ANNUAL REPORT

OF

THE PAPUA NEW GUINEA OIL PALM RESEARCH ASSOCIATION

1986

SIXTH ANNUAL REPORT

of the

PAPUA NEW GUINEA OIL PALM

RESEARCH ASSOCIATION

1986

CONTENTS

INTRODUCTION

PART I. ADMINISTRATION AND DEVELOPMENT

PART II. RESEARCH

AGRONOMY

PHYSIOLOGY

ENTOMOLOGY

PATHOLOGY

WEED CONTROL

APPENDICES

MANAGEMENT BOARD

CHAIRMAN	R.A. Gillbanks (to March) F.E. McGuire (from March)
NEW BRITAIN PALM OIL DEVELOPMENT LTD.	J.R. Gilbert
DEPARTMENT OF PRIMARY INDUSTRY	R. Doery/J. Christensen (alternate to Secretary, DPI)
HARGY OIL PALMS PTY. LTD.	N. Van der Laan
HIGATURU OIL PALMS PTY. LTD.	F.E. McGuire
MILNE BAY ESTATES	N. Hanson
DIRECTOR OF RESEARCH	T. Menendez

In attendance

MANAGING AGENTS REPRESENTATIVE AND SECRETARY	J.F.W. Benn
BY INVITATION	T. Fleming

SCIENTIFIC ADVISORY BOARD
as at 24th October, 1986

F.E. McGUIRE	Chairman, PNGOPRA
R. DOERY	Department of Primary Industry
J. PIGGOTT	Higaturu Oil Palms Pty. Ltd.
N. VAN DER LAAN	Hargy Oil Palms Pty. Ltd.
P.D. TURNER	New Britain Palm Oil Development Ltd.
T. MENENDEZ	Director of Research

In attendance

J.F.W. BENN	Secretary, PNGOPRA

By invitation

A. BENTON	Higaturu Oil Palms Pty. Ltd.
J.A. VUGTS	New Britain Palm Oil Development Ltd.
N. HANSON	Milne Bay Estates Pty. Ltd.
T. FLEMING	Harrisons Fleming Advisory Services Ltd.
E.A.ROSENQUIST	Harrisons Fleming Advisory Services Ltd.
H.C. HARRIES	New Britain Palm Oil Development Ltd.
R.N.B. PRIOR	Entomologist, PNGOPRA
R.L. ATHERTON	Soils Agronomist, PNGOPRA
M.VUGTS-HOVERS	Agronomist, PNGOPRA
M. SHEARER	Cranfield Institute of Technology

EXECUTIVE STAFF

DIRECTOR OF RESEARCH	T. Menendez, B.Sc., DPB., M.I. Biol.
AGRONOMIST	Ir. M. Vugts-Hovers.
SOILS AGRONOMIST (Higaturu)	R.L. Atherton, B.Sc.
ASSISTANT AGRONOMIST	P. Navus, B.Ag. Sc.
RESEARCH ASSISTANT	P. Sereva, B.Ag. Sc.
ENTOMOLOGIST[1]	R.N.B. Prior, M.Sc.

NON-EXECUTIVE STAFF

PRIVATE SECRETARY	C. Pa'Agau (to May)
	A. Kaile (June to December)
SENIOR TECHNICAL ASSISTANT	S. Embupa
TECHNICAL ASSISTANT	D. Tomare (Higaturu)
SUPERVISORS	B. Rimandai
	D. Yapasi (Higaturu)
SENIOR FIELD ASSISTANT	J. Nagi (Hargy)
RECORDS CLERK	C. Golu
TYPIST/CLERK	A.Pagiran (July-December)
RECORDER CLERICAL	B. Bubu
SENIOR RESEARCH RECORDER	B. Lukara
RESEARCH RECORDER	P. Sio
RECORDERS	J. Dapo
	S. Makai
	W. Kanama (Higaturu)
	G. Betari (Higaturu)
	G. Bonga (Higaturu)
	M. Yaura (Higaturu)
	P. Lus
	A. Poka
	J.Yalikua (from July)
DRIVERS/HANDYMEN	K. Duke
	E. Luscombe (Higaturu)

---

1. on attachment from Department of Primary Industry

CHAIRMAN'S STATEMENT

Concern over palm product prices came to fruition with a vengeance and the year to December 1986 was indeed a traumatic one for the oil palm industry in PNG, with all time lows in the price of both palm oil and palm kernels being experienced.

The effect on all sectors of the oil palm industry was devastating but with stringent economies we have survived - a tribute to our inner strengths of which this Association is one.

Work in all traditional areas of research continued (excepting pathology which was temporarily shelved due to lack of staff), with particular emphasis on nutrition and entomology.

Our attempt to introduce *Mystrops costaricensis* as a back-up pollinator particularly for drier areas, had to be abandoned resulting from the discovery of its polyphagus nature. The project will continue however, and our attention is now focusing on another *Elaeidobius* species - *E. plagiatus*.

Nutritional trials continued apace with more emphasis on smallholder blocks although the logistics are immense. In addition, the Association had the assistance of two students from the Cranfield Institute of Technology, who conducted preliminary investigations into herbicide usage and methods. It is hoped to build on these initial findings this year and produce some definitive recommendations.

Financially, the Association has benefited first and foremost from the support of its members, who have continued to contribute at a rate of K0.80 per tonne FFB. The financial burden has, however, been considerably eased by the assistance from the National Government in the form of a grant of K116,000 for 1986, with a promised further payment of K93,000 for 1987.

This generous help will go a long way to ensuring the Association remains a viable and effective organisation.

Thanks must go to Mr. Menendez, the Director of Research, and his staff for their efforts during the year. Sadly Marita Hovers leaves the Association in April of this year, and our best wishes go with her. One new member of staff, Allan Oliver, has been recruited in February to strengthen the team at Popondetta and we bid him welcome.

My gratitude is also extended to the Managing Agents and our Secretary for their hard work and assistance during the year.

Finally I would like to express my thanks to my fellow members of the Management and Scientific Advisory Boards for their continued support in 1986 and a further appreciation is extended to Mr. Roger Gillbanks, chairman of the Association since its foundation and moving force for many years, who left the industry during the period. We wish him well in his new venture.

F.E. McGuire

PART 1. ADMINISTRATION AND DEVELOPMENT (T.M.)

MANAGEMENT BOARD AND SCIENTIFIC ADVISORY BOARD

The Management Board met twice, at Lae on 13th March and at the Dami Research Station of New Britain Palm Oil Development on 24th October. The Fifth Annual General Meeting of the Association was held in Lae on 13th March. At this meeting Mr. F.E. McGuire was elected as Chairman. Messrs. Harrisons and Crosfield (PNG) Ltd were re-appointed as Managing Agents for the coming year.

To the Association's regret Mr. R.A. Gillbanks had announced his retirement from Harrisons and Crosfield (PNG) Ltd and consequently P.N.G.O.P.R.A. As the person who was the Association's principal architect and one who was confident of the value of appropriate scientific research, his personal knowledge and encouragement will be very much missed.

The Scientific Advisory Board met once at Dami Research Station on the 23rd October, after a trip to trials on estates and adjacent oil palm blocks during the previous day. There were again changes to the membership of this Board, Dr. J. Piggott returning as the representative of Higaturu Oil Palms Pty. Ltd. Amongst those attending the meeting were also personnel from the member companies and Mr.T.Fleming and Mr.E.A. Rosenquist of Harrisons Fleming Advisory Services Ltd. It was agreed this Board would meet in Oro Province next year.

FINANCE

Income from the levy from growers of 80 toea per tonne of fresh fruit bunches was 30% more than estimated expenditure. Because of the falling price of palm oil, with corresponding poor financial prospects for the industry in the immediate future, actual expenditure had been minimized to 93% of these estimates, leaving a surplus for the year of K40,785 and accumulated funds of K75,028. The latter gave only a very small reserve.

Messrs. Price Waterhouse were re-elected as auditors.

STAFF

Stability of executive staff was enjoyed throughout the year. The Department of Agriculture and Livestock's Senior Entomologist, Mr. R.N.B. Prior, continuing his attachment to PNGOPRA. The Agronomist and Soils Agronomist, who had been appointed in 1985, settled into their work as they gained experience of the oil palm and local conditions. Two post graduate students, who had completed studies towards M.Sc. degrees at the International Centre for Applied Pest Control at the Department of Bio-aeronautics of the Cranfield Institute of Technology in England, were engaged to complete a project on the control of weeds in West New Britain. During the course of this work Mr. Sereva (Research Assistant) was trained in methods appropriate to this kind of research. The students were Mr. M. Muncey from June to September and Miss. M. Shearer from September to December. They were supported by student travel grants from their home Institute. They gained valuable experience of work overseas and the Association was able to work economically in an unfamiliar area of research and to augment the specialist skills of its staff. This kind of arrangement again encouraged similar exercises in the future.

Amongst the Junior staff at Dami there was extended disruption at the secretarial/clerical level after the resignation of the Confidential Secretary. At Higaturu it also took time to find a suitable replacement for the records clerk. This situation had stabilized by the end of December. One additional recorder was engaged at both Dami and Higaturu.

Mid-year salary increments were paid to all staff. Non-executive staff also benefited from a revision of wages in March to offset increases in the cost of living.

The distribution and establishment of staff during 1986 and recommendations for 1987 were as follows:

Post	Base	Filled as at 31/12/85	31/12/86	Recommended 1987
Director of Research	Dami	1	1	1
Agronomists	Dami	1	1	1
	Higaturu	1	1	1
Assistant Agronomists	Dami	1	1	1
	Higaturu	0	0	1
Research Assistant	Dami	1	1	1
Entomologist	Dami	1	1	1
	Totals	6	6	7
Private Secretary	Dami	1	1	1
Accounts Clerk	Dami	1	1	1
Typist/clerk	Dami	0	0	1
Recorders (clerical)	Dami	1	1	1
	Higaturu	1	1	1
Driver/handyman	Dami	1	1	1
	Higaturu	1	1	1
Supervisors	Dami	1	1	1
	Higaturu	1	1	1
Senior technical assistants	Dami	1	1	1
Technical assistants	Higaturu	1	1	1
Senior field assistants	Hargy	1	1	1
Field assistants	Dami	1	1	1
	Milne Bay	0	0	1
Recorders	Dami	6	7	7
	Higaturu	4	5	5
	Totals	22	24	26

TOURS AND VISITS

For most of the staff there was little contact with scientists outside Papua New Guinea with the exception of visitors recorded on page*. Apart from this, the Director of Research while on leave in May visited C.J. Breure, Dr. Van Heel and Mr. Made at the Department of Tropical Agriculture and the Statistical Unit at Wageningen, Holland, the Director of the Agricultural Extension and Rural Development Centre at the University of Reading, England, and the International Centre for the Applications of Pesticides at the Cranfield Institute of Technology, England. From 26th March to 24th May, the Senior Entomologist was in England at the Pathology Laboratories of the Ministry of Agriculture, Harpenden, England, where he was also in contact with scientists at the Commonwealth Institute of Biological Control and the quarantine facilities at the Royal Botanic Gardens, Kew.

In Papua New Guinea the visits requiring overnight accommodation by executive staff are summarized below. During one visit to Port Moresby the Senior Agronomist remained on duty from 24th May to 28th June to handle *Mystrops* in quarantine. The Assistant Agronomist's visit to Oro Province was extended in order for him to act as officer-in-charge while the Soils Agronomist was on leave.

	Dami	Bialla	Lae	Markham Farming	Oro	Milne bay	Konedobu	Goroka	Total
Director of Research	-	1	2	-	2	1	1	1	8
Senior Entomologist	-	1	3	1	-	-	3	-	8
Soils Agronomist	1	1	-	-	-	2	-	-	4
Agronomist	-	4	-	-	-	-	-	-	4
Assistant Agronomist	-	1	-	-	1	-	-	-	2
Research Assistant	-	4	-	1	-	-	-	-	5
TOTALS	1	12	5	2	3	3	4	1	31

In West New Britain smallholder's blocks and Bebere, Kumbango, Togulo, Malilimi plantations of NBPOD were visited regularly from Dami as was Kapiura plantation. In Oro Province smallholder's blocks were also visited regularly and the Soils Agronomist and Senior Entomologist also visited Mamba plantation from Higaturu.

PUBLICATIONS AND REPORTS

A paper entitled "The early development of inflorescences and flowers of the oil palm seen through the scanning electron microscope" by Van Heel, Breure and Menendez was circulated to the Board and later published in Vol.32, No.1 of Blumea. Summaries of three papers to be presented at the 1987 Oil Palm Conference in Malaysia were similarly circulated. These were, "The results of thinning oil palm in West New Britain" by T. Menendez, "Insect pests of oil palm in Papua New

Guinea and their control" by R.N.B. Prior, and "Insect pollination of oil palm in Papua New Guinea" by Prior and Menendez. The last of these was later shelved.

LIBRARY

The library was maintained and administered by NBPOD at Dami, with some support and subscriptions from PNGOPRA who also shared the wages of a librarian.

VISITORS

Visitors recorded at the Directorate of Research at Dami and the station at Higaturu Oil Palms (with apologies to those who escaped the recording system) were:-

Adams M.T., Harcros Trading (PNG) Ltd., Lae.
Adzmi Hassan, Palm Oil Registration and Licensing Authority, Kuala Lumpur, Malaysia.
Baker G., Remington Office Machines, Lae.
Balu N., Palm Oil Registration and Licensing Authority, Kuala Lumpur, Malaysia.
Barnes A.J., Department of Primary Industry, Kimbe.
Burton G., Analytical Services Ltd., Cambridge, New Zealand.
Beck A.R., Ain & Mexie, Media Niugini Pty Ltd., Port Moresby.
Belawa W., Secretary, Department of West New Britain, Kimbe.
Benton A.A., Higaturu Oil Palms Ltd., Popondetta.
Beoit Alphonse, Papua New Guinea University of Technology, Lae.
Bruce Smith G., Harcros Trading (PNG) Ltd., Lae.
Charles des Bordes, Papua New Guinea University of Technology, Lae.
Brownlie A., I.C.I. (PNG) Ltd., Lae.
Cassell B., Papua New Guinea University of Technology, Lae.
Catton N., WestPac Bank (PNG) Ltd., Port Moresby.
Chotisakul Sanskin, Department of Agriculture and Extension, Bangkok, Thailand.
Cocks J.B., MacKay, Queensland Australia.
Collins M., Commonwealth Development Corporation, London, U.K..
Dickson I.A., Kapiura Plantations Ltd., W.N.B.P.
Doery R.C., Department of Primary Industry, Konedobu.
Elias R., Melanesian Oil Products, Lae.
Fleming T., Harrisons Fleming Advisory Services Ltd., London, U.K.
Gau J., Malaysian High Commission, Port Moresby.
Gilbert J.R., Harrisons & Crosfield (PNG) Ltd., Lae.
Gilbert W., Lae.
Gregory, J., Australian High Commission, Port Moresby.
Grose C., Pohamba Estate, Kavieng.
Grose J., Pohamba Estate, Kavieng.
Greasly W.A., Harrisons Fleming Advisory Services Ltd., London, U.K.
Holmes J., Cairns, Australia.
Howell J., Port Moresby.
Howell M., High Commissioner for Great Britain, Port Moresby.
Ismay J.W., Department of Primary Industry, Konedobu.
Jacobsen J.H., "Swambu" Plantation, Lae.
Jenkins R., I.C.I. (PNG) Ltd., Lae.
Khoo Hy., Singapore.
Kerina R.B., Harrisons & Crosfield (PNG) Ltd., Lae.
Kerrigan N., Dow Chemicals, Townsville, Australia.
Kohun Pikah, Papua New Guinea University of Technology, Lae.
Lawrence W.A., Travelodge, Port Moresby.
Leitch R., WestPac Banking Corporation, Sydney, Australia.
Lindsay R.W.H., Harrisons & Crosfield Ltd., London, U.K..
Luckie B., WestPac Bank (PNG) Ltd., Kimbe.
Maniha N., Papua New Guinea University of Technology, Lae.

