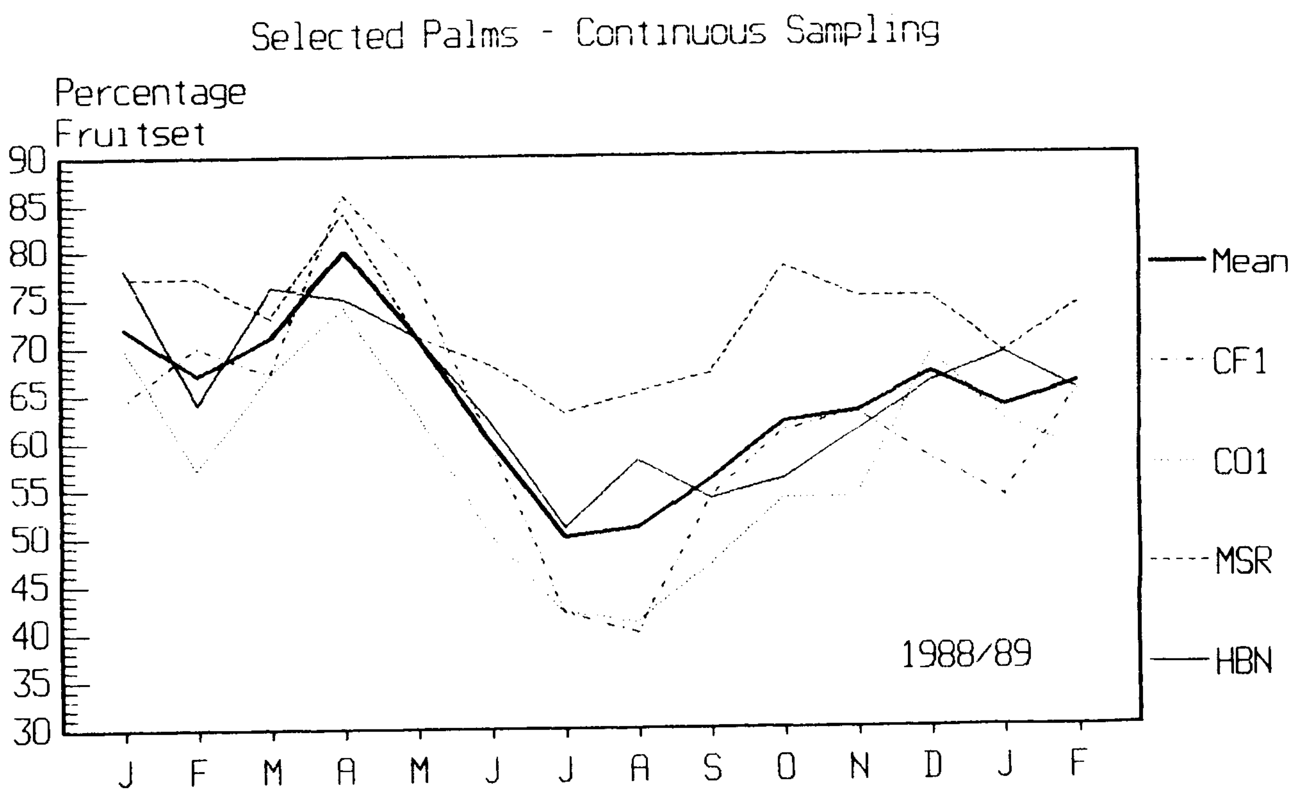
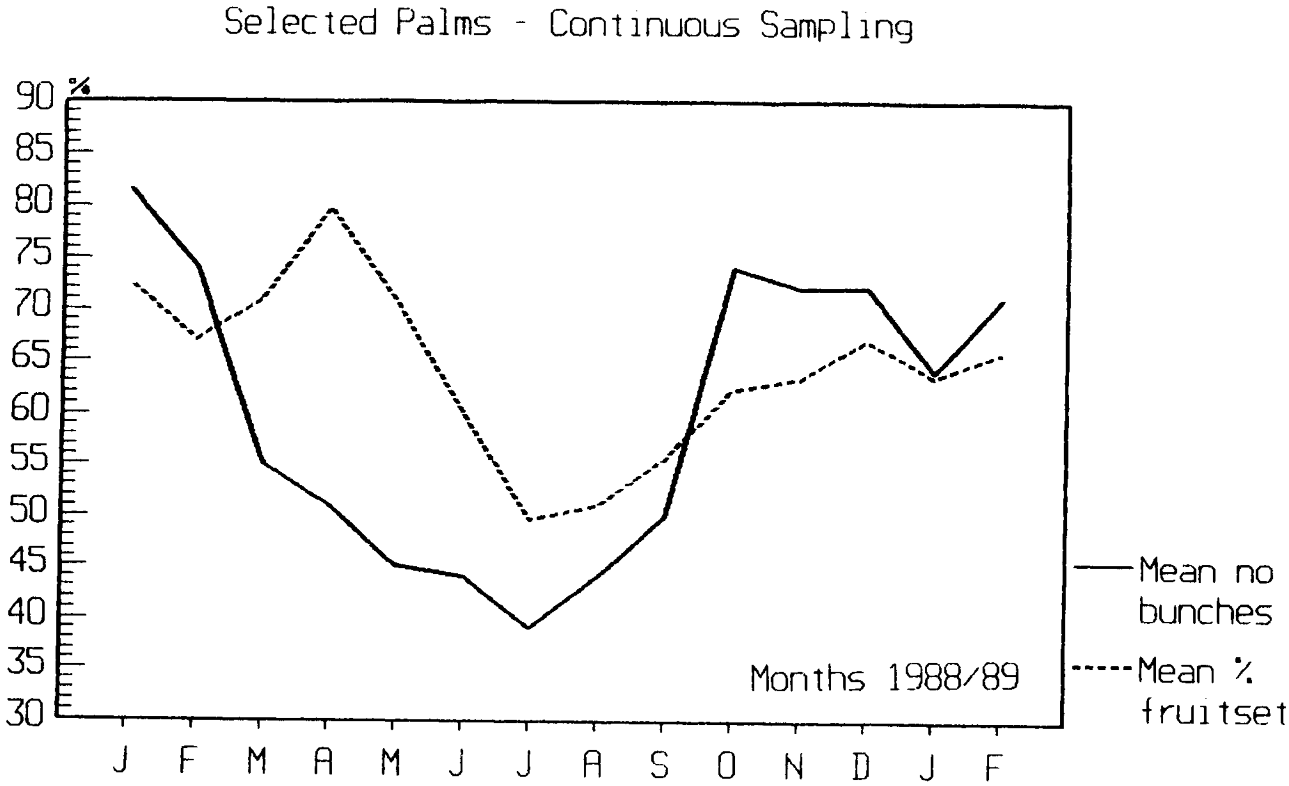