Marsh A., New Britain Palm Oil Development, Mosa.
McConnachie D., WestPac Bank (PNG) Ltd., Lae.
McGuire F.E., Higaturu Oil Palms Ltd., Popondetta.
McLeod J., Harrisons & Crosfield PLC, London, U.K..
McLeod S., Harrisons & Crosfield PLC, London, U.K..
Merret Peter, Papua New Guinea University of Technology, Lae.
Montgomerie J., New Britain Palm Oil Development, Mosa.
Morris P., Remington Office Automation, Lae.
Nuli Caspar, Kimbe.
Ongapa L., National Broadcasting Commission, Port Moresby.
Paul G. & M., Harrisons & Crosfield PLC, London, and Pauls PLC, Ipswich, U.K..
Piggott C.J., Higaturu Oil Palms Ltd., Popondetta.
Popp T., BASF Agricultural Research Station, Limburgerhof, Federal Republic of Germany.
Preston T.D., Harrisons & Crosfield Pty Ltd., Sydney, Australia.
Remaus R., Ponini Agriculture Centre, W.N.B.P..
Rovi G., National Broadcasting Commission, Kimbe.
Sassah R. Sevua, Papua New Guinea University of Technology, Lae.
Sherrington J., Department of Primary Industry, Konedobu.
Skym G.C., I.C.I. (PNG) Ltd., Lae.
Smith R., Australian High Commission, Port Moresby.
Taisiri Boonruska, Department of Agriculture, Bangkok, Thailand.
Tanabe Yasuo, Sumito Australia Ltd., Port Moresby.
Tanner B., WesPac Bank (PNG) Ltd., Port Moresby.
Turner P.D., Harrisons Fleming Advisory Services Ltd., London, U.K..
Van der Laan N., Hargy Oil Palms Pty Ltd., Bialla.
Vatasan G., Papua New Guinea University of Technology, Lae.
Wadsworth B., Dow Chemical (Australia) Ltd., Sydney, Australia.
Wilson M., Harcros Trading (PNG) Ltd., Kimbe.
Wilson M., High Commissioner of Australia, Port Moresby.

PHYSICAL DEVELOPMENT

Buildings

The revamped offices at Dami were fully occupied in May and have worked out well, providing a better feeling of unity for the staff and much more convenient working conditions.

Executive staff continued to be accommodated as previously at Dami and Higaturu Oil Palms. The field assistant based at Bebere was relocated to Dami. Accommodation for non-executive staff was not entirely satisfactory outside Dami, however, the solution clearly will be for appropriate housing to be constructed specifically for PNGOPRA wherever its sub-stations are placed. The allocation of rented buildings is shown below.

	31/12/85	31/12/86
N.B.P.O.D.		
Offices and laboratory (rooms)	7	7
Entomological building	1	1
Storerooms	4	4
"M" houses	1	1
"A" houses	2	2
"AR" houses	1	1
"IB" houses	3	3
Junior Grade quarters	7	7
Double labour quarters	0	1
Single man's quarters	1	1

HARGY OIL PALMS		
Office	1	1
Bossboi quarters	1	1
HIGATURU OIL PALMS		
Agronomy Building	1	1
Entomological Office	1	1
Insectory	1	1
Executive Duplex	1	1
Supervisors quarters	2	2
Bossboi quarters	1	1
IM quarters	1	1
Labour quarters	2	2

Vehicles

The High-Ace Commuter used to carry workers to the field and other haulage was replaced with a Daihatsu Delta truck with bench seats and canopy fitted to the tray. A small four wheel drive Daihatsu Scamp utility was purchased for additional work on smallholdings. At Milne Bay it was necessary to hire a vehicle. All vehicles were kept in good running condition throughout the year. The pick-up utility allocated to the Entomologist and the Director of Research's vehicle at Dami were not replaced in November after 3 years use as planned, because it was decided as an economy to run vehicles until their replacements were considered unavoidable. They were surveyed and the cost of overhauling them was taken into consideration. The fleet of work vehicles is listed below.

Vehicle	Reg.No	Customary user	Purchased	Km run at 31/12/86
Toyota				
Hilux 4WD twin cab utility	AEJ 558	Director of Research	Nov. 1983	50,438
Hilux 2W single cab utility	AEJ 601	Entomologist	Dec. 1983	84,532
Hilux 4WD single cab utility	AEJ 621	Agronomist	Jan. 1984	78,385
Hilux 4WD single cab utility	AEQ 283	Driver/handyman Higaturu	Mar. 1985	81,330
Daihatsu				
Scamp 4WD single cab utility	AKA 951	Asst Agronomist	Jan. 1986	25,062
Delta 2WD single cab truck	AHA 967	Driver/handyman	Feb. 1986	38,326

Services

At Dami the PBX functioned satisfactorily only to the offices. A proportion of the costs was paid to NBPOD on the basis of half the rental and a count of the number of calls made. A telephone in the office at Higaturu would have been particularly useful but it was not possible to obtain this. Telex and facsimile services were enjoyed from NBPOD, Harcros Trading, Harrisons & Crosfield and Higaturu Oil Palms at cost. Electricity was well supplied at Dami and Higaturu throughout the year. At Dami costs for power were pro-rated at approximately 20%. Also at Dami a new piped water supply from the Ko creek installed by NBPOD began to serve non-executive quarters and offices in Dami, much improving the living conditions of those affected. Because of the cost of pumping water at Dami proportional charges were instituted for water to commence in the New Year. Rented executive houses, with their larger area of roof, were in the main satisfactorily supplied by rainfall provided that strict economy was enforced in prolonged dry weather. Because of worsening conditions in the area an additional security guard was engaged at Dami and paid for by PNGOPRA.

Medical services were provided as usual, with charges pro-rated at Dami and Mosa. Staff requiring treatment at local hospitals or clinics were transported as necessary. At Mosa the company doctor visited at regular intervals. Generally, hospital and doctor's services had shortfalls locally.

Driving was much improved in Oro Province by the roads being macadamized. Roads in West New Britain were good on the tar but bad off it. Some stretches of road to Kapiura and Bialla remained in particularly poor shape and inaccessible in wet weather where the earthquake of 1985 had confused the issue or where adequate culverts had not been introduced.

P A R T   II   R E S E A R C H

AGRONOMY

WEST NEW BRITAIN PROVINCE

(M.V.H.)

Experiment 106: Fertilizer experiment on young, replanted palms, Bebere

Planted in August 1982 at 135 palms/ha, 1152 palms (recorded and total). Area 8.5 ha. The site had previously been under oil palm for 14 years.

Design: Two replicates of a 3x2x3x2 factorial (N,P,K/Mg and age of planting material). The 72 plots were arranged in 6 blocks of 12 plots, each with 16 recorded palms, without guard rows between plots.

Treatments: Fertilizers, the last application of which was in June 1985, were applied twice yearly at rates increasing with age, according to the following schedule:

kg fertilizer/palm

	N			P		K			Mg		
Level	0	1	2	0	1	0	1	2	0	1	2
Mths from planting											
6	0.25	0.25	0.4	-	-	-	-	-	-	-	-
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	1.5	3.0	0	0.6	1.2
28	0	1.2	2.4	-	-	0	1.25	2.5	0	1.0	2.0
34	0	1.2	2.4	-	-	0	1.25	2.5	0	1.0	2.0

Nitrogen was given as sulphate of ammonia, phosphate as triple superphosphate, potassium as bunch ash or muriate of potash and magnesium as kieserite. Phosphate was applied during the first year only. Bunch ash was applied 3 months after the nitrogenous fertilizer to avoid volatilization of ammonia. The ratio K/Mg was kept constant in plots fertilized with the combination of K and Mg. Seedlings planted were either 16 or 24 months of age.

An atypically long drought immediately after planting checked growth.

Recording: Petiole cross section was measured in February and September. Soil samples in all plots were taken in January and leaf samples in October. Yield per palm was recorded throughout the year.

Results: The response of vegetative growth to nitrogen and different seedling age at planting that was seen in February had disappeared in September. The effect of potassium/magnesium became more pronounced over this period (Table 1).

Leaf nutrient levels in 1986 and 1984 are presented in Table 2. Major effects were due to sulphate of ammonia the acidifying effect of

Table 1: Experiment 106, Petiole cross section (cm^2), February and September 1986

TREATMENT	FEBRUARY	SEPTEMBER
N_0	16.4 a	19.9
N_1	17.2 b**	20.4 n.s.
N_2	17.6 b	20.1
K/Mg_0	16.6 a	19.5 a
K/Mg_1	17.3 b(*)	20.2 b**
K/Mg_2	17.3 b	20.6 b
Age_1	18.1 a***	20.3 n.s.
Age_2	16.0 b	20.0

significant at (*) 10%, ** 1%, *** 0.1%

Table 2: Experiment 106, Nutrient levels frond 17, October 1986 and 1984

	N	P	K	Mg	Ca	S	Cl	Fe	Mn	Zn	Cu	B
	'86 '84											
N_0	2.7(2.6)	.16(.16)	1.09(1.2)	.21(.20)	.93(1.05)	.18(.19)	.38(.36)	63(72)	32(30)	16(21)	6(7)	13(13)
NP_1	2.7(2.7)	.16(.16)	1.10(1.2)	.20(.18)	.90(1.02)	.18(.19)	.39(.34)	65(69)	47(42)	16(20)	6(7)	12(13)
N_2	2.7(2.7)	.16(.16)	1.09(1.2)	.20(.18)	.93(1.03)	.18(.19)	.40(.32)	64(72)	67(61)	17(19)	6(7)	13(14)
P_0	2.7(2.7)	.16(.16)	1.09(1.2)	.20(.19)	.92(1.03)	.18(.19)	.39(.34)	65(70)	48(44)	16(20)	6(7)	12(13)
P_1	2.7(2.7)	.16(.16)	1.10(1.2)	.20(.19)	.91(1.04)	.18(.19)	.40(.34)	63(72)	49(44)	16(20)	6(7)	12(13)
K/Mg_0	2.7(2.7)	.16(.16)	1.15(1.2)	.19(.18)	.93(1.08)	.18(.19)	.24(.25)	62(70)	49(45)	16(19)	6(7)	13(13)
K/Mg_1	2.7(2.7)	.17(.16)	1.08(1.2)	.20(.19)	.91(1.01)	.18(.19)	.43(.34)	65(71)	49(44)	16(20)	6(7)	12(13)
K/Mg_2	2.7(2.7)	.16(.16)	1.06(1.2)	.21(.19)	.90(1.01)	.18(.19)	.50(.42)	64(71)	48(43)	17(20)	6(7)	12(13)
1 yr	2.6(2.7)	.16(.16)	1.12(1.2)	.20(.18)	.90(1.00)	.18(.19)	.38(.35)	65(72)	48(41)	17(20)	6(7)	12(13)
2 yrs	2.7(2.7)	.17(.16)	1.07(1.2)	.21(.20)	.94(1.06)	.18(.19)	.40(.33)	63(70)	49(47)	16(20)	6(7)	13(13)

which increased manganese levels, and muriate of potash which increased the chloride levels (both significant at 0.1%). The reduction of leaf potassium (significant at 0.1%) is a usual phenomenon on these soils when muriate of potash is applied which is often accompanied by an increase of leaf calcium, though not in this case. The slight increase of leaf magnesium after applying Kieserite was significant (P= 0.5%).

In general, nutrients are at satisfactory levels and the initial strong response to nitrogen in 1985 does not come to expression in these results. Compared to the 1984 results the levels of K, Ca, Fe and Zn show a rather sharp (but not unusual) decline.

Soil analysis results are presented on page 32. Individual plot values do not show anomalies to explain the differences in yield. The significant block effect on growth and yield is, therefore, probably due to physical soil factors.

A year and a half after the last application of fertilizer the following effects on yield were still apparent (Tables 3 & 4).

Table 3: Experiment 106, Production per hectare for 1986.

	Age 1			Age 2			Average		
	No. of bunches	Wt. of bunches t	s.b.w. kg	No. of bunches	Wt. of bunches t	s.b.w. kg	No. of bunches	Wt. of bunches t	s.b.w. kg
N0	2930	21.0	7.2	2260	16.7	7.4	2595	18.8	7.2 a
N1	3063	22.3	7.3	2308	17.7	7.7	2685	20.0	7.4 b*
N2	3023	22.8	7.5	2272	17.6	7.7	2648	20.2	7.6 b
P0	3061	22.4	7.3	2252	17.2	7.6	2657	19.8	7.5
P1	2949	21.7	7.4	2308	17.4	7.5	2629	19.5	7.4
K/Mg0	3007	21.4	7.1	2273	17.1	7.5	2640	19.3	7.3
K/Mg1	3026	22.5	7.4	2346	17.4	7.4	2686	20.0	7.4
K/Mg2	2983	22.2	7.4	2220	17.4	7.8	2602	19.8	7.6
Mean	3005a***	22.0a***	7.3a*	2280b	17.3b	7.6b	2643	19.7	7.5

Means with different letters differ significantly at * 5%, *** 0.1%

Table 4: Experiment 106, Cumulative production per hectare, (Dec 1984 - Dec 1986)

	Age 1		Age 2		Average	
	No. of bunches	Wt. of bunches t	No. of bunches	Wt. of bunches t	No. of bunches	Wt. of bunches t
N0	6358	35.0	4939	30.9	5649	32.9
N1	6553	36.5	5178	32.2	5865	34.3
N2	6541	37.2	5231	31.9	5886	34.6
P0	6557	36.7	5039	31.3	5799	34.0
P1	6410	35.8	5192	31.9	5802	33.8
K/Mg_0	6404	35.1	5112	30.8	5758	33.0
K/Mg_1	6534	36.8	5188	31.9	5860	34.4
K/Mg_2	6514	36.8	5046	32.2	5781	34.5
Mean	6484	36.2	5116	31.6	5800	34.0

The earlier yield response to nitrogen over the two different ages of planting material was no longer significant in 1986 although single bunch weight has improved ($P<0.05$).

The yield increase due to nitrogen amounted to 1.4t/ha in 1986 compared to 0.7t/ha in 1985. The increase was statistically significant only for the first 9 months of harvest. The two age groups responded differently, 1 year old planting material yielding twice as much as the 2 year old.