Figure 49: Monthly Fruitset and Numbers of Bunches Harvested for the Selected Palms



Summary:

The Cameroon material is more variable than the Dami material, with a substantial proportion of poor palms, but also some excellent material.

The Cameroon C01 had the poorest yield, but there was no significant difference between the CF1, MSR and HBN selections, although HBN continued to have the highest yield.

For growth the Cameroon material was distinctly shorter in height, and also had lower frond dry matter production.

The C01 progeny had distinctly poorer fruitset than other progenies, although it was morphologicaly well suited to insect pollination.

Study of the seasonal variation in fruitset suggested a physiological effect, mirroring the annual cycling of bunch production, with lowest fruitset occurring on the bunches pollinated during higher production periods. This would account for the marked variations found in similar material according to age, location and season.

5. ENTOMOLOGY

(R.N.B.P.)

INVESTIGATION 602: POLLINATORS

It was decided to shelve further investigation on a second, backup pollinator until sufficient funds are made available to properly advance the work required.

INVESTIGATION 603: *ELAEDOBIUS KAMERUNICUS* FIELD STUDIES

Fruitset

Figs. 50 - 56 show average fruitset data collected on a two to three weeks harvesting cycle from twenty marked palms in three areas in West New Britain and two in Oro Province. Each palm has every bunch harvested in a pre-ripe condition to avoid any loss, and the contents of every frond is recorded.

Comparison of monthly fruitset averages for each site with last years data: In West New Britain the 1973 I.R.H.O material at Hargy maintained an average of between 60 and 84 percent except for April with the lowest monthly average of 54 percent which may, in part, be due to the very high rainfall in the previous December. Last years data is similar except the lowest fruitset of 62 percent was recorded in August and this low could also have been an effect of exceedingly high rainfall in the preceding March. Also at Hargy the 1979 Dami material followed a similar seasonal pattern with a range of 48-67 percent, the lowest recorded in March.

At the Buluma site the 1979 Dami material had large seasonal fluctuations similar in scale to the 1987 data but not in time. The lowest average fruitset was 41 percent in March which correlates with the second highest recorded rainfall for the preceding December. The highest average fruitset of 70 percent was recorded in September.

In Oro Province the fruitset on Ambogo continues to be cause for concern. The range of 29 to 63 percent was similar to the previous year but the prolonged very low average fruitset of below 37 percent for July to September was only matched previously in 1985. With no pronounced dry season through out this year, and with what can be regarded as optimum rainfall for weevil reproduction and activity, no correlation can be found to explain the low figures.

It is noteworthy to compare P.N.G's fruitset data with that of Malaysia. In PORIM's 1988 Annual Report tables of fruitset data for the past five years show that the annual average fruitset has remained consistently above 70 percent. In P.N.G. only the I.R.H.O. material growing at Hargy W.N.B. can equal that level. Kernel to bunch rates in Malaysia is above 7 percent which is a level rarely reached in P.N.G.

Fig. 50 % Fruitset in IRHO material at Hargy

Fig. 51 %Fruitset in Dami material at Hargy

Fig. 52 %Fruitset in Dami material at Buluma

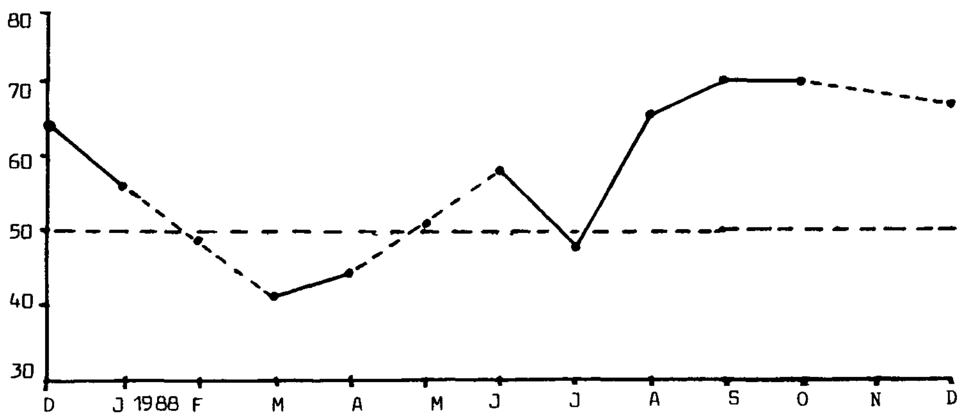


Fig. 53 Yield Fluctuation at Arehe - 1987/88

Fig. 54 %Fruitset at Arehe - 1987/88

Fig. 55 Yield Fluctuation at Ambogo Plantation - 1987/88

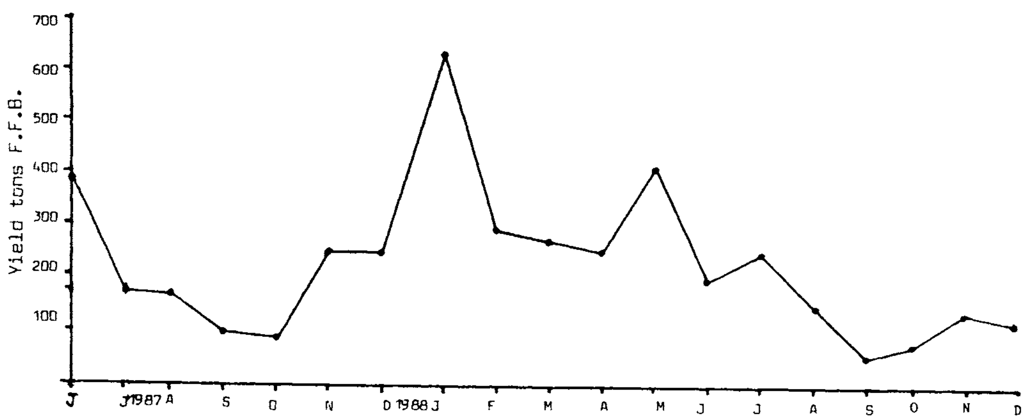


Fig. 56 %Fruitset in Dami material at Ambogo Expt.306 - 1988

Because of the possibility that nutritional or other related stress factors might be involved in fruitset, data from high and low fertilizer plots in Fertilizer Experiment 306 were examined and is shown graphically (Figs. 57 and 58). The fertilizer treatments were:- HIGH = N2K2P2 and LOW = N0K0P0. Quite clearly the results, although illustrating a high peak in fruitset on the high fertilizer plots, were very similar. The depression following the peak period is similar in both graphs and indicates that enhancement of fruitset could not be sustained with this particular fertilizer regime. It is noteworthy that both these sets of data and those from the 20 palm study plot compliment each other and illustrate the general trend for this area.

Fig. 57 % Fruitset in High Fertilizer Plots of Expt. 306

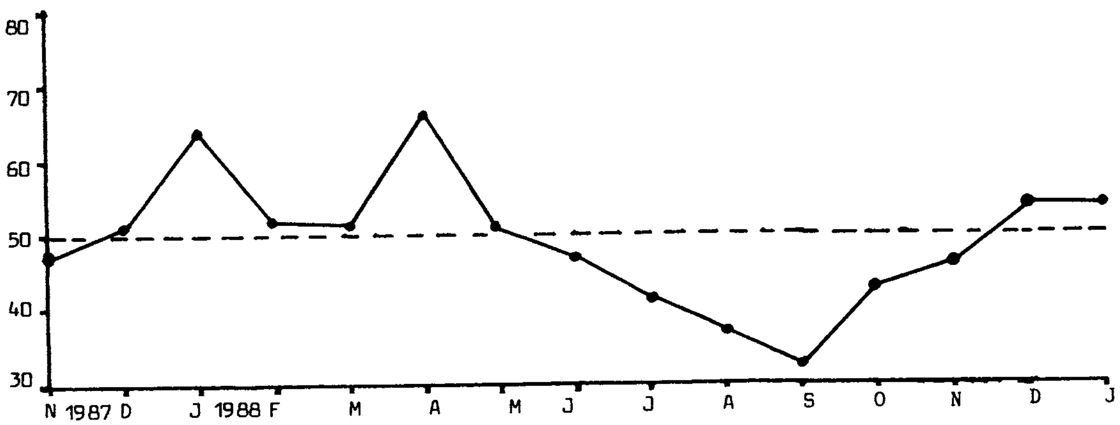
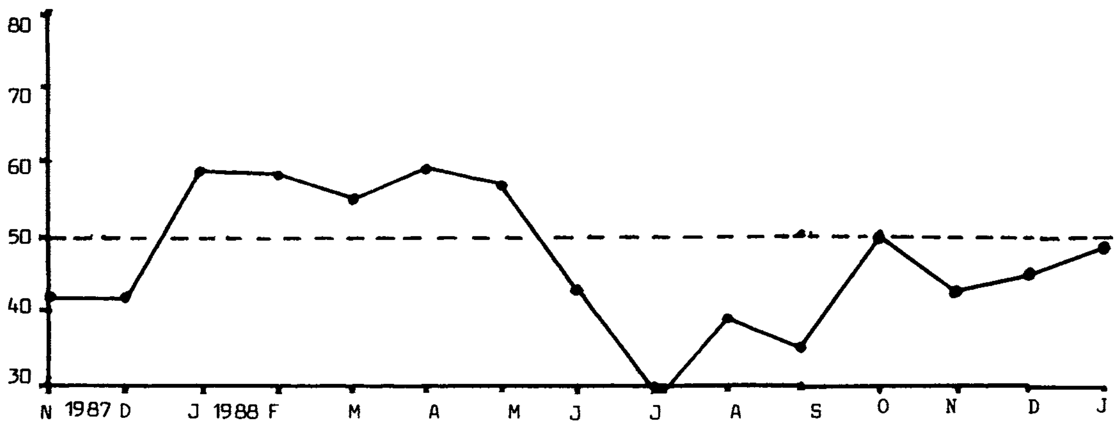


Fig. 58 % Fruitset in Low Fertilizer Plots of Expt. 306



In Oro Province weevil emergence data over the year gave an average of 70 per spikelet for Ambogo compared with 68 at Dami in West New Britain. The pollination force for the two Provinces also appears similar with an average per month of 200,000 per hectare. However the figure for Oro Province could only be compiled from six month data due to a gap in recording. Numbers of male flowers in anthesis per hectare are normally recorded every month in both Provinces. The range for West New Britain is 10-35, average 17 (12 months data) and for Oro the range is 7-19, average 11 (6 months data).

In a further attempt to explain the low fruitset data, Ambogo plantation (Oro Province) yield data was plotted against the fruitset using a six month time differential. The monthly yields from 127 hectares on Ambogo, incorporating the fruitset study plots are shown in Fig. 55. The very large peak yield in January does correlate with depressed fruitset in June and subsequent months. Interestingly the peak yield also corresponds with the highest fruitset and vice-versa. That stress factors are involved with a lowering of fruitset appears likely. If the mechanism involved is discovered it might be possible to prevent recurring unacceptably low fruitset. However no strong correlation could be found between yield (Fig. 53) and fruitset (Fig. 54) in the 1983 planting study block at Arehe (Oro Province).