The response to potassium/magnesium that was reported at the end of 1985 was about 1 ton/ha in the 1 year old seedlings during 1986, but negligible in the 2 year olds. The cumulative data show that the level of K/Mg had nearly twice as much effect on the 1 year olds as compared to the 2 year olds.

There was a highly significant interaction between nitrogen and phosphorus. In the absence of the former, phosphorus had a depressive effect on bunch yield and its components but it appeared to enhance the effect of low level of nitrogen. These differences were reflected in the N:P ratio but do not appear to explain them.

The biggest and highly significant differences were seen in the average production between 1 year and 2 year old seedlings as nearly 5 tons more were harvested from the 1 year olds during 1986, due to a higher number of bunches of slightly greater weight.

It is concluded that nitrogen applied during the establishment phase increased yield. However, the yield response of about 2 ton/ha over the first 2 years of production was less than anticipated. As a result, it is estimated that at a price of K166/ton for ammonium chloride the application of 2.4kg/palm during the establishment phase would have been cost-effective only at a price of FFB not lower than K37 per ton. The interesting response to K/Mg will be followed both in this experiment and in Expt.107 in which K and Mg are applied independently.

The planting of 2 year old seedlings reduced yields drastically and these seedlings responded less to fertilizers than normal aged ones under the condition of this trial, which was affected adversely by drought during the three months after planting.

Experiment 107: Fertilizer experiment on mature, replanted palms, Bebere

Planted in December 1982/January 1983 at 135 palms/ha, 2592 palms in total, 1152 palms recorded. Area 19.2 ha. The site had previously been under oil palm for 14 years.

Design: $3^2 x 2^3$ factorial (N,P,K,Mg and establishment N). The 72 plots were arranged in 6 blocks of 12 plots each, 36 palms per plot of which the central 16 were recorded. The recorded palms are of 16 different progenies arranged in the same array in each plot, as an agro-genetical trial. Five of these progenies were selected in 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. At three months, all plots received 0.25 kg sulphate of ammonia per palm and an additional 1 Kg/palm was applied at 12 months as treatment "establishment N". The other treatments commenced in February 1985. Half the amounts are being applied twice yearly as follows:

	kg/palm. year		
level	0	1	2
Sulphate of ammonia	0	1	2
Triple superphosphate	0	0.5	1
Sulphate of potash	0	1.8	-
Kieserite	0	2	-

In 1986 fertilizers were applied in February (NPMg), March (K) and September (NPKMg).

Recording: Petiole cross section was measured in September. Leaf samples in all plots were taken in December. Yield per palm was recorded throughout the year.

Results: Positive trends due to nitrogen and magnesium fertilization on petiole cross section just failed to be significant at the 10% level. TSP had a negative influence on growth (10% significance) (Table 5).

Table 5: Experiment 107, Petiole cross section, September 1986 (cm^2)

	WxT		WxT
N0	19.7	P_0	20.5
N1	20.0	P_1	19.8
N2	20.3$^{(*)}$	P_2	19.8$^{(*)}$
K0	20.1	Mg_0	19.8
K1	20.0	Mg_1	20.2

Linear component $^{(*)}$=P<.05

Leaf nutrient levels are given in Table 6. Twenty months after the first application of fertilizer, very few responses were to be found. These were: an increase in manganese due to the acidifying effect of sulphate of ammonia, a trend in magnesium and chloride levels due to kieserite (kieserite containing chloride salts), and a slight positive trend in the nitrogen levels. When leaves were sampled in 1985 only establishment nitrogen had been given, which has not come to be expressed in the leaf levels a year later.

Table 6: Experiment 107, Nutrient levels frond 17, Dec 86 and Jan 85)

	%							ppm				
	N	P	K	S	Ca	Mg	Cl	Fe	Mn	Zn	Cu	B
						'86 '85						
N_0	2.5(2.6)	.17(.16)	1.01(1.08)	.18(.17)	1.00(1.17)	.20(.22)	.18(.22)	59(64)	37(44)	15(15)	5(8)	14(14)
N_1	2.6(2.7)	.17(.16)	1.01(1.07)	.18(.17)	1.01(1.18)	.19(.21)	.17(.21)	58(62)	41(42)	15(15)	5(7)	14(13)
N_2	2.6(2.6)	.17(.17)	1.01(1.06)	.19(.17)	1.01(1.22)	.18(.22)	.16(.23)	57(63)	48(43)	14(15)	6(7)	13(15)
P_0	2.6(2.6)	.17(.16)	1.00(1.07)	.19(.17)	0.99(1.17)	.19(.22)	.16(.22)	59(64)	41(42)	15(15)	6(8)	14(14)
P_1	2.6(2.6)	.17(.16)	1.02(1.07)	.18(.17)	1.02(1.19)	.18(.21)	.17(.23)	57(62)	43(45)	14(14)	5(7)	13(14)
P_2	2.5(2.6)	.17(.16)	1.02(1.06)	.18(.17)	1.01(1.21)	.19(.21)	.18(.21)	58(63)	42(44)	15(15)	6(7)	14(14)
K_0	2.6(2.6)	.17(.16)	1.01(1.07).	.18(.17)	1.00(1.19)	.19(.22)	.16(.24)	59(64)	42(43)	15(14)	6(7)	13(14)
K_1	2.6(2.6)	.17(.16)	1.01(1.07)	.19(.17)	1.02(1.19)	.19(.22)	.18(.20)	58(62)	41(43)	15(15)	5(7)	14(14)
Mg_0	2.6(2.6)	.17(.16)	1.02(1.07)	.18(.17)	1.01(1.21)	.18(.21)	.16(.20)	58(62)	43(44)	15(15)	6(7)	14(14)
Mg_1	2.6(2.7)	.17(.16)	1.00(1.07)	.18(.17)	1.01(1.17)	.20(.22)	.19(.23)	58(64)	41(43)	15(15)	5(7)	14(13)
-Est N	2.6(2.6)	.17(.16)	1.02(1.09)	.18(.17)	1.00(1.19)	.19(.22)	.17(.22)	57(64)	41(41)	15(15)	6(8)	13(14)
+Est N	2.6(2.6)	.17(.16)	1.00(1.05)	.18(.17)	1.01(1.19)	.19(.21)	.17(.22)	59(62)	43(46)	15(14)	5(7)	14(14)

Levels of magnesium, chloride and manganese are generally sub-optimal. In some plots nitrogen levels were as low as 2.2.

Apart from kieserite the application of fertilizers appeared to have had little effect on yield (Table 7). However, doubt existed whether or not this magnesium response was real. Pre-treatment

Table 7: Experiment 107, Yield per hectare, 1986 and to date

	1986			March 1985-December 1986		
	No. of bunches	Wt. of bunches t	s.b.w kg	No. of bunches	Wt. of bunches t	adjusted[1]
N0	2607	17.3	6.6	4976	27.2	28.6
N1	2624	17.0	6.5	5045	27.2	28.8
N2	2670	17.8	6.7	5043	27.8	29.4
P0	2639	17.5	6.6	5008	27.5	28.8
P1	2643	17.4	6.6	4985	27.2	29.0
P2	2619	17.2	6.6	5071	27.4	29.1
K0	2639	17.4	6.6	4975	27.1	28.7
K1	2629	17.3	6.6	5068	27.6	29.9
Mg0	2569a	16.5a	6.4a	4916	26.1	28.3
Mg1	2699b(*)	18.2b(*)	6.7b(**)	5128	28.5	29.6
-est N	2663	17.5	6.6	5049	27.4	29.1
+est N	2605	17.2	6.6	4994	27.3	28.8
Mean	2634	17.4	6.6	5022	27.4	29.0

significant at (*)10%, **1%

[1]adjusted by covariance with pre-treatment WxT

petiole cross section measurements revealed a positive bias towards the Mg1 plots and the magnesium "effect" was ,indeed, removed by an analysis of covariance. This analysis also improved the precision of the experiment by 20%, which is equivalent to an experiment with 40-50% more plots and emphasises the value of WxT pre-treatment data in young plantings. A previously significant 2 factor interaction (Nx establishment N) also disappeared when adjusted in this way.

HBN (High Bunch Number) and MSR (Medium Sex Ratio) progenies produced approximately the same number of bunches on average, but MSR progenies produced higher yields due to a greater single bunch weight, but those differences were not statistically significant in 1986 or overall. There was more variation amongst the MSR than the HBN progenies (Table 8).

Table 8: Experiment 107, Yield per progeny per hectare, 1986 and to date

	1986			Since March 1985	
	No. of bunches	Wt. of bunches t	s.b.w. kg	No. of bunches	Wt. of bunches t
Progeny					
HBN					
1	2826	15.6	5.5	5354	24.4
2	2557	18.0	7.1	4907	27.6
3	2529	17.1	6.7	5227	28.0
4	2432	14.7	6.0	4823	24.2
5	2794	16.1	5.8	4883	25.1
Mean	2628	16.3	6.2	5039	25.9
MSR					
6	3071	19.5	6.3	5539	30.0
7	2640	19.5	7.4	4650	27.8
8	2841	15.6	5.5	4992	22.7
9	1755	12.5	7.1	3917	22.7
10	2674	19.4	7.3	5235	32.1
11	2638	16.1	6.1	5027	25.5
12	3111	17.7	5.7	6059	29.1
13	2541	21.0	8.3	4712	31.7
14	2724	20.8	7.6	5100	32.0
15	2663	17.1	6.4	5011	27.1
16	2334	17.0	7.3	4847	27.6
Mean	2636	17.8	6.8	5008	28.0

Experiment 108: Systematic nitrogen fertilizer trial, Kumbango

This experiment was initiated in 1985 in an area of Kumbango plantation which had shown a decreasing layer of topsoil and where yields had fallen to about 15 ton/ha year. The site was planted in 1972 at 120 palms/ha. Recorded palms: 2134. Area 18 ha.

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 ton/ha empty bunches in March '85 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 following were applied at half the rate twice yearly. Application commenced in July 1985.

	kg/palm. year							
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
Di-ammonium phosphate	0	1.2	2.4	3.6	4.8	6.0	7.2	8.4

(rates of N at each level are the same)

R[illegible]g: Petiole cross section was measured in July and leaf samples were taken in August. The soil was sampled in March from every other plot plus all nil plots giving 36 plots in total. Fertilizers were applied in January and August. Yield per twin row (plot) was recorded throughout the year.

Results: Petiole cross section data for 1985 and 1986 are given in Table 9. No trend is apparent yet. At both sites where DAP was applied, palms were of smaller petiole cross section and consequently lower yield than where ammonium chloride was used. This was a chance effect and not caused by treatments.

Results of the leaf analyses of samples taken just before the third fertilizer application are shown in Table 10. Nitrogen increased markedly with the application of ammonium chloride but with DAP the increase was only marginal. Phosphorus levels were higher in 1986 but a systematic trend had not developed. Potassium levels had not reacted systematically either. In the DAP plots calcium levels dropped with increasing levels of fertilizer. No explanation is suggested for this. Magnesium levels were erratic but this element normally has a high coefficient of variation. Chloride levels were not low initially but an increase was observed following the application of ammonium chloride. Soil analysis results are given on page *.

Table 9: Experiment 108, Petiole cross section (cm^2), July 1985 and 1986

	Amm. chloride			Di-Amm. phosphate		
level	1985	1986	diff.	1985	1986	diff.
0	43.1	40.5	-2.6	39.2	36.7	-2.5
1	41.1	41.1	0.0	39.0	38.2	-0.8
2	41.3	40.4	-0.9	37.8	37.4	-0.4
3	43.0	41.4	-1.6	38.5	39.5	1.0
4	44.5	41.7	-2.8	39.3	39.1	-0.2
5	43.3	43.2	-0.1	38.1	39.1	1.0
6	41.5	41.7	0.2	38.4	39.8	1.4
7	41.0	40.6	-0.4	38.2	38.0	-0.2
Pretreatment mean	42.4	-	-	38.6	-	-

Monthly values for single bunch weight are presented in Table 11. Heavier bunches occurred mainly from February till May. Both types of fertilizer showed a similar pattern. Despite some variation there was a clear trend that greater bunch weights were obtained at the higher levels of fertilizer. This effect was becoming apparent in the 7th month after applying fertilizer, which shows that bunches whose component parts had already been determined put on more weight. Any effect of changes in bunch composition could not be expected until the end of the year.

By the 13th month (after the first fertilizer application) a clear trend in production started to develop. Data for 1986 as a whole are shown in Table 12.

Parabolic regression showed high correlation coefficients (0.94

and 0.93 resp), with a maximum production of 22.4 ton/ha (132%) for ammonium chloride applied at 6.7kg/palm year, and 20.6 ton/ha (136%) for DAP applied at 5.9kg/palm year. The optimum economic level of application, however, depends highly on the price of FFB and cost of fertilizer. For ammonium chloride this level was 3.37kg/palm year at a value for 1 ton FFB of 25 Kina, but 4.32kg/palm year for 1 ton FFB at 35 Kina. The cost of ammonium chloride was taken as 166 Kina/ton. The price of di-ammonium phosphate is too high to be economical at around 400 Kina/ton. Curves for maximum and optimum yield can be seen in Figure 1. Estate fertilizer recommendations were made as a result of this data which so clearly demonstrated a deficiency of nitrogen and a series of additional systematic trials scheduled for 1987 on other sites and ages of planting.