Rainfall (Figs. 59 & 60) :
In West New Britain Province the two main areas:- Hoskins (Dami Plantation) and Bialla (Hargy Plantation) followed a similar seasonal rainfall pattern and reached record peaks during February and December. The total annual rainfall of 5485mm at Dami is the highest since recording began in 1969.

In Oro Province rainfall was fairly evenly distributed over the year without the usual dry season between May and August. At Arehe the total annual rainfall was 2700mm and Ambogo slightly less with 2597mm. Only one month, June at Ambogo, recorded less than 100mm, with 97mm.

INVESTIGATION 601: SEXAVA CHEMICAL CONTROL.

The amount of chemical treatment increased over last year but other than small outbreaks on Navarai plantation, the areas infested were new and had not had parasites released previously. In the Hoskins scheme, West New Britain, the worst area affected were parts of Kavugara - 50 blocks requiring treatment in July and a further 15 in November. Previous Sexava damage at Kavugara was confined to a different area.

Damage to Navarai plantation required 20 hectares treated in February along with a release of about 60,000 egg parasites,*Leefmansia bicolor*. Further chemical treatment of 5 hectares in June and 15 hectares in August were in different areas on Navarai. Parasites were released at the same time as the chemical treatment.

Fig. 59 Rainfall: West New Britain Province 1988

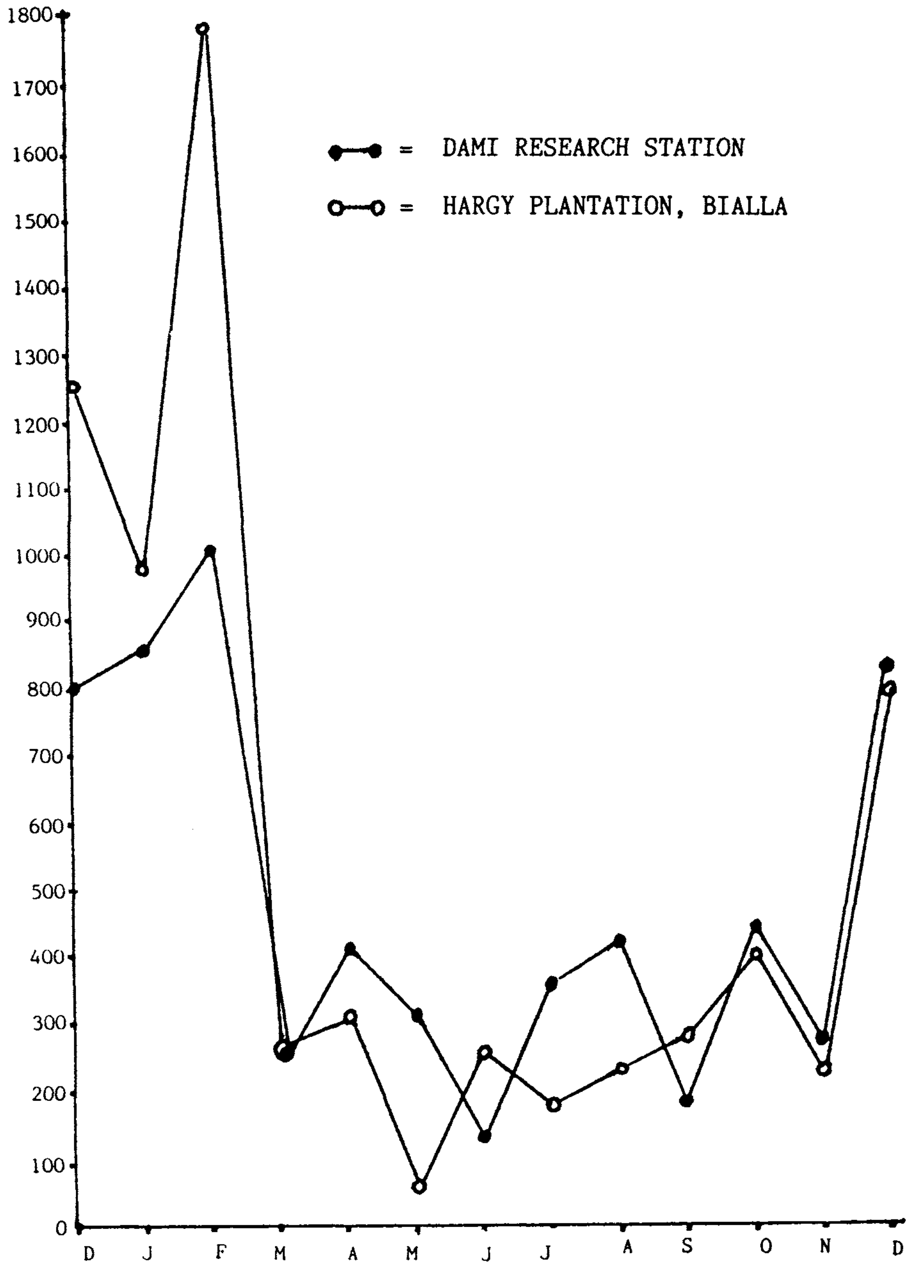
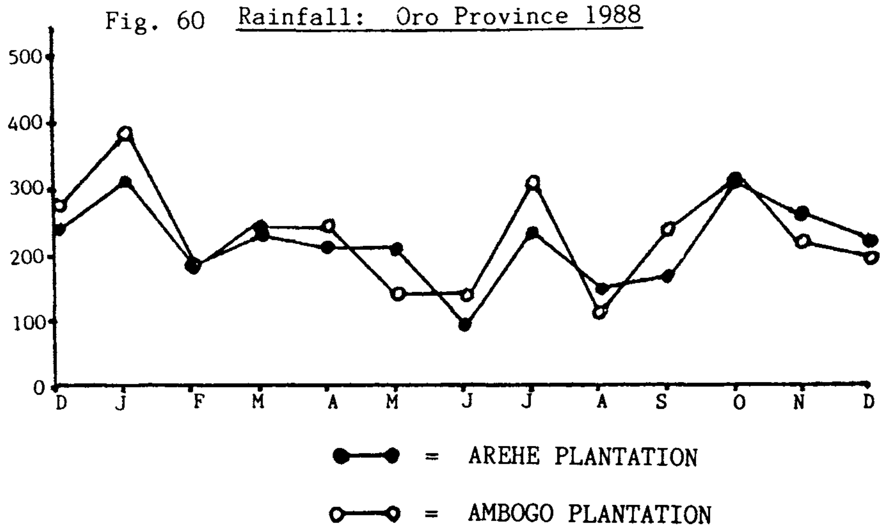


Fig. 60 Rainfall: Oro Province 1988



On Dami Research Station in July, 15 hectares of seed palms were treated for a light Sexava infestation, principally because they were valuable seed producing palms. Three blocks of V.O.P's at Gule required treatment in October.

At Bialla West New Britain, damage continued on Hargy plantation but significantly areas where parasites had previously been released appeared not to have further outbreaks. However Sexava damage was widespread throughout the area and required almost continuous treatment. Approximately 500 hectares were treated during the year.

In Oro Province small areas of Sexava damage, often in conjuction with cockchafer (*Dermolepida* species) and or Stick insect (*Eurycantha* species), continued to be reported and monitored throughout the year. At Isaveni 10 smallholder blocks were recommended for treatment in January. Later surveys carried out in smallholder blocks at Koropata, and Sorovi indicated a high percentage of biological control, which resulted in these blocks not being recommended for treatment and which during the course of the year improved - with damage never reaching economic levels.

INVESTIGATION 607: SEXAVA BIO-CONTROL.

In West New Britain, at Dami, mass rearing and release of biocontrol agents continued throughout the year. The details of the releases made in West New Britain area are as follows:-

		No. of *L. Bicolor*
FEB	Navarai Pltn NBPOD, 2 releases	81,315
	Bialla, Hargy Plantation	22,500
MARCH	Kavugara Smallholdings	49,275
	Bialla, Hargy Plantation	26,280
APRIL	Bialla, Hargy Plantation	55,575
JUNE	Bialla, Hargy Plantation	39,150
	Dami Plantation NBPOD	22,500
JULY	Dami Plantation NBPOD	20,000
AUGUST	Kavugara Smallholdings	30,720
	Navarai Plantation NBPOD	21,360
SEPT	Dami Plantation NBPOD	48,320
OCT	Dami Plantation NBPOD	34,400
	Gule V.O.P.	16,840
NOV	Bialla, Hargy Plantation	15,360
	Bialla, Tiauru Smallholdings	15,360
	Total parasites released Jan-Dec 88	498,955

Conclusion:- As mentioned under Investigation 601 above, it appeared significant that in the majority of areas where parasites have released no resurgence of Sexava had occurred and this had lead to extreme difficulty in finding any Sexava eggs at all after the initial releases were made.

At Navarai small outbreaks had occurred in areas adjacent to release sites and a few eggs collected there had parasite emergence holes similar to those made by *L. bicolor*. However field collected unhatched eggs kept in the laboratory produced no parasites.

The problem of resurgence of Sexava at Navarai, even after treatment and parasite release, is probably linked with the presence of two species of Sexava, one of which - *Segestes decoratus* is parthenogenetic. *S. decoratus* is found only in the female form in this area and thus every individual is capable of reproduction and adding to the population explosion in the current high rainfall conditions which favour egg and nymphal survival.

In Oro Province two internal parasites of nymphs and adult 'Sexava' - *Segestidea nouvaeguinae* occur - they are the Tachinid fly, *Exorista notabilis* (Wlk), and the Stresipteran *Stichotrema dallatoreum* Hoff. Sometimes both parasite are found in the same host. Rates of parasitism vary greatly from area to area and during the year. The records of parasitism by *Exorista* from September 1985 number forty seven and give an average rate of parasitism of 43 percent for this insect. *Stichotrema* was recorded in twenty two collections and gave an average of 27 percent. In many cases both parasites occurred in the same collection and frequently in the same insect. Where both parasites were present combined levels of parasitism were usually above 60 percent and, at this level, numbers of Sexava were reduced with damage levels remaining below the economic threshold.

Since 1987 transfer of live parasitised 'Sexava' to areas where no parasites could be found resulted in establishment of both parasites after a few months. Numbers of parasitised 'Sexava' transferred were usually in the order of 30-40 adult insects.

Attempts to transfer both these 'Sexava' parasites from Oro Province to West New Britain have not so far resulted in success, principally because the emergence of adult *Exorista* parasites, had insufficient numbers of both sexes emerging simultaneously. In the case of *Stichotrema* the identity of the host of the male parasite has to be discovered. Oro Province remains fortunate in having both these parasites occurring naturally and although Sexava egg parasites have also been released, no proof of their field establishment has been recorded.

RECENT ADVANCES IN BIOLOGICAL CONTROL IN EARLY 1989

First proof of field establishment of laboratory reared Sexava egg parasites *Leefmansia bicolor* in West New Britain.

Over 3 million egg parasites have been reared and released from the PNGOPRA laboratory at Dami West New Britain since November 1985. In all areas where both chemical treatment and parasite releases were made no reappearance of Sexava has occurred during the past three years. However in January 1989 reports of a further outbreak at NBPOD's Navarai Plantation gave us the opportunity to collect Sexava eggs in fields near to sites where the parasite *Leefmansia bicolor* had been released six months previously. Two collections were made at Navarai and each batch of eggs were divided and placed either singly, or in groups, in tubes and containers.

The first parasites emerged from these field collected eggs on 7th February and continued to emerge until 5 March. *Leefmansia bicolor* emerged from eight different samples and in one case the total number of parasites recorded emerging from one Sexava egg was 52. The distance from the original release site to the recent collection sites is about 1 kilometer. This agrees well with the only previously recorded field release data in 1935 (Froggatt J.L. 1935) which gives 1.2 kilometres as being the range covered by this parasite after five months release in a coconut plantation.