Table 10: Experiment 108, Leaf nutrient levels, August 1986

	Mean	Ammonium chloride levels					
%	1985	0	1	3	4	6	7
nitrogen	2.20	2.3	2.1	2.4	2.5	2.4	2.6 **
phosphorus	.14	.17	.15	.16	.16	.16	.16
potassium	1.00	.99	.93	.96	.96	.94	.97
sulphur	.14	.19	.16	.16	.17	.16	.16
calcium	.92	.88	.94	.91	.98	.92	.93
magnesium	.27	.23	.27	.25	.27	.23	.24
chloride	.41	.34	.43	.46	.51	.49	.51(*)
ppm							
iron	69	69	70	73	102	82	73
manganese	64	63	61	68	66	71	75
zinc	25	28	32	26	24	27	26
copper	6	8	7	7	7	7	7
boron	16	25	18	17	19	15	16
	1985	Di-ammonium phosphate levels					
%		0	1	3	4	6	7
nitrogen	2.1	2.1	2.2	2.3	2.2	2.2	2.3
phosphorus	.14	.17	.16	.17	.15	.15	.18
potassium	1.01	.86	.98	.95	.98	1.01	.96
sulphur	.14	.19	.16	.16	.15	.15	.19
calcium	.98	1.02	.96	.94	.88	.94	.88(*)
magnesium	.30	.26	.26	.25	.26	.29	.25
chloride	.34	.32	.31	.28	.33	.30	.31
ppm							
iron	61	68	73	77	79	73	77
manganese	64	65	69	66	63	67	67
zinc	24	28	26	28	27	26	28
copper	6	6	6	7	6	7	7
boron	18	31	20	22	18	17	30

regression significant at 10% (*) or 1%**

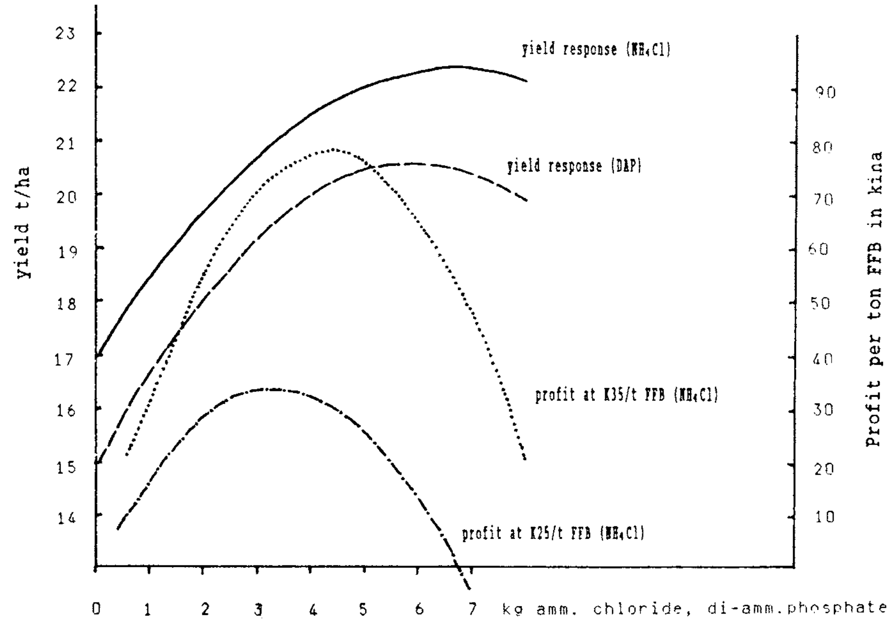
Table 11: Experiment 108, Single bunch weight, 1986

LEVELS	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Ammonium chloride												
0	22.1	23.1	23.2	21.7	21.3	19.3	19.4	19.6	19.1	19.8	20.9	20.5
1	21.4	22.5	22.5	23.1	21.8	19.8	19.6	19.5	20.4	21.2	21.2	21.7
2	20.0	24.6	23.5	24.3	21.7	21.0	19.5	20.3	19.8	20.7	21.8	21.8
3	19.9	23.7	23.9	25.7	22.5	22.7	21.6	19.5	21.8	20.5	22.3	23.4
4	22.6	25.1	25.0	24.3	24.0	22.5	20.5	21.0	22.1	23.8	23.2	21.7
5	20.7	19.2	24.9	25.3	23.3	22.1	21.9	21.5	21.9	21.7	23.7	23.9
6	20.5	24.3	24.8	25.1	22.0	22.4	20.8	19.9	22.7	22.3	24.6	21.1
7	21.4	23.7	24.1	23.7	23.9	23.6	21.0	21.0	22.6	21.4	22.9	21.5
Di-ammonium phosphate												
0	19.2	22.1	22.6	21.2	19.6	19.6	18.5	20.7	18.5	20.1	20.5	18.9
1	18.1	21.8	23.0	21.3	19.8	19.8	18.1	18.8	19.2	20.6	21.5	19.4
2	18.9	21.3	22.1	22.3	21.8	19.9	19.7	19.0	19.9	19.2	21.1	21.9
3	21.5	23.4	22.5	21.7	21.7	20.9	19.8	17.9	20.9	20.0	20.7	21.0
4	19.7	21.0	23.5	25.5	23.3	21.6	20.4	20.2	21.2	22.4	21.6	21.0
5	17.0	20.5	21.6	23.9	24.8	21.3	20.1	18.7	20.5	22.1	22.9	21.2
6	18.4	17.9	23.3	22.4	22.3	20.8	20.3	20.9	21.8	20.3	22.0	20.5
7	19.2	21.9	25.8	23.2	24.7	22.9	21.2	20.8	21.6	23.0	24.0	22.9

Table 12: Experiment 108, Yield per hectare, 1986

	AMMONIUM CHLORIDE				DI-AMMONIUM PHOSPHATE			
LEVEL	No. of bunches	s.b.w.	Wt. of bunches	%	No. of bunches	s.b.w.	Wt. of bunches	%
0	827	20.6	17.0	100	764	19.9	15.2	100
1	882	21.0	18.5	109	862	19.8	17.1	113
2	918	21.1	19.4	114	878	20.4	17.9	118
3	926	22.0	20.4	119	969	20.4	19.8	131
4	947	22.5	21.3	125	985	21.5	21.2	140
5	949	22.4	21.3	125	943	21.1	19.9	131
6	1045	22.2	23.2	136	998	21.0	21.0	138
7	979	22.3	21.9	128	870	22.2	19.3	127

Figure 1: Yield response to ammonium chloride and di-ammonium phosphate and profit curves (ammonium chloride)



Experiment 109a: Mill waste usage experiment on young palms, Bebere

Planted in 1978 at 135 palms/ha; 1080 palms in total, 480 recorded. Area 8 ha.

Design: 5 replicates of randomised blocks, with 5 treatments of which the nil treatment is repeated to give 6; 36 palms per plot of which the central 16 are recorded.

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

	time of application
1. Nil	-
2. Nil	-
3. Raw effluent 500 l/palm	Oct.'84, Sept.'85, Nov.'86
4. Raw effluent 1000 l/palm	Oct.'84, Sept.'85, Nov.'86
5. Munched bunches + raw effluent 100 t/ha	Apr.'86
6. Munched bunches 100 t/ha	May - July'85

Effluent was applied annually and the other treatments once. The overdue application of munched bunches mixed with effluent (78t MB plus 22t POME per ha) was finally completed in April.

Recording: Bimonthly samples of leaf 17 were taken in the selected plots as part of Investigation 708; in January leaves 1, 9 and 25 were included. Soil acidity was measured in the laboratory for samples taken in July in plots treated with munched bunches, using a similar sampling method as for the plots treated with POME in the previous year. Ground flora was surveyed in May. Soil samples were taken in all plots in June. The chemical composition of POME, Empty Bunches and Decanter Sludge (as used at Hargy Oil Palms) was determined. Vegetative measurements taken included height, petiole cross section, stem girth, leaf area and leaf dry weight and frond production in selected plots in the course of Investigation 707. Yield recording continued on a weekly base.

Table 13: Experiment 109a, Leaf nutrient levels, January - November, 1986

	Jan		March		May		July		Sept		Nov	
	nil	1000	nil	1000	nil	1000	nil	1000	nil	1000	nil	1000
%												
Nitrogen	2.4	2.3	2.3	2.4	2.6	2.6	2.5	2.6	2.4	2.5	2.7	2.7
Phosphorus	0.16	0.15	0.15	0.15	0.16	0.15	0.15	0.15	0.15	0.16	0.17	0.16
Potassium	1.06	0.99	1.07	1.02	0.95	0.85	1.08	1.02	1.05	1.00	0.97	0.92
Sulphur	0.16	0.16	0.15	0.16	0.17	0.17	0.16	0.17	0.16	0.16	0.17	0.17
Calcium	0.91	0.85	0.96	0.89	1.05	0.99	0.99	0.91	0.90	0.89	0.91	0.89
Magnesium	0.14	0.17	0.15	0.18	0.19	0.22	0.16	0.19	0.17	0.20	0.13	0.16
Chloride	0.14	0.21	0.13	0.21	0.16	0.24	0.15	0.24	0.14	0.24	0.12	0.20
Sodium	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
ppm												
Iron	45	47	56	57	51	55	65	58	66	67	62	66
Manganese	37	32	38	37	38	35	38	35	38	39	37	40
Zinc	17	22	21	23	20	20	30	21	20	19	15	16
Copper	6	5	5	5	6	6	5	5	4	3	7	7
Boron	13	11	14	13	16	13	14	13	13	12	12	9

Results: Leaf nutrient levels are presented in Table 13. Trends were for higher levels of nitrogen, magnesium and chloride in the plots treated with 1000 l POME, but lower levels of potassium and calcium. Seasonal trends will be discussed in Investigation 708. Table 14 presents the results for leaves of different ages (leaf 1, 9, 17 and 25) expressed as a percentage of leaf 17. Steep gradients were found for potassium, magnesium, chloride and zinc. The only element showing higher levels in the older leaves was calcium.

Table 14: Experiment 109a, Nutrient levels in fronds of different age as % of frond 17, January 1986

	nil plots				10001 plots			
Frond	1	9	17	25	1	9	17	25
N	107	107	100	87	109	107	100	94
P	122	106	100	90	129	109	100	94
K	157	114	100	88	164	118	100	85
S	104	104	100	92	107	102	100	96
Ca	60	86	100	116	62	87	100	121
Mg	159	154	100	67	137	142	100	81
Cl	203	109	100	76	171	127	100	101
Fe	136	122	100	103	92	95	100	97
Mn	73	91	100	95	66	76	100	99
Zn	160	127	100	90	142	111	100	79
Cu	120	127	100	70	127	118	100	92
B	93	93	100	104	106	103	100	126

Soil under munched bunches showed a pH of 7.2 as against a pH of 6.9 for untreated plots but the difference was not significant. An alkalizing trend is apparent, however.

Species found during the ground flora survey in May included *Paspalum conjugatum* and *Ageratum conyzoides*, followed by *Calopogonium caerulium* and ferns. *Paspalum* and *Ageratum* spp. seem to have been encouraged more by the application of POME than other species. *Calopogonium* tended to dominate in the nil plots.

Soil analysis results are presented in Table 15. The following trends are noted:

Organic Matter: the munched bunch treatment gave an appreciable increase in organic matter content. This is also reflected in an increase in CEC. The increase due to effluent is probably a sampling anomally.

Available P: P increased considerably in the plots treated with effluent. This may have been caused by a change in pH (although Table 15 shows lack of response; measurements in 1985 indicated a drop of pH due to effluent) or an increased activity of soil microbes due to the application of large quantities of liquid rupturing soil aggregates.

Exchangeable potassium: all treatments increased the amount of readily available K in the soil. Effluent contained large amounts of K, but most of this was probably leached out of the profile at the time of application (also reflected in the low K levels of the leaves). The munched bunches, however, remained in situ longer and have increased soil K contents by way of easily assimilated organic K

Table 15: Experiment 109a Topsoil analysis,June 1986

TREATMENTS	pH a	pH b	pH c	Organic matter %			Bulk density g/ml			P-Olsen mg/ml			P-retention %		
1 nil	6.6	6.7	6.7	5.7	5.2	5.8	0.67	0.67	0.66	4	3	3	66	64	64
2 nil	6.7	6.7	6.8	6.0	5.4	6.1	0.66	0.67	0.63	4	4	4	61	59	62
3 5001 POMK	6.7	-	-	6.3	-	-	0.64	-	-	5	-	-	62	-	-
4 10001 POMK	6.7	-	-	6.3	-	-	0.67	-	-	7***	-		62	-	-
5 MB+POMK	-	6.9	-	-	-	6.0	-	-	0.67	-		4	-	-	61
6 MB	6.9				6.2			0.65			4			60	
Mean	6.7	6.8	6.7	6.1	5.7	5.9	0.66	0.66	0.65	5	4	4	62	60	62
SD	.06	.14	.14	0.3	0.6	.07	.01	.01	.02	1	1	.6	.6	.7	1.4
CV%	.9	2	2	4.7	11	1.2	1.5	1.5	3.1	28	16	16	.9	1	2

TREATMENTS	K Exchangeable me/100g			Ca Exchangeable me/100g			Mg Exchangeable me/100g			Na Exchangeable me/100g		
1 nil	0.33	0.25	0.27	10.8	10.3	12.6	0.77	0.79	0.82	0.04	0.07	0.06
2 nil	0.27	0.20	0.22	13.5	11.9	14.5	0.89	0.83	0.97	0.03	0.05	0.06
3 5001 POMK	0.33	-	-	12.1	-	-	1.48 **	-	-	0.03	-	-
4 10001 POMK	0.35	-	-	11.4	-	-	1.69***	-	-	0.03	-	-
5 MB+POMK	-	-	0.44	-	-	11.4	-	-	1.02	-	-	0.04
6 MB		0.68			11.3			1.82**			0.03	
Mean	0.33	0.45	0.31	11.9	11.2	12.4	1.33	1.31	0.95	0.03	0.04	0.05
SD	.2	.32	.12	0.4	.14	1.5	0.45	0.71	0.09	-	0.02	0.01
CV%	6	71	39	3.4	1.2	12	34	54	9	-	50	20

TREATMENTS	CEC me/100g			K Saturation %			Ca Saturation %			Mg Saturation %			Na Saturation %		
1 nil	14	13	15	2.5	1.9	1.8	79	78	85	5.6	6.0	3.6	0.3	0.6	0.4
2 nil	16	14	17	1.7	1.5	1.2	85	82	85	5.7	5.9	5.7	0.2	0.3	0.4
3 5001 POMK	15	-	-	2.2	-	-	78	-	-	9.6***	-	-	0.	-	-
4 10001 POMK	15	-	-	2.3	-	-	75	-	-	11.2***	-	-	0.2	-	-
5 MB+POMK	-	-	15	-	-	2.8	-	-	77	-	-	6.1	-	-	0.2
6 MB		17			2.7			77			9.3***			0.2	
Mean	15	15	15.5	2.2	2.2	2.1	78	78	81	8.8	7.6	5.8	0.2	0.3	0.3
SD	-	2.8	.71	0.1	6.7	0.92	3.5	2.1	5.7	2.8	2.4	.35	-	.14	.14
CV%	-	19	5	4.5	32	44	4.5	2.7	7.0	33	32	6.0		47	47

Means with different letters differ significantly at *5%, **1%, ***1%

complexes. No leaf samples were taken in plots treated with munched bunches this year.

Exchangeable Ca: there was little change in the calcium status of the soils other than a decrease in the MB + effluent plots.

Exchangeable Mg: appreciable increases in exchangeable magnesium were observed in all plots except the MB + effluent plots. In the latter case, this was because the increase in potassium was so large that the relative increase in soil magnesium was kept to a minimum. It should also be borne in mind that this treatment was only applied 3 months prior to sampling.

Cation Exchange Capacity: the sole notable difference in CEC was the increase caused by the munched bunches only treatment.

Conclusion: The treatments have increased the soils' fertility in all cases. The advantage of the munched bunch treatment lies in its ability to increase OM contents, CEC and markedly improve Mg and K nutrition. As such it is probably a superior treatment. The empty bunches will provide similar advantages in the long run but are unlikely to give short term responses.

The nutrient composition of the various factory wastes is shown in Table 16. Percentages vary because of the differences in dry matter content. N:P:K:Mg ratios were approximately:

	N		P		K		Mg
POME	5	:	1	:	6	:	2
Empty Bunches	11	:	1	:	27	:	2
Dried Sludge	10	:	1	:	3	:	1.5

Table 17 presents vegetative measurements most of which showed a positive trend indicating a treatment effect.

Yield data since January 1985 are given in Table 18. Although the treated plots yielded about 4 tons more than the nil plots, statistical analysis showed no significant treatment effects.

Table 16: Experiment 109a, Factory waste nutrient composition, October 1986

	POME		Empty Bunches		Dried sludge	
	%	per 1000 l kg	%	per 1000kg kg	%	per 1000kg kg
N	0.16	1.6	0.22	2.2	1.2	1.2
P	0.03	0.3	0.02	0.2	0.13	0.13
K	0.19	1.9	0.54	5.4	0.33	0.33
S	0.04	0.4	0.03	0.3	0.12	0.12
Ca	0.08	0.8	0.07	0.7	1.4	1.4
Mg	0.05	0.5	0.04	0.4	0.16	0.16
Na	0.01	0.1	0.003	0.03	0.01	0.01
Cl	0.07	0.7	0.08	0.8	0.02	0.02
	ppm	g		g		g
Fe	54	54	31	31	640	64
Mn	3	3	2	2	17	2
Zn	<2	<2	5	5	7	1
Cu	2	2	4	4	22	2
dry matter	6		32		20	

Table 17: Experiment 109a, Vegetative measurements (selected plots), for nil plots and treated plots

POME per palm	Height 8/86 (cm)	WXT 5/86 (cm^2)	LA 11/86 (m^2)	LDW 11/86 (kg/yr)	Girth 8/86 (cm)	FP 1/86 - 1/87
nil	364	32.4	7.1	3.65	53	2.17
1000l	377	33.2	8.9	3.74	52	2.25

Table 18: Experiment 109a, Production per hectare, January-December 1986 & to date

	1986			Jan 85 - Dec 86		
	No. of bunches	Wt. of bunches t	s.b.w. kg	No. of bunches	Wt. of bunches t	s.b.w. kg
Nil	1215	21.2	17.4	2833	47.8	16.9
500L raw effluent/ palm	1359	25.1	18.6	2961	52.2	17.6
1000L raw effluent/ palm	1379	24.8	18.1	3070	53.6	17.5
100t munched bunches plus effluent/ha	1431	25.9	18.2	3098	52.8	17.0
100t munched bunches/ha	1454	25.5	17.5	3081	51.7	16.8
Mean	1368	24.5	18.0	3009	51.6	17.2

Experiment 109b: Mill waste trial on old palms, Bebere

This experiment repeats on a larger scale treatments from Expt. 109a in an area where yields had declined markedly and the topsoil appeared depleted after 15 years of oil palm cultivation.

Planted in 1970 at 143 palms/ha, later thinned to 123 palms/ha.

Design: 4 replicates of six treatments in completely randomised blocks. Each plot consists of 2 twin rows (approximately 60 palms). One twin row was left between plots as guard rows.

Treatments:

Treatment	Applied
1. Nil	-
2. Nil	-
3. 500 l raw effluent/palm	June-Sept'85, July'86
4. 1000 l raw effluent/palm	June-Sept'85, July'86
5. 50 t empty bunches/ha	Sept-Oct'85
6. 50 t munched bunches/ha	Oct-Nov'85

Recording: Petiole cross section was measured in August. Leaf samples were taken in all plots in August, and soil samples in June. Ground flora was surveyed in the last quarter year. Twin row yield recording continued throughout the year.

Results: Petiole cross section measurements revealed no significant differences due to treatments. (Table 19).

Table 19: Experiment 109b, Yield per hectare current and cumulative and petiole cross section, August

	Jan - Dec'86			Oct'85 - Dec '86			Aug'86
	No. of bunches	Wt. of bunches t	s.b.w. kg	No. of bunches	Wt. of bunches t	s.b.w. kg	WxT cm²
Nil	765a	16.0a	20.8	977a	20.5a	21.0	38.6
500l raw effluent per palm	870b*	18.2b*	20.9	1067b(*)	22.4ab	21.0	36.9
1000l raw effluent per palm	818ab	17.4ab	21.3	1009ab	21.4ab	21.2	38.6
50t empty bunches per ha	816ab	17.8ab	22.0	1031ab	22.2ab	21.5	42.6
50t munched bunches per ha	884b*	19.1b*	21.6	1092b*	23.6b*	21.6	37.6
Mean	831	17.7	21.3	1035	22.0	21.3	38.9

Means with different letters differ significantly at *5%, (*)10%

Leaf nutrient levels of leaf 17 are presented in Table 20. Approximately one year after the first application of treatments the following trends were noted: the 1000 l POME treatment increased nitrogen from 2.1 to 2.2. Although exchangeable soil potassium was greatly increased no effect was scored by the K leaf levels. Calcium levels increased rather inconsistently. Magnesium levels increased marginally. Chloride levels were raised in all treatments except the 500 l POME treatment.

Table 20: Experiment 109b, Nutrient levels frond 17,August

	%								ppm				
TREATMENT	N	P	K	S	Ca	Mg	Cl	Na	Fe	Mn	Zn	Cu	B
1 nil	2.1	0.14	0.91	0.15	0.89	0.26	0.46	0.01	63	66	25	5	15
2 nil	2.1	0.14	0.89	0.15	0.91	0.26	0.50	0.01	61	68	26	7	18
3 500l POME	2.0	0.14	0.89	0.16	0.98	0.25	0.50	0.01	68	66	26	5	17
4 1000l POME	2.2	0.14	0.90	0.15	0.89	0.26	0.54	0.01	66	70	25	6	12
5 EB 50t/ha	2.1	0.15	0.88	0.17	0.99	0.27	0.54	0.01	65	69	25	5	16
6 MB 50t/ha	2.1	0.14	0.86	0.15	0.92	0.27	0.56	0.01	65	71	26	6	14
Mean	2.1	0.14	0.89	0.15	0.93	0.26	0.52	0.01	65	68	26	6	15
s	.06	.00	.02	.01	.04	.01	.04	-	2.4	2.1	0.6	0.8	2.2
cv %	2.8	2.8	2.2	6.7	4.3	3.8	7.7	-	3.7	3.0	2.1	13.7	14.4

Table 21 presents the results of soils analysis, samples were taken in June. The following trends are noted:

pH: the effluent applications appear to have increased the pH. Last year the opposite effect was noted in Expt. 109a. The 50 ton EB treatment also increased the pH slightly.

Organic Matter: the samples from under the frond heap contain appreciably more OM than the other samples (POME was applied on the frond heaps). However, only MB gave a relative increase in soil OM because of their accelerated break down.

Available P: the increase in pH caused by the 1000 l effluent application had also made more P available in the soil. Also, the application of such large amounts of liquid will have broken open soil aggregates which would then have been utilized by soil micro-organisms, which in turn solubilize inorganic P. Strangely, the addition of the mulching treatments did not drastically increase soil P.

Exchangeable K: all the treatments increased the actual amount of K in the soil, the effluent less so than the mulches, because of leaching of the former. Potassium of the mulches is present as readily available organic K complexes which are more easily taken up by the palm than K in it's inorganic form. Despite all this, K did not increase in the leaves, as compared to Expt. 306(q.r.) where K leaf levels did increase.

Exchangeable Ca: calcium contents were increased by the effluents only.

Exchangeable Mg: all treatments increased the levels of magnesium in the soil, especially the empty bunch treatment, despite the relative low content of Mg in EB.

Cation Exchange Capacity: the marked increase in pH caused the CEC to increase, especially in the 1000 l treatment.

Yield data are also presented in Table 19. A significant increase of production was found in the 500 l POME and the MB treatment. The lack of response in the 1000 l treatment is hard to explain. Because the experiment has only run for just over a year, the differences must be due to better bunch development and reduced abortion. The experiment has run for a shorter time than Expt.109a, but soil and palms are more depleted and, hence, are expected eventually to be more responsive.

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

Planted in February 1985 at 135 palms/ha; 1152 palms (total and recorded). Area 8.8 hectares. The site had previously been under oil palm for 15 years. It was initially intended for a factorial establishment fertilizer trial repeating Expt.106 but this was abandoned in its early stages.

Design: 3 replicates of completely randomised blocks of 24 treatments. Blocking was based on petiole cross section measured in April, to obtain better uniformity.

Table 21: Experiment 109b Topsoil analysis,June 1986

TREATMENTS	pH a	pH b	pH c	Organic matter % a	b	c	Bulk density g/ml a	b	c	P-Olsen mg/ml a	b	c	P-retention % a	b	c
1 nil	6.4	6.4	6.5	8.7	6.8	5.3	0.64	0.66	0.69	4	3	5	59	61	64
2 nil	6.5	6.5	6.5	8.7	5.8	5.4	0.63	0.63	0.70	4	4	3	57	61	61
3 5001 POME	6.7			7.9			0.64			4			54		
4 10001 POME	6.8			8.3			0.64			5			53		
5 MB+POME		6.6			6.3			0.67			4			60	
6 MB			6.5			5.9			0.67			3			61
Mean	6.6	6.5	6.5	8.1	6.3	5.6	0.64	0.65	0.68	5	4	4	55	61	62
SD	0.21	.14	-	0.4	-	.42	.01	.02	.01	1	1	1	2.6	.7	.7
CV%	3.0	2.1	-	4.8	-	7.5	1.6	3.1	1.5	16	20	20	4.8	1.2	1.1

TREATMENTS	K Exchangeable me/100g a	b	c	Ca Exchangeable me/100g a	b	c	Mg Exchangeable me/100g a	b	c	Na Exchangeable me/100g a	b	c
1 nil	0.29	0.20	0.15	14.4	9.9	8.2	1.00	0.48	0.37	0.05	0.10	0.08
2 nil	0.32	0.13	0.15	16.3	10.2	10.0	1.08	0:47	0.41	0.05	0.03	0.09
3 5001 POME	0.39			16.7			1.49			0.03		
4 10001 POME	0.43			19.9			1.85^{**}			0.03		
5 MB+POME		0.89			9.9			1.41			0.03	
6 MB			0.33			9.7			0.65^{**}			0.05
Mean	0.37	0.53	0.24	17.3	9.95	9.4	1.46	0.95	0.52	0.04	0.45	.065
SD	.07	.52	.13	2.4	.07	.42	0.4	0.66	0.18	0.01	0.02	0.02
CV%	19	98	54	13.6	0.7	4.5	27	70	34	25	44	31

TREATMENTS	CEC me/100g a	b	c	K Saturation % a	b	c	Ca Saturation % a	b	c	Mg Saturation % a	b	c	Na Saturation % a	b	c
1 nil	18	14	11	1.6	1.4	1.4	78	70	76	5.4	3.4	3.5	0.3	0.7	0.7
2 nil	20	14	13	1.6	1.0	1.2	81	74	76	5.3	3.4	3.2	0.3	0.7	0.7
3 5001 POME	20			1.9			82			7.6			0.2		
4 10001 POME	23			1.9			85			8.2^{*}			0.1		
5 MB+POME		14			3.7			72			10.1^{**}			0.2	
6 MB			14			2.5^{**}			72			48			0.3
Mean	21	14	13	1.8	2.4	1.9	82	72	74	7.0	6.7	4.1	0,2	0.45	0.5
SD	2.8	-	1.4	.17	1.77	.85	3	-	2,83	1.53	4.74	1.13	0.1	0.35	.28
CV%	9.9	-	10.8	9.4	73.7	44.7	3,6	-	3,8	21.8	70.7	27.6	50	77.8	56

Means with different letters differ significantly at *5%, **1%, ***1%

Treatments:

	Anion level	kg/palm. year Source of nitrogen	Additional ammonium nitrate
		ammonium chloride	
1. Chloride	0	0	1.60
2.	1	0.50	1.20
3.	2	1.00	0.80
		ammonium sulphate	
4. Sulphate	0	0	1.60
5.	1	1.25	0.80
6.	2	2.50	0
		di-ammonium phosphate	
7. Phosphate	0	0	1.60
8.	1	1.40	0.80
9.	2	2.80	0
10. Nil	0	0	0
11. Nil	0	0	0
12. Nil	0	0	0

13 - 24. Same as above but under mulched conditions.

All levels receive the same amount of nitrogen, the only difference between them being the source of nitrogen and the accompanying anion (either chloride, sulphate or phosphate). Plots receiving treatments 1 - 12 are unmulched, plots receiving treatments 13 - 24 are mulched with about 100 kg empty bunches/palm in April/May 1984. Application of fertilizer started in June 1985 and was continued at half yearly intervals. The above rates are the ones used since June 1986, the two applications during 1985 were applied at half these rates.

Recording: Leaf samples were taken in June. Petiole cross section was measured every 3 months. Fertilizers were applied at the end of July and in December. Harvesting commenced in January and yield/palm was recorded throughout the year.

Results: Leaf nutrient levels are given in Table 22. A decrease in leaf potassium at the high level of ammonium chloride was observed, and an increase in chloride and manganese. The latter reaction is because ammonium chloride has an acidifying effect on the soil which makes soil manganese more soluble.

Table 22: Experiment 110, Nutrient levels of frond 17, June 1986

	mulch	N	P	K	S	Ca	Mg	Cl	Fe	Mn	Zn	Cu	B
nil	-	2.8	.17	1.11	.18	1.23	.23	.34	59	49	18	7	13
	+	2.8	.17	1.09	.18	1.29	.23	.36	62	42	17	7	12
N only	-	2.8	.18	1.06	.18	1.30	.21	.35	53	49	17	7	13
	+	2.9	.18	1.09	.19	1.24	.22	.36	58	49	19	7	11
Chloride	-	2.9	.18	1.01	.19	1.27	.23	.57	58	68	16	6	12
low	+	2.9	.18	1.09	.19	1.28	.24	.53	69	60	17	6	14
	-	2.9	.17	.94	.18	1.28	.23	.58	60	86	16	6	14
high	+	2.8	.17	.98	.18	1.29	.20	.61	54	64	16	6	11
Sulphate	-	2.8	.17	1.13	.19	1.22	.21	.35	62	63	15	7	13
low	+	2.9	.18	1.11	.19	1.25	.24	.38	57	59	15	6	17
	-	2.8	.16	1.07	.18	1.27	.21	.30	56	57	17	7	12
high	+	2.9	.17	1.14	.20	1.30	.24	.38	70	59	18	6	12

Petiole cross section showed the same trend at each measurement and data for October are given in Table 23. The yield response to mulch is still convincingly present, other trends are not clear yet.

Table 23: Experiment 110, Petiole cross section (cm2), October 1986

AMMONIUM FERTILIZER		- mulch	+ mulch
Nil		14.8	16.1
Nitrate	only nitrogen	14.5	16.4
Mean		14.7	16.3**
Chloride	nitrogen + Cl	14.8	16.6
	nitrogen + high Cl	15.3	15.9
Sulphate	nitrogen + S	15.2	16.0
	nitrogen + high S	14.5	15.7
Phosphate	nitrogen + P	15.5	15.4
	nitrogen + high P	15.5	15.7
Mean		15.1	15.9*

significant at ** 1%, *5%

The first year's production figures are shown in Table 24. Effects other than due to mulch have not yet developed. Single bunch weights for each month showed no reaction to anion.