Of additional interest was the recovery of two indigenous egg parasites which have been recorded in WNB previously by the author. The largest Sexava egg parasite, known as *Prosapegus* sp., was recorded from two samples, only one parasite emerges from each Sexava egg. A second indigenous parasite, probably a *Tetrastichus* species, was the most numerous; recorded from thirteen different samples. Little is known about the fecundity or efficiency of this species and it was interesting to record 62 *Tetrastichus* emerging from a single Sexava egg. Samples of both parasites are being sent to Dr. Huber (Canadian biosystematics unit) who expressed interest in Sexava egg parasites at the Entomology Congress in Vancouver last year.

The percentage parasitism in the two collections was 17 percent of which 7 percent was due to the introduced parasite *L. bicolor*. Although this low percentage may appear insignificant it has to be viewed as part of the total mortality affecting the Sexava population where the percentage of Sexava surviving to the adult stage on coconuts has been found to be as low as 8 percent of all eggs laid in the absence of any egg parasitism (Room et al 1984).

It is of interest to compare this field data with those of Frogatt's coconut data (1935) which gives 11,6 and 8 percent respectively for three parasites of Sexava eggs laid in the soil with a culmutive total of 25 percent. Levels of parasitism of Sexava eggs laid in epiphytes on the coconuts was 27 percent and in the crown of the palms 24 percent, giving an overall rate of egg parasitism of 25 percent.

Whilst the above information enables one to be optimistic in terms of establishing laboratory reared parasites in the field, cautious optimism remains for the ability for both introduced and indigenous egg parasites to limit Sexava population explosions when suitable climatic conditions prevail. However the rainfall pattern over the past two years in West New Britain has been very suitable for Sexava population development. At the end of the third year since regular parasite release were started, it is significant that no major outbreaks have occurred in the Hoskins development. In Bialla, where far fewer parasites have been released, a very large number of outbreaks have occurred during the prolonged wet weather and are continuing to spread, particularly among smallholdings. The Bialla scheme is now receiving most of the egg parasites produced and will continue to do so over the rest of this year.

References

Froggatt, J.L. (1935) The Longhorned tree-hopper of coconuts Sexava spp. New Guinea agric. Gaz 1, 16-27.

Room P.M. et al. (1984) A population study of the coconut pest *Segestidea uniformis* on an equatorial island. Bull. ent. Res. 74, 439-451.

INVESTIGATION 606 BAGWORM (*Psycididae*) CONTROL.

Throughout this year, which had well above average rainfall for all the oil palm development areas, no significant damage by any bagworm species occurred.

INVESTIGATION 605 RECORD AND OBSERVATION ON OTHER PESTS.

Longicorn beetle: *Mulciber linnaei* in Oro Province.

Damage by *M. linnaei* was first recorded in September 1982 where its larvae were found tunnelling inside the frond rachis on moribund oil palms affected by lightening strike. In July 1984 damage by the adult beetle was observed on leaves of oil palms in the same area and up to six adult beetles were found resting around the base of the central spear on affected palms. *M. linnaei* causes considerable damage to *Pandanus* spp and its characteristic rough edged holes, about 1cm across, often reduced *Pandanus* leaves to a 'lace curtain' effect.

In 1984 this beetle was observed on oil palms over a wide area in Oro Province. In June this year, larval damage was confirmed on numerous palms growing on three smallholdings at Sehora, Oro Province. The palms were 2 1/2 years old and in a very poor condition. Damage to several fronds per palm was severe and death of the frond occurred following destruction of the internal tissue of the rachis by the beetle larva. It is considered that this attack by *M. linnaei* was because of the extremely poor condition of the palms and as such it was an exceptional occurrence.

Treatment recommendations were as follows:-

1. In very young palms, by trunk injection using a smaller diameter drill and only 5ml of concentrated monocrotophos. The systemic applied by trunk injection would reach the larvae inside the frond rachis. Larval damage was easily confirmed by splitting the rachis longitudinally when both tunnelling and larvae were revealed.

2. A mixture of moist sawdust and Lindane granules were applied around the central spear. This technique, used for Rhinoceros beetle control, is to control adult M. linnaei which were found resting in between the fronds and the spear, and against which the smell of Lindane should have a repellant effect. During the dry season in Oro Province this method should give a longer period of protection to young palms than any insecticide applied as a spray.

1 Kg of Sulphate of Ammonia was applied to each palm at the same time as the insecticide treatments. In November 88, apart from a few palms which had died from a combination of insect attacks and poor nutritional condition, the affected blocks had fully recovered and no further insect damage was observed.

<u>Stick Insects: *Eurycantha* species (Phasmidae)</u>

A *Eurycantha* species damaged smallholder blocks at Igora in April and at Korupata in May and August. Damage was light to moderate and usually in conjunction with 'Sexava' damage. No treatment of this insect was recommended and although parasitism by a tachinid has been confirmed, no adult flies have emerged to identify the fly species. More specimens of the *Eurycantha* have been sent to the E.I.E. in London for a species dertermination.

<u>Sugarcane Weevil, *Rhabdoscelis obscurus* (Coleoptera, Curculionidae)</u>

No damage by this insect to unripe or ripe bunches has been recorded this year. However examination of sugarcane stools in a garden at Dami research station, West New Britain, revealed several larvae which had been parasitised by a Tachinid. This is believed to be the first record of *Rhabdoscelis* parasites outside the Port Moresby area.

INVESTIGATION 608 *SCAPANES* CONTROL. (*Coleoptera, Dynostidae*)

Observations were concluded in September this year on two 1000 palm plots on Bebere Plantation, West New Britain set up in December 1986. One plot was clear felled prior to replanting and one was underplanted and then subsequently the mature palms were poisoned and left standing. After initial damage of between 1 and 4 percent of the underplanted palms and no damage to the control plot, recovery of some of the damaged palms resulted in a net loss of between 1 and 2 percent.

No further incidence of damage has been recorded for this year and the palms are now considered old enough to withstand any subsequent damage by *Scapanes*. It would be pre mature to draw any firm conclusions from the observations on these plots as they did not exactly represent what is happening in practice with the replanting phase. However, in conjunction with reports from Bebere plantation it can be said that the incidence of *Scapanes* damage in underplanting has not been any greater than is usually experienced under the clear felling system, and at 1-2 percent damage it is quite uneconomic to consider any form of chemical treatment.