Table 24: Experiment 110, Production per hectare, 1986

		1986				December 1986 only	
		No. of bunches		Wt. of bunches t		s.b.w. kg	
AMMONIUM FERTILIZER		-mulch	+mulch	-mulch	+mulch	-mulch	+mulch
Nil		2733	2852	10.1	10.4	4.5	4.5
Nitrate	only nitrogen	2547	2799	9.2	10.4	4.2	4.6
Mean		2640	2826*	9.7	10.4(*)	4.4	4.6*
Chloride	nitrogen + Cl	2714	2933	10.0	11.2	4.6	4.9
	nitrogen + high Cl	2790	2981	10.7	12.0	4.9	5.3
Sulphate	nitrogen + S	2872	2666	11.0	9.8	5.1	4.7
	nitrogen + high S	2911	2627	10.6	9.8	4.3	4.7
Phosphate	nitrogen + P	2464	2841	9.4	10.7	5.0	4.8
	nitrogen high P	2880	2793	10.4	10.9	4.7	4.8
Mean		2772	2807	10.3	10.7(*)	4.8	4.9

significant at (*) 10%, * 5%

Experiment 111: Fertilizer experiment on young palms, Malilimi

Three pilot sites had been planted in September 1983 at 135 palms per hectare. The opportunity was taken to superimpose a simple experiment to detect the differences expected from analysis of the soil. The soils at Malilimi are extremely variable in composition and frequently contain compacted layers.

Design: Four replicates of completely randomised blocks, each of two sites containing 2 replicates. Two plots of the site were treated at a later date for comparison.

Treatments: The objective of this experiment is to test if soil characteristics permit normal growth of palms, with or without fertilizers (N and P):

Treatment	Ammonium chloride	TSP
	kg/palm. year	
1.	0	0
2.	0	0.5
3.	1.0	0.5

Recording: Petiole cross section was measured in January, March, June, September and December. Leaf samples were taken in January, soil samples in February. Fertilizers were applied in April (N + P) and October (N). Production per palm was recorded throughout the year.

Results: Leaf analysis results are summarised in Table 25. Magnesium and potassium levels were above the critical level and chloride and boron were low in the untreated plots. Effects due to ammonium chloride were a sharp increase in leaf chloride, decrease in potassium and an increase in calcium. This can be explained if the theory is accepted that chloride favours the absorption of calcium which in its turn depresses potassium by K/Ca antagonism. The fall in K and rise in Ca has been found several times after application of KCL. Some authors have warned that K levels could be forced below the critical value by the anion and so diminish the expression of the effect of chloride fertilizers. A simultaneous rise in Ca has not always been found, as in the case of Expts. 106 and 110 for example. Soil analysis results are summarised and discussed on page 35.

Table 25: Experiment 111, Leaf nutrient levels, January 1986

	BLOCK 1			BLOCK 2			BLOCK 3
TREATMENT	Nil	P	NP	Nil	P	NP	Nil
Nitrogen	2.6	2.5	2.7	2.6	2.6	2.6	2.5
Phosphorus	.17	.17	.18	.17	.17	.18	.18
Potassium	1.03	.95	.88	1.01	1.11	.88	.96
Sulphur	.18	.18	.18	.18	.18	.19	.20
Calcium	1.19	1.22	1.28	1.14	1.11	1.25	1.20
Magnesium	.27	.30	.27	.30	.27	.27	.29
Chloride	.13	.12	.52	.10	.13	.44	.13
Iron	56	59	55	53	54	51	52
Manganese	35	38	54	24	28	37	39
Zinc	17	16	17	16	16	15	15
Copper	6	5	6	7	6	6	6
Boron	9	11	9	8	9	9	10

The low petiole cross section values (Table 26) of site 3 (and to a lesser degree the values of site 2) are undoubtedly a reflection of the physical limitations of the soil, which impeded proper growth of the roots and suppressed yield. Sites 2 and 3 produced about 30% less than site 1. The effect of the fertilizers is not clear.

Table 26: Experiment 111, Yield per hectare Nov 85 to Dec 86 and petiole cross section, October 1986

SITE	Fertilizer	No. of bunches	wt. of bunches t	s.b.w. kg	W X T cm^2
1	Nil	2933	12.4	4.2	14.5
	P	2823	12.1	4.3	14.2
	NP	2766	12.5	4.5	15.6
2	Nil	2329	9.8	4.2	15.3
	P	1971	8.4	4.3	14.1
	NP	1920	8.3	4.3	13.8
3	Nil	2093	8.0	3.8	12.8

EXPERIMENT 112: Nitrogen and phophate trial, Buvussi

Design: 8 replicates of completely randomised blocks. Each replicate sited in a separate smallholding. Plots are of at least 4 rows and comprise of approximately 30 recorded palms with double guard rows between plots.

Treatments:

Fertilizer	Kg/palm. year
1. Nil	-
2. Triple superphosphate	1.0
3. TSP + ammonium chloride	1.0 + 1.0

Treatments commenced in May 1986.

Recording: Yield, petiole cross section, leaf nutrient levels and monthly black bunches were recorded. It had been intended to record production on a twin row basis but this proved impracticable for these smallholdings (as it had in Oro Province), therefore, individual palm recording had to be adopted. Black bunch counts were made to study the correlation between assessments of yield from these counts together with monthly values of single bunch weight from random samples of 20 bunches, and real yield. A method based on counts and samples would enable many more blocks than at present to be evaluated for survey or experimental purposes.

Results: Yield recording had been in progress for six months by the end of the year, ten months after the fertilizer treatments commenced. This is the stage when an effect on single bunch weight might first be expected and such a response to nitrogen is suggested by the data. There were significant differences in yield between the blocks. Production during the last 3 months and over the six months period is given in Table 27.

Table 27: Experiment 112 Production July - December 1986

	Per Palm			Per Hectare	
Treatment	No. of bunches	Wt. of bunches	s.b.w.	No. of bunches	Wt. of bunches
		kg	kg		t
Nil	5.0	54.0	10.8	598.2	6.9
P	4.7	48.9	10.4	567.0	6.2
P + N	5.3	62.1	11.5	642.5	7.7

EXPERIMENT 113: 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 by D.A.L. for the foodcrops, where available.

Demonstration:

		Ammonium chloride/palm kg Year 1	Ammonium chloride/palm kg Year 2	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 Aibika	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.

Sites were chosen and work commenced to lay out the gardens once the palms had been planted.

Demonstration Plots: nitrogen in replanted palms

In September 1985, PNGOPRA Advisory Leaflet No. 1 was published. This recommended a new regime of nitrogen fertilizers for palms replanted from oil palm in the Hoskins scheme of W.N.B.P. where similar soil to that on Bebere plantation occurred. Demonstrations of new recommendations were set up in smallholder divisions where replanting was underway.

Design: Unreplicated layouts on each of the smallholder blocks. Each of the latter comprised two plots following the new recommendation on either side of a single plot receiving the old recommendation.

Treatments:

		Ammonium chloride g/palm				
Mths from planting		3	6	12	18	24
	Plot					
	1.	200	240	480	480	960
	2.	200	240	480	480	960
	3.	200	240	480	480	960

Ammonium chloride for this work was donated by the Sumitomo Corporation of Japan.

	Kapore block 283	Sarakolok 912	Buvussi 1333
Replanted	August 1985	August 1985	November 1985
Treatment Commenced	November 1985	November 1985	February 1986

Progress: Explanatory field demonstrations were conducted for staff of the Department of Primary Industry in December 1985. The better colour and apparent establishment of palms with additional nitrogen prompted further field demonstrations to DPI staff and smallholders in October 1986. Despite the local interest in these demonstrations, it was necessary for PNGOPRA staff to carry out ring weeding at all sites to obtain passable standards of maintenance.

EXPERIMENT 114: Discoloured fronds, Togulo

In March 1985, an observational trial was started at Togulo plantation to elucidate and seek to alleviate symptoms of apparent nutrient deficiency in palms during their early productive period. The following characteristic areas were identified:

A: magnesium type deficiency symptoms, 1979 planting.
B: potassium type deficiency symptoms, 1981-1982 planting.
C: symptomless in March 1985, 1983-84 planting.
D: severe boron type deficiency symptoms, 1979 planting.

Three replicates of the following treatments were applied in March 1985 to alternate rows, leaving 1 guard row between treated rows:

Area A - C: 1. Sulphate of Potash 4 kg/palm.

2. Muriate of Potash 4 kg/palm.
3. Kieserite 2 kg/palm.
4. Nil

Area D: 1. Borax 50g (mixed with 300g talcum powder).
2. Nil

Leaf samples were taken in each area (partly in March, partly in August 1985). In August, petiole cross sections of rows to be included in the observational experiment were measured. Also leaf deficiency symptoms were scored visually on a scale of 0-4 in areas A, B and C.

Petiole cross section measurements and scoring of deficiency symptoms were repeated after 4 and 12 months. Leaf samples were taken 12 months after applying fertilizer. Data are presented in Table 28.

Table 28: Experiment 114, Leaf nutrient levels, growth and deficiency symptoms1

AREA B

		Leaf nutrient levels %							ppm	
		N	P	K	S	Ca	Mg	Cl	Mn	B
March 1985		2.7	.17	1.10	.17	1.30	.27	.13	48	13
		2.6	.15	1.12	.16	1.28	.21	.12	50	11
Sept. 1986	Nil	2.7	.17	1.03	.20	1.14	.20	.17	60	14
	MOP	2.8	.17	.90	.20	1.23	.19	.60	68	13
	Kies	2.8	.17	1.05	.20	1.14	.20	.16	55	13
	SOP	2.7	.17	1.16	.20	1.07	.18	.16	53	12

W x T (cm²) Difference Aug '85 - Aug '86		deficiency symptoms (scale 0-4 where 0=absent) Aug '85	Feb '86	Aug '86
Nil	2.0	1.3	0.4	1.9
MOP	2.1	1.7	0.5	2.5
Kies	3.2	2.3	0.3	2.0
SOP	2.9	2.6	0.3	2.2

AREA C

		Leaf nutrient levels %							ppm	
		N	P	K	S	Ca	Mg	Cl	Mn	B
March 1986		2.8	.17	1.13	.18	1.28	.23	.10	46	13
Aug. 1986		2.26	.16	1.14	.15	1.19	.20	.12	51	13
Sept. 1986	Nil	2.6	.18	1.23	.20	1.17	.23	.18	57	13
	MOP	2.6	.16	1.24	.19	1.16	.22	.51	64	10
	Kies	2.7	.17	1.28	.20	1.16	.23	.19	54	11
	SOP	2.7	.17	1.23	.20	1.05	.21	.18	59	12

W x T (cm²) Difference Aug '85 - Aug '86		deficiency symptoms (scale 0-4 where 0=absent) Aug '85	Feb '86	Aug '86
Nil	3.6	0.6	0.7	2.0
MOP	4.8	1.0	0.6	2.0
Kies	3.7	0.8	0.4	2.4
SOP	5.2	0.7	0.6	2.1

Results: In area A, Mg levels were below the critical level in 1985. Other nutrients, apart from Cl, were adequate. Sulphate of potash increased K levels marginally, muriate of potash decreased K and Mg levels, but increased Cl considerably. Kieserite seems to have increased Mg slightly, but the difference is not convincing (from 0.18 to 0.20). Differences in petiole cross section were small. Deficiency symptoms were much less severe in February (rainy season). None of the fertilizers prevented the symptoms from reappearing later in the year, however.

In area B, despite the apparent K deficiency symptoms, leaf levels for this element were good in 1985. Muriate of potash and sulphate of potash showed an opposite reaction: KCL decreased K and increased Ca (preferential uptake of Ca), but K_2SO_4 increased K and decreased Ca. Kieserite did not increase Mg levels. Kieserite and SOP appeared to improve petiole cross section. Deficiency symptoms showed the same pattern as in Area A, however.

Area C had been chosen because it was relatively "symptom-free" to see if applied fertilizers would prevent symptoms from appearing. Magnesium and chloride levels were low in 1985 for a young planting. Apart from the rise in Cl (due to KCL) and the drop in Ca (due to sulphate of potash) no other reactions occurred. K levels increased by the same proportions as in the unfertilized plots. In this area both potassic fertilizers improved petiole cross section. Deficiency symptoms eventually occurred as much in the nil plots as in the treated plots, however, and the treatments were ineffective in preventing their onset.

In area D, Borax application did not increase B levels of leaf 17, but levels were not low at the start. Cl and K levels increased "naturally", that is, in line with the control plots.

Conclusions: The frond discolouration in Area B seen in 1985, which involved orange-spotting, was likened to symptoms of K deficiency. Seen in a more severe stage in 1986 it has more the appearance of Mg-deficiency and the yellow discolouration was followed by dessication. Symptoms that have appeared in Area C were of the magnesium deficiency type, so it was concluded that in all three sites the discolouration of the palms was symptomatic of Mg deficiency. Leaf magnesium status is highly heritable and is used as an important selection criteria because of its positive correlation with yield. Current Dami seed is selected on leaf levels but the seed planted in Togulo would only have been selected by visual assessment of leaf yellowing which is now known to be less effective. It is probable that the pre-disposition of seedlings to the kind of yellowing seen on Togulo will be less prevalent in currently available commercial seed.

The opposite effects of muriate of potash and sulphate of potash on leaf levels were also found in Expt. 103 (Sources of potash trial, annual report 1983). In areas with low K levels, there is the danger that by applying muriate of potash K levels would be decreased even further.

Experiment 201: Fertilizer trial, Hargy

Planted in 1973 with IRHO DxP at 115 palms/ha; 2916 palms total, 1296 recorded. Area 25.4 ha.

Design: One replicate of a 3^4 factorial (N,P,K,Mg), in 3 blocks of 27 plots, each with 36 palms of which the central 16 are recorded.

Treatments: Treatments were first applied in June 1982. Rates are:

	kg/palm.year		
LEVEL	0	1	2
Sulphate of ammonia	0	1.0	2.0
Triple superphosphate	0	0.8	1.6
*Bunch ash	0	1.5	3.0
Kieserite	0	1.0	2.0
*now replaced by muriate of potash	0	1.0	2.

Fertilizers are being applied twice yearly, bunch ash following the other fertilizers by 3 months because of incompatibility with ammonium sulphate. Applications were in January (bunch ash), April (N, Mg), May (P), July (bunch ash), October (N,P,Mg) and December (K as muriate of potash). The replacement of bunch ash by muriate of potash was a decision of the Scientific Advisory Board, in relation to the chloride issue.

In December 1985, 50g borax was applied to all palms numbered 1-8 of each plot, as a split plot treatment. This was to test the opinion of Hargy Oil Palms that many symptoms seen in the plantations were due to a deficiency of boron, which they resembled.

Recording: Leaf samples were taken in the selected plots in January, March, May, July and September for Investigation 708 and in all plots in November. The leaf samples taken in the selected plots in January 1987 were split for palms 1-8 and 9-16 for the analysis of boron. They are presented in this annual report for convenience, together with the results of visual scores of boron deficiency symptoms in December. Petiole cross section was measured in June. First frond marking in the selected plots was started in September on a monthly basis. This is a separate exercise in relation to Investigation 706.

Results: Magnesium soil levels were very low indeed but the application of kieserite did not seem to have alleviated the situation. Chloride levels were low to moderate but the introduction of muriate of potash will certainly increase levels in the K_1 and K_2 plots. The soils are probably well buffered since the manganese levels are uniform for all N treatments, sulphate of ammonia does not seem to be having had an acidifying influence on these soils.