An interesting development in October with the underplanting programme was the severe damage by *Scapanes* to one smallholder block at Galai sub-division. Here 43 palms out of 245 were damaged by *Scapanes* which at 18 percent, is an unacceptably high level of damage. On investigation it was noticed that the block was very dark and although it had been scheduled for poisoning, prior to underplanting, the work had not been carried out.

On the estates a heavy pruning round is commenced before underplanting and poisoning is scheduled to be done about a year later. Previously the only serious level of damage by *Scapanes* was recorded in the underplanted plots in the OPRA *Ganoderma* trial, where it was also very dark and over-shaded, and there may be a connection between the two incidents. It has been conveyed to DAL that they should endeavor to keep their replanting programme in step with the poisoning of the palms to avoid a repetition of this damage. Because *Scapanes* damage is often locally severe due to proximity of suitable breeding sites in recently felled forest, these few observations cannot be conclusive. However it is encouraging to report that with the quite extensive replanting carried out to date, on both smallholder and plantations, no serious incidence of *Scapanes* damage has been reported outside those discussed here.

In conjunction with work on *Scapanes* in coconuts carried out by the Cocoa and Coconut Research Institute in East New Britain, future control strategy may incorporate pheromone baiting systems if pheromones are identified in studies on *Scapanes* behaviour.

PATHOLOGY

In Oro Province, crown and stem rotting occurred in many oil palm smallholder blocks, mainly on Isavene sub-division, but also on Sorovi, Wasita, and Sangara. Most of the affected blocks had less than 6 palms diseased, but one block on Isavene recorded 26 dead palms, which must be the largest number ever recorded for one locality in P.N.G. Many of the palms collapsed with middle or upper stem rot. Possible fungal causative organisms *Phellinus noxius* and *Ganoderma* were reported. A full investigation was carried out by Dr. Peter Turner, Director of the Cocoa and Coconut Research Institute who considered that the very poor nutrional condition of the palms could have predisposed them to infection.

Two experiments are ongoing in the Mosa area of West New Britain to monitor incidence of lower stem rot:

EXPERIMENT 801, Incidence of Ganoderma disease (H.L.F.)

This experiment was set up in 1982 in Section 9 of Bebere, to monitor the incidence of *Ganoderma* disease after replanting. 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. Since 1984, samples of seedlings have been dug up every year, split and the stem and root tissues examined for any sign of fungal infection.

In 1988, a total of 300 seedlings were examined and as in all previous years, not one showed any sign of infection. All the remaining seedlings will be dug up and inspected next year.

EXPERIMENT 803, Ganoderma pathogenicity tests (H.L.F.)

In this experiment established in the Dami beach area, infected palm wood was buried at the base of young field palms. In 1988, five years later, no visual signs of any infection by *Ganoderma* has been observed.

PUBLICATIONS

Antony,G., Kauzi,G.Y. and Prior,R.N.B.(1988). Returns to research on insect pollination of oil palm in Papua New Guinea ACIAR Project Paper No. 10

Navus,P.R. (1988) Effective ways of ensuring maximum harvesting of smallholder oil palm blocks in West New Britain, Papua New Guinea. M.Sc. (Agric.Ext.) Thesis. Reading University

PNGOPRA (1988). "Sexava". Its life history, biological and chemical control. PNGOPRA Advisory Leaflet No.2

Prior, R.N.B. (1988). Biological control in pest management of oil palms in Papua New Guinea. Proc. XVIII International Congress of Entomology, Vancouver.

APPENDIX I

Table 104: Meteorological Data, Dami, 1988

	Rainfall mm		Rainy days		Sunshine (h/m)	
	1970-88	1988	1970-88	1988	1970-88	1988
January	643.9	855.0	24.7	29	115.8	104.1
February	648.9	1005.6	23.9	23	109.9	84.9
March	521.8	255.4	25.0	19	123.9	153.9
April	355.5	413.8	21.2	21	149.6	139.3
May	234.1	314.2	17.8	17	167.2	152.1
June	152.2	133.8	16.0	17	161.1	141.6
July	188.7	354.2	15.7	20	151.8	136.0
August	159.0	420.8	15.1	20	179.4	178.7
September	178.5	182.0	13.9	16	179.5	151.6
October	174.9	443.2	15.2	20	178.4	130.7
November	248.5	274.4	17.8	22	174.3	125.2
December	411.2	832.8	22.7	24	128.4	113.4
Total	3917.4	5485.2	229.0	248	1819.2	1611.5

Table 105: Rainfall (mm) all sites 1988

	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
<u>W.N.B. PROVINCE</u>													
Dami	855	1006	255	414	314	134	354	421	182	443	274	833	5485
Bebere	868	1224	242	214	127	128	146	331	155	260	273	491	4459
Kumbango	552	947	538	122	84	2	210	53	120	114	132	950	3824
Hargy	986	1789	254	312	63	257	NR	NR	NR	NR	NR	695	NR
Navo	1309	2054	322	413	185	200	184	233	277	401	231	801	6610
<u>ORO PROVINCE</u>													
Arehe	387	183	232	249	140	138	306	124	232	311	217	192	2711
Ambogo	313	186	243	214	209	97	231	147	164	317	259	217	2597
Isavene	305	275	146	183	164	108	225	113	191	284	273	199	2466
<u>MILNE BAY PROVINCE</u>													
Hagita	126	237	174	222	165	28	168	45	115	25	97	335	1737

(NR = Not recorded)

Table 106: Meteorological Data, Higaturu 1988

	Rainfall mm			Sunshine hrs			Rainy days		
	1987	1988	1981-88	1987	1988	1981-88	1987	1988	1981-88
January	327	387	257	172	132	157	23	21	18
February	157	183	253	99	154	125	21	19	20
March	586	232	348	174	170	165	25	21	20
April	307	249	255	153	177	170	24	18	19
May	114	140	180	216	205	178	11	17	15
June	61	138	163	161	123	140	11	14	16
July	34	306	96	203	190	168	5	19	10
August	23	113	116	100	187	179	10	14	14
September	276	232	159	136	187	174	16	14	13
October	96	311	228	225	206	186	12	24	18
November	103	217	236	223	184	187	12	20	17
December	277	192	293	146	143	154	23	22	20
Total	2361	2700	2584	2108	2058	1983	193	223	200

APPENDIX II

THE ASSOCIATION'S ACCOUNTS FOR 1988

Auditor's Report to the members of Papua New Guinea Oil Palm Research Association Inc.