Leaf nutrient levels are given in Table 29. Despite the yield response to TSP, no major increase of leaf phosphorus levels was found. No differences between the nitrogen levels per N treatment could be detected but when the plots were grouped per block a very indicative trend of 2.6 - 2.4 - 2.2 was found down the lower slope of the dormant volcano on which the plantation is situated. (Table 30). There has been no relation between levels of nitrogen and yield as yet, but it is likely that the palms on the higher ground will suffer from nitrogen deficiency before those lower down. One year after the application of borax palms 1-8 showed a boron level of 17.8 as against 14.8 of the untreated palms.

Table 31 gives an indication of how boron deficiency symptoms changed between 1985 and 1986. Amongst the palms treated with borax light symptoms had increased, moderate and severe symptoms decreased, whereas amongst the untreated palms both light and moderate symptoms increased. However, these effects were marginal and, bearing in mind that it was a subjective visual assessment, cannot be considered as showing a recovery so far.

Table 29: Experiment 201, Leaf nutrient levels, November 1986

	N	P	K	S	Ca	Mg	Cl	Fe	Mn	Zn	Cu	B
N_0	2.4	.16	.96	.18	.99	.13	.22	53	67	23	6	19
N_1	2.4	.17	.97	.19	.94	.13	.24	55	67	23	7	19
N_2	2.4	.16	.96	.19	.96	.13	.24	55	65	23	6	20
P_0	2.4	.16	.97	.19	.96	.12	.24	54	66	22	7	20
P_1	2.4	.17	.96	.19	.95	.13	.23	53	67	23	6	20
P_2	2.4	.16	.95	.19	.97	.13	.23	55	66	23	6	19
K_0	2.4	.17	.98	.19	.94	.13	.23	55	67	23	7	20
K_1	2.3	.16	.95	.18	.97	.14	.24	52	66	23	6	19
K_2	2.4	.16	.96	.19	.97	.12	.23	56	66	23	6	19
Mg_0	2.4	.17	.97	.19	.96	.13	.22	54	66	23	7	20
Mg_1	2.4	.16	.97	.19	.96	.13	.25	55	67	23	6	20
Mg_2	2.4	.16	.95	.18	.96	.13	.23	54	66	22	6	18

Table 30: Experiment 201, Nitrogen levels per block, November 1986

BLOCK	NO	N1	N2	Mean
1	2.6	2.6	2.6	2.6
2	2.4	2.4	2.4	2.4
3	2.2	2.2	2.3	2.2

Table 31: Experiment 201, Percentage of palms with boron deficiency symptoms, December 1985 and December 1986

SYMPTOMS	1985		1986	
	palms 1-8 +B	9-16 -B	1-8 +B	9-16 -B
Light	8.5	10.2	12.7	15.2
Moderate	6.9	7.4	2.4	11.5
Severe	4.4	5.5	1.7	1.1

None of the fertilizer treatments had a significant effect on petiole cross section but a positive trend can be seen in the N treatments (Table 32).

The average annual yield of 26.5 ton/ha for these 13 year old palms is good (Table 33). The response of previous years to TSP was still seen but only at a significance level of 10% (the extra yield is 1.1 to 1.9 ton/ha). Kieserite reduced single bunch weight and increased the number of bunches, which taken together did not increase yield significantly.

A covariance analysis for yield and pre-treatment petiole cross section had no effect in improving the precision or results of this experiment.

Table 21: Experiment 201, Petiole cross-section (cm^2), June 1986

W X T

N0	36.1	K0	36.2
N1	36.7	K1	37.1
N2	37.2	K2	36.7
P0	36.3	Mg0	36.9
P1	36.9	Mg1	36.6
P2	36.8	Mg2	36.5

Table 22: Experiment 201, Yield per hectare, 1986 and to date

	1986			Since June 1982
	No. of bunches	Wt. of bunches t	s.b.w. kg	Wt. of bunches t
N0	1184	26.1	22.0	118.5
N1	1177	26.1	22.2	117.2
N2	1242	27.2	21.9	120.3
P0	1179	25.5a	21.6	109.9
P1	1197	26.6b(*)	22.2	119.7
P2	1227	27.4b	22.3	122.7
K0	1240	27.2	21.9	118.7
K1	1178	26.2	22.2	119.0
K2	1185	26.0	21.9	118.0
Mg0	1162a	26.2	22.5a	117.5
Mg1	1181a	25.8	21.8b(*)	117.7
Mg2	1261b*	27.5	21.8b	121.0
Mean	1201	26.5	22.1	118.7

significant at (*) 10%, * 5%

Experiment 202: Bunch refuse manurial experiment, Hargy

Planted in 1973 with IRHO DxP at 115 palms/ha; 1080 palms total, 480 recorded. Area 9.4 ha.

Design: Five replicates of randomised blocks, each with 4 treatments plus 2 nil plots; 36 palms per plot of which the central 16 are recorded.

Treatments:

		Applied
1+2.	Nil	
3.	50 t empty bunches/ha	Aug.-Dec.'84
4.	100 t empty bunches/ha	Aug.-Dec.'84
5.	100 t empty bunches/ha+SOA (1kg/palm)	Aug.'84-Jan.'85
6.	25 t empty bunches/ha	Jan.-Feb.'85

Treatments are applied only once.

Recording: Petiole cross section was measured in July. Leaf samples were taken in August and soil samples in September. Yield recording per palm continued throughout the year.

Results: Results for the petiole cross section measurements are presented in Table 34. Although not significant a positive trend is present indicating that mulching has a beneficial effect on vegetative growth. About 2 years after the application of empty bunches the following effects are noted on the soil elements (Table 35):

- a 30 to 50% increase in the amount of exchangeable K in the treated plots versus the control. This is not surprising considering the high amount (+ or - 0.5%) of K found in wet empty bunches.

- levels of exchangeable Mg increased by 24% in the 25 ton plots, and by over 80% in the blocks receiving larger amounts of empty bunches. This is surprising since the EB contain little Mg, (0.04%). The bunches contain more Ca and yet there was no increase in the Ca content of the soil.

Relating these results to the leaf levels (Table 36) it can be seen that leaf potassium increased whereas magnesium levels remained the same as compared to the untreated plots. Also chloride levels increased due to treatments.

Production data are also shown in Table 34. A significant response was obtained with the application of 50 ton EB or more via an increased single bunch weight. In terms of production per hectare only the 50 ton EB/ha treatment was significantly better than the controls.

Table 34: Experiment 202, Production per hectare, 1986 and todate and Petiole cross section (July)

	1986			April 85-Dec 86			July
	No. of bunches	Wt. of bunches t	s.b.w. kg	No. of bunches	Wt. of bunches t	s.b.w. kg	W x T m^2
nil	1147	23.5a	20.5a	1974	41.2	20.9	35.7
25 ton EB/ha	1100	24.6ab	22.1ab	1814	40.9	22.5	35.4
50 ton EB/ha	1160	27.4b*	23.6b	1853	43.9	23.7	37.4
100 ton EB/ha	1080	26.2ab	24.3bc**	1849	44.0	23.8	37.6
100 ton EB/ha + SOA	1044	24.6ab	23.6b	1747	40.8	23.4	39.2

Means with different letters differ significantly at * 5%, ** 1%

Table 35: Experiment 202, Soil analysis results, September

TREATMENT	NIL	25t EB/ha	50t EB/ha	100t EB/ha	100t EB/ha + SOA
Bulk density, g/ml	0.68	0.69	0.69	0.71	0.68
pH	6.5	6.5	6.6	6.6	6.6
Phosphorous, g/ml	3	3	2	3	3
P retention, %	89	91	89	89	89
Exch K, me/100g	0.09	0.13	0.12	0.14	0.13
Exch Ca, me/100g	13.3	12.5	12.8	12.4	13.6
Exch Mg,me/100g	1.16	1.44	2.11	2.11	2.20
Exch Na, me/100g	0.07	0.06	0.06	0.05	0.05
CEC, me/100g	20	20	20	19	20
TBS, %	72	72	75	77	81
K Sat., %	0.5	0.6	0.6	0.7	0.7
Ca Sat., %	65	64	65	65	69
Mg Sat., %	5.7	7.4	10.8	11.1	11.0
Na Sat., %	0.3	0.3	0.3	0.2	0.2
OM %	9.1	9.2	9.1	8.8	9.2
Res Mg, me/100g	10.6	10.3	10.0	10.8	10.6

Table 36: Experiment 202, Leaf analysis results, August

				%						ppm		
	N	P	K	S	Ca	Mg	Cl	Fe	Mn	Zn	Cu	B
nil	2.4	.15	.91	.18	.93	.16	.20	60	66	26	8	18
25t	2.4	.15	.98	.17	.93	.16	.21	59	66	26	7	18
50t	2.5	.15	.95	.18	.92	.16	.23	62	67	26	6	18
100t	2.4	.15	.99	.18	.86	.16	.27	64	64	26	6	20
100t+SOA	2.5	.15	.95	.18	.89	.14	.26	56	64	26	7	18

Experiment 203: Phosphate establishment trial, Navo

Planted in May 1986 at 120 palms/ha, 200 palms total and recorded.

Design: 50 replicates of pairs of equal sized seedlings.

Treatments: 3 months after planting one of each pair received 300g sulphate of ammonia and the other 300g sulphate of ammonia and 400g triple superphosphate.

This experiment will serve as a small establishment trial to see if phosphate will enhance the effect of nitrogen which the soil analysis suggested as a possibility. For results of soil samples, taken in January 1986, see page*.

Recording: Petiole cross section will be measured every 3 months, starting in 1987.

SOIL ANALYSES. (R.L.A., M.H.)

Experiment 106: Soil analysis results, January 1986

A significant block effect was found in the 13 months' yield data (Dec.84-Dec.'85) rating block 1 as the best, then 4-6-2-5 and 3 as the lowest yielding. This trend changed only slightly in 1986: 1-4-6-5-2-3. Petiole cross section, measured in February, also showed a significant block effect, block 4 being the best, then 1-6-2-5-3. For the September measurements the trend was 4-1-2-3-6-5. So there is a possible less fertile area running through the experiment.

Soil analysis data are presented in Table 37 together with the 1982 data for comparison.

Table 37: Experiment 106, Chemical soil analysis, block means

Block	1		2		3		4		5		6		Mean	
	1982	1986	1982	1986	1982	1986	1982	1986	1982	1986	1982	1986	1982	1986
Bulk density	0.73	0.70	0.72	0.70	0.72	0.73	0.71	0.71	0.67	0.71	0.69	0.72	0.70	0.71
pH	6.5	6.6	6.5	6.9	6.5	6.8	6.6	6.8	6.5	6.7	6.6	6.7	6.5	6.8
P(mg/ml)	6	7	7	15	5	9	6	10	5	12	6	9	6	10
K	0.70	0.60	0.80	0.77	0.51	0.81	0.70	0.80	0.60	0.98	0.57	0.89	0.65	0.80
Ca	10.1	11.4	10.0	11.6	9.1	8.1	9.9	12.8	9.3	11.2	10.5	8.2	9.8	10.0
Mg	0.95	1.53	1.00	1.81	0.80	1.25	0.77	1.28	0.82	1.57	0.99	1.33	0.89	1.40
Na	0.16	0.07	0.18	0.03	0.09	0.05	0.09	0.05	0.15	0.09	0.14	0.08	0.13	0.0
CEC	14	16	14	16	13	12	13	12	14	19	15	12	14	15
% K	4.8	3.8	5.7	5.2	4.0	6.9	5.4	5.0	4.4	6.8	3.9	7.4	4.7	5.8
% Ca	70	72	72	73	70	67	74	77	67	74	71	68	71	72
% Mg	6.6	9.6	7.1	11.6	6.2	10.7	5.8	7.9	5.9	10.9	6.7	11.2	6.4	10.3
% Na	1.1	0.4	1.3	0.2	0.7	0.4	0.7	0.3	1.0	0.6	1.0	0.7	0.9	0.4
organic matter	6.1	6.1	5.6	5.3	5.2	3.9	5.3	5.0	5.3	5.0	5.3	4.1	5.5	4.9
Available N	-	99	-	74	-	60	-	85	-	72	-	60	-	75
P retention	57	53	59	52	54	49	55	49	59	49	57	49	57	50
Reserve Mg	1.6	-	1.9	-	1.7	-	1.4	-	1.5	-	1.5	-	1.6	-
Total % base sat.	85	85	86	89	81	85	88	124	78	73	81	88	82	86

Possible reasons for the fact that block 3 shows significantly lower yield and petiole cross section are:

- K was comparatively low in '82 but had picked up dramatically, presumably due to fertilization. Blocks 1 and 2, however, appear to be using (or losing) fertilizer K faster than it is being supplied.

- Mg was below critical (1.0 meq/100g) in 1982 but is now marginally above critical.

- The CEC for block 3 is moderate to low, but is similar for the rest of the experiment.

- Organic Matter levels are slightly low as they are in the rest of the experiment. OM is, however, important in K and N nutrition, and block 3 has the lowest OM and N levels of the 6 blocks. This may be of some importance.

It appears that the lower yields and poorer growth in block 3 are related more to physical rather than chemical soil factors.

Other possible effects of fertilizer treatments: pH appears to have risen. However, pH changes naturally over time and more so over space. Plots grouped by the same treatments did not reveal the expected rise in pH due to bunch ash (which is an alkali), nor a fall in pH due to sulphate of ammonia which is known to acidify the soil. The exchange complexes of these soils are dominated by alkaline metals which may explain why the H^+ from SOA had little observable effect on pH.

Available P has increased as the experiment progressed as a direct result of fertilization. Levels are now moderate (Table 38).

Table 38: Experiment 106, Effects of fertilizers on available P

	1982	1986	relative change
N0	5.3	9.3	+ 3.4
N1	6.4	10.5	+ 4.1
N2	5.7	10.8	+ 5.0
P0	6.3	9.2	+ 2.9
P1	5.7	11.2	+ 5.5
K/Mg	5.7	9.3	+ 3.6
K/Mg1	6.3	11.5	+ 5.2
K/Mg_2	6.0	9.8	+ 3.8

From the nil treatments (No, Po, etc) the natural change over time can be deduced. The treatment effects (N1, N2, etc) partly consist of this time factor and partly of an added fertilizer factor.

The soils have relatively low P retention. This has been reduced slightly by fertilizer application as a whole, i.e. fertilizer anions now occupy the sites onto which P would have been adsorbed. Thus, more of the added P fertilizer is in solution and available to the plants.

With relation to cations, calcium has become less available after application of fertilizers (especially K/Mg fertilizers) (see Table 39), or it may have been taken up by the palms in greater quantities. Percentage saturation by K has increased.

There is a possibility of Ca/K antagonism. This is especially true when KCl is used as a source of K^+. The Cl- combines with the Ca^{2+} which is taken up by the palm in preference to K^+ which may be absorbed by the soil or leached.

Also, the percentage saturation of Mg has increased due to fertilization. In general, the effect has been an increase in the relative base saturations of potassium and magnesium with a decrease of the overall percentage saturation of calcium.

Availability of nitrogen appears to be only average to slightly below average. Strangely, there was no difference between the plots fertilized with SOA and those not.

Table 39: Experiment 106, Effects of applied fertilizers on soil Ca & K.