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 1988 and of its income and expenditure for the period ended on that date.

Price Waterhouse
Chartered Accountants
Lae, 29th March 1989

Balance sheet as at 31st December, 1988

	KINA	
Accumulated funds	1988	1987
	84,726	159,322
Represented by:		
FIXED ASSETS (Note 2).....................	88,927	49,498
CURRENT ASSETS:		
Cash at bank and on hand..................	6,769	91,652
Debtors...................................	89,850	110,992
	96,619	202,644
CURRENT LIABILITIES:		
Trade Creditors..........................	78,897	78,352
Other Creditors and Accruals.............	21,923	14,458
	100,820	92,810
Net Current (liabilities)................ Assets	(4,201)	109,834
	84,726	159,332

Statement of Income and Expenditure for the year ended 31st December 1988

	KINA	
INCOME:	1988	1987
FFB Levy................................	372,541	379,527
Profit on Disposal of Fixed Assets.......	-	1,499
Interest received.......................	3,845	15,895
Government grant received...............	100,000	93,300
	476,386	490,221
EXPENDITURE;		
Agency, Audit, Legal and Professional fees	13,917	14,057
Bank charges............................	975	1,309
Depreciation............................	27,581	13,915
Direct experiment costs.................	59,981	57,936
Electricity, water and gas..............	14,547	15,376
Insurance...............................	2,518	8,305
Laboratory..............................	886	504
Medical.................................	4,424	4,908
Motor vehicle...........................	24,769	33,705
Office expenses.........................	22,906	14,411
Rentals and other accommodation costs....	84,312	73,951
Repairs and Maintenance - buildings......	19,166	20,413
Salaries, wages and allowances...........	248,941	211,235
Staff recruitment.......................	7,972	10,440
Staff training..........................	2,499	6,484
Travel and entertainment................	12,724	23,473
Loss on disposal of fixed assets.........	2,874	-
	550,992	510,422
(DEFICIT)/SURPLUS FOR THE YEAR	(74,606)	(20,201)
ACCUMULATED FUNDS BROUGHT FORWARD	159,332	179,533
ACCUMULATED FUNDS CARRIED FORWARD	84,726	159,332

The accompanying notes form part of these accounts.

NOTES TO AND FORMING PART OF THE ACCOUNTS
31 December 1988

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	
	1988	1987
Household, office and laboratory, furniture and equipment at cost.........	64,138	47,039
Less accumulated depreciation...........	18,759	19,955
	45,379	27,084
Motor vehicles at cost..................	95,173	59,691
Less accumulated depreciation...........	51,625	37,277
	43,548	22,414
Total written down values...............	88,927	49,498

CAPITAL COMMITMENT

Capital expenditure authorised and contracted for totalled K Nil (1987 K Nil).

MANAGEMENT BOARD'S STATEMENT 31 DECEMBER 1988

We, F.E. McGuire 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 1988 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

F.E. McGuire

J.P.C. Baskett

Lae
28th March 1989

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 1988 and of the results for the period ended on that date.

A.R. McMASTER
SECRETARY

Lae,
28th March 1989

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	7
"DLQ" houses	2
"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
Sirogo house	1
Supervisor's houses	2
Intermediate	1
Labour houses	3

APPENDIX IV

ALLOCATION OF VEHICLES

Vehicle	Reg.No.	User	Purchased	Km run
Toyota Hilux 4WD (twin)	AFL 659	DOR	3/88	15,640
Toyota Hilux 4WD (single)	AFH 562	Oic, Higaturu	5/88	21,217
Toyota Hilux 4WD (single)	AFF 235	Soils Agron.	8/87	55,180
Toyota Hilux 4WD (single)	AEJ 558	Entomologist	11/83	100,695
Daihatsu Delta	AHA 967	Driver (Dami)	2/86	(N.R.)
Daihatsu Scamp 4WD	AKA 951	Asst. Agron.	1/86	54,996
Toyota Hilux 4WD (single)	AEQ 283	Driver (HOPPL)	3/85	153,919
Yamaha XT 125	AO 057	Agron (HOPPL)	9/87	22,867

(N.R.= Not recorded)

APPENDIX V
LIST OF INVESTIGATIONS

Number	Location	Title	Initiated	Concluded
AGRONOMY				
101a	Bebere	NPKMgMnP factorial fertilizer trial	1968	1982
101b	Bebere	Leaf nutrient monitoring plots	1982	1984
102a	Dami	Density/fertilizer trial	1970	
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 crop 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	
121	W. Nakanai	Smallholder Demo/Trial series	1988	
201	Hargy	Fertilizer trial	1982	
202	Hargy	Refuse manurial trial	1984	1988
203	Navo	Effect of establishment phosphate	1986	1988
301	Higaturu	Monitoring plots	1977	1982
302	Higaturu	Monitoring plots	1977	1982
303	Higaturu	Monitoring plots	1978	1983
304	Higaturu	Sources of potash and nitrogen trial	1979	1982
305	Arehe	Fertilizer factorial experiment	1981	
306	Arehe	Fertilizer factorial 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 Fertilizer Trial	1988	
312	Ambogo	NK Fertilizer Trial	1988	
313	Higaturu	Soil assessment trial	1988	
314	Higaturu	Smallholder demonstration Trials	1988	
315	Higaturu	Smallholder rehabilitation trials	1988	
316	Higaturu	Cover Crop Investigations	1988	1988
501	Hagita	Establishment fertilizer trial	1986	
503	Hagita	Nursery fertilizer trial	1987	1988
505	Waigani	Trace element trial	1988	1988

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	
PHYSIOLOGY			
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	
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	
PATHOLOGY			
801	Incidence of Ganoderma disease	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