	1982	1986	relative change
	exchangeable Ca (meq/100g)		
K/Mg0	9.7	11.2	+ 1.5
K/Mg1	10.0	10.5	+ 0.6
K/Mg2	9.9	10.0	+ 0.1
	% saturation Ca		
K/Mg0	70	74	+ 4
K/Mg1	71	71	-
K/Mg2	71	70	- 1
	% saturation K		
K/Mg0	4.8	5.6	+ 0.8
K/Mg1	4.9	5.8	+ 0.9
K/Mg2	4.5	6.1	+ 1.6

Experiment 108: Soil analysis results, March 1986

phosphorus: Phosphorus showed a systematic increase due to DAP fertilization (Table 40). Other elements did not and their data therefore were averaged (Table 41).

Table 40: Experiment 108, Soil Phosphorus (mg/l), DAP plots

level	0	1	2	3	4	5	6	7
Field F/8	2	4	5	4	8	7	6	16
Field E/7	3	3	4	20	10	22	21	34

pH: variable between plots but on average around the neutral point, apart from Field E/7 (DAP) where the pH was slightly more acid (plots 55-59 drop to 6.2 - 6.3).

potassium: there was considerable variation from plot to plot. Levels in Field E/7 were markedly higher which may have been an effect of mulching. Levels in Field F/8 were low but above critical.

calcium: levels were variable from plot to plot. Averages per field were around the critical level, but plot values dropped below this level in plots 5-9-11-16-21-41-45-53-55-57-59-63.

magnesium: levels were very low in all plots apart from plot 17 which was above the critical value of 1.0 me/100g.

sodium: levels were very low in all plots.

CEC: levels were low but adequate.

Base saturation: there was a strong bias towards calcium. Calcium was below average in field E/7 (DAP). Magnesium levels were adequate as were potassium levels apart from Field F/8 (Amm. chl)

N availability: levels varied highly from plot to plot and from field to field. Averages per field are considered low. No systematic trend has developed due to application of ammonium chloride or DAP.

Table 41: Experiment 108, Chemical Soil analyses results (March 1986) (C.V. between brackets)

	Field F/8 (unmulched)				Field E/7 (mulched			
	Amm. chloride		DAP		Amm. chloride		DAP	
bulk density	0.71	(5.4)	0.69	(6.1)	0.73	(4.0)	0.71	(4.2)
pH	6.8	(2.5)	6.9	(2.6)	6.7	(3.5)	6.5	(3.5)
phosphorus	3	(42)	6	(71)	3	(18)	13	(87)
potasium	0.17	(30)	0.15	(10)	0.25	(25)	0.24	(33)
calcium	6.4	(34)	7.3)	(28)	7.5	(25)	6.0	(43)
magnesium	0.42	(32)	0.63	(51)	0.53	(38)	0.47	(39)
sodium	0.13	(30)	0.15	(19)	0.08	(37)	0.10	(59)
CEC	9	(20)	9	(20)	10	(10)	10	(21)
% K	2.1	(32)	1.6	(17)	2.4	(24)	2.4	(41)
% Ca	72	(15)	76	(12)	72	(17)	58	(22)
% Mg	4.8	(25)	6.5	(35)	5.1	(32)	4.7	(36)
% Na	1.6	(43)	1.6	(25)	0.8	(33)	1.0	(47)
org. matter	3.1	(31)	3.6	(27)	3.8	(16)	3.6	(16)
available N	29	(32)	41	(41)	48	(22)	46	(44)
phosphate retention	58	(8.4)	60	(11)	57	(3.6)	56	(6.9)

Experiment 111, February 1986:

The experimental area comprises 3 pilot blocks at 3 sites which are situated at about 1 kilometre apart, sites 1 and 2 consist of 6 plots each, site 3 has 2 plots. Site 3 was considered to have the worst physical properties and was maintained for comparison with the 2 sites of the trial. Results are presented in Table 42 as averages per site. Analyses were done on individual plot samples.

Bulk densities: these were low, probably due to the high pumice gravel contents of these soils.

phosphorus: very low availability with low to moderate P retention. A response to P fertilizers should be possible unless leaching is excessive.

Exchangeable K: levels were adequate in all blocks and notably high in site 3.

Exchangeable Ca: Ca and correspondingly Mg levels were well below critical in sites 1 and 2, but above in site 3.

Organic Matter and nitrogen: OM contents were low for sites 1 and 2 and marginally better in site 3. OM content figures correspond well with available N figures which were all low.

.s: growth and yield are considerably affected by the physical e of these soils. The physical nature of the soils and drift material at Malilimi are complex. Features such as buried horizons and compacted pumice gravel layers are likely to have a significant effect on palm growth, overriding chemical factors in some cases. Thus, whilst growth and yield should apparently be by far the best from a chemical standpoint in site 3, site 1 is the most productive. Thus, yield responses attributable to the fertilizers will be limited by physical soil factors. However, responses with N and K fertilizers are still likely and are also possible with P and Mg.

Table 42: Experiment 111, Chemical soil analysis results, Feb. 1986

	plot 1 - 6 pilot block 1	plot 7 - 12 pilot block 2	plot 13 - 14 pilot block 3
bulk density	0.65	0.68	0.61
pH	6.7	6.6	6.8
phosphorus	3	3	4
potassium	0.16	0.15	1.00
calcium	6.1	4.3	11.7
magnesium	0.70	0.55	1.58
sodium	0.03	0.01	0.02
CEC	8	6	16
% K	2.0	2.4	6.3
% Ca	73	69	73
% Mg	8.9	8.9	9.9
% Na	0.3	0.2	0.1
organic matter	3.8	2.9	6.0
available N.	51	34	73
phosphate retention	59	54	44

Experiment 204: Fertilizer trial, Navo

A factorial fertilizer trial on mature palms is scheduled to be established on Navo plantation in 1987. Results of a soil survey carried out in 1986 to determine a suitable site and guide experimental treatments are reported here. Physical soil descriptions were made and soil samples taken from 6 different pits in blocks 6 and 7, area 3 which were then the candidate sites for the Navo fertilizer experiment. Another site at the Western boundary was included for comparison because it was believed to have more fertile soil.

Textures found were: black coarse sand to fine gravel and gravelly clay loam. Overall the soils of this area are physically uniform. They are well drained but are likely to have a moderate waterholding capacity because of the large amounts of pumice gravel present. Therefore, water stress is not anticipated. Rooting was moderate to 75 and 100cm. There are no compacted horizons so neither rooting nor drainage will be restricted. Aeration will be good. The soils are young, have little structural development and are relatively unweathered, although clay content increases with depth until a dark grey pumice gravel layer is reached at between 75 and 100cm. The horizons containing the most clay may represent a buried soil which has since been covered by subsequent ash falls.

Table 43: Experiment 204, Chemical soil analysis Navo Plantation (Average of 7 sites), January 1986

Soil Depth	0 - 30 cm		30 - 60 cm	
	average	range	average	range
bulk density	0.82	0.77 - 0.89	0.83	0.78 - 0.91
pH	6.8	6.6 - 6.9	7.1	6.8 - 7.3
phosphorus	3	2 - 5	1	1 - 2
potassium	0.12	0.07 - 0.18	0.12	0.08 - 0.18
calcium	10.1	6.2 - 13.7	4.5	2.3 - 7.0
magnesium	1.54	1.02 - 2.08	1.13	0.53 - 2.09
sodium	0.06	0.00 - 0.10	0.07	0.04 - 0.09
CEC	13	9 - 16	7	3 - 10
% K	1.0	0.7 - 1.4	1.8	1.1 - 3.0
% Ca	80	68 - 86	67	60 - 71
% Mg	12.1	10.6 - 13.4	16.4	11.8 - 21.3
% Na	0.5	0.0 - 0.8	1.2	0.6 - 1.8
organic matter	5.6	4.2 - 7.4	2.8	2.0 - 4.9
available N	126	62 - 233	19	12 - 30
phosphate retention	50	34 - 62	73	49 - 89

Table 43 summarises the results of chemical analyses. The following were noted.

Bulk density: bulk densities are moderate. The soils are very young and relatively unweathered. Their structure was apedal to crumb, open and free draining.

pH: the soils are neutral to very slightly alkaline, hence, base saturations are all high. Calcium dominates the exchange complex with its high saturation levels. The subsoils are uniformally more alkaline than the topsoils.

Available phosphorus: levels of available phosphorus are low (topsoil) to very low (30-60cm). Fixation of P by the soil is moderate in the topsoil (less than 50% but high at 30-60cm (more than 50%)). There is, thus, more amorphous material in the subsoils. Only if the soil can be "saturated" with P by applying P fertilizer in concentrated bands is a response to P likely. Application of phosphate fertilizers could also increase the effective CEC. However, the base saturation of these soils is already high and the latter might not occur. P fertilizer applied at this site might be washed through the topsoil but should be retained in the subsoil where it would become slowly available to the deeper roots.

Exchangeable potassium: levels are generally low. Interestingly, the subsoil of one of the sites has an adequate supply of K which may indicate a buried horizon. The balance of cations on the exchange complex favours Ca to the detriment of K (Ca - K antagonism).

Exchangeable calcium: calcium levels are not low in the absolute sense but are in fact relatively low for a volcanic soil. However, there is no calcium deficiency here, (although 2 pits may be borderline) and in most cases the base saturations are heavily biased towards calcium.

Exchangeable magnesium: levels are relatively low but well above critical in most sites. Mg base saturations are quite high especially in the subsoil. Reserve magnesium has not been determined for these samples but samples analysed in 1984 showed that it is very high (14-22 meq/100g), probably due to the high Mg content of the volcanic ash.

Cation Exchange Capacity (CEC): the CECs are low to moderate with exceptions, i.e. a very low CEC of the subsoils of 2 sites. Presumably the moderate topsoil CECs are related to the OM present in the top 10 cm. However, taken in bulk the organic matter contents are low. Clay content increases somewhat with depth, thus, the low subsoil CEC values are not critical. There may be more clay present than at first thought. However, applied nutrients are likely to be leached to a considerable extent. Preservation of topsoil OM might ameliorate the situation.

Nitrogen availability: suprisingly high. This is probably a feature to the OM in the topsoil and the fact that the area was planted from virgin bush. The missing topsoil at Navo West (bulldozer activity?) probably accounts for the low available N.

Base saturation: the balance is biased towards calcium especially in the topsoils (calcium possibly being associated with OM.) Magnesium saturations are good and K levels low in the topsoil. In the subsoil, the balance swings to high saturation levels for Mg, moderate Ca and moderate to low K. There appears to be a physical and chemical transition in these soils at a depth of about 40cm. The volcanic material above this line is of a different variety to that below it, indicating two distinct periods of volcanic deposition and soil formation.

ORO PROVINCE

(R.L.A.)

EXPERIMENT 305: Factorial fertilizer experiment, Arehe

Initiated in 1981 on a 1978 planting occupying an area designated as an "A" type soil: a yellowish brown clay loam with a dark brown humic topsoil. Drainage is moderate.

Design: A 3x2x3x2 (N,P,K,Mg) factorial, confounded in blocks of 12 plots and replicated twice. There are 36 palms per plot of which the central 16 are recorded.

Treatments: Fertilizers were applied in March, April, July and September and were as follows for the year:

	kg/palm. year		
Level	0	1	2
Ammonium sulphate	0	2.0	4.0
Triple superphosphate	0	2.0	-
Potassium chloride	0	2.0	4.0
Magnesium sulphate	0	1.0	-

Results: Yield data for the past 12 months are presented in Table 44.

Table 44: Experiment 305, Yield per hectare, 1986 and to date

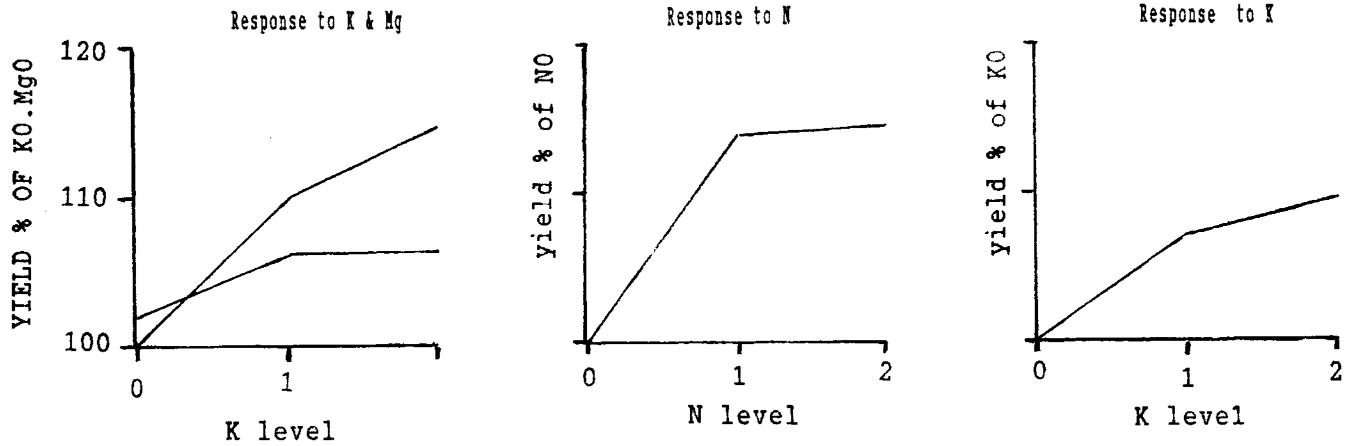
	Jan - Dec '86			Oct'81 - Dec'86
TREATMENT	No. of bunches	Wt. of bunches t	s.b.w. kg	Wt. of bunches t
N0	1626	28.0[l]***	17.2	156.6
N1	1842	31.9[q]**	17.3	166.7
N2	1852	32.0	17.3	167.3
P0	1803	30.7	17.0	162.8
P1	1744	30.6	17.6	164.5
K0	1799	29.1[l]***	16.2	157.7
K1	1763	31.1	17.6	165.7
K2	1758	31.7	18.0	167.2
Mg0	1799	31.1	17.3	163.5
Mg1	1748	30.1	17.2	163.6

Regression component l=linear, q=quadratic, **P=<0.01, ***P=<0.001

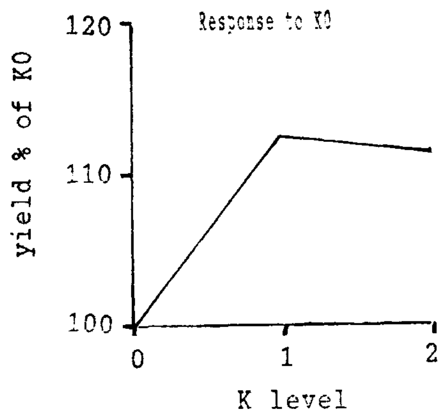
Statistical analysis of yield/ha for 1986 again indicated very clear responses to both N (P=0.001) and K (P=0.01). No response to P or Mg was identified, nor any interactions apart from a possible negative interaction between Mg and K (linear component: P=0.1) with Mg applications reducing the response to K applications (Figure 2).

Figure 2: Yield responses to N and K in Experiments 305,306, 1986

EXPT. 305



EXPT. 306



Trend analysis identified linear response components (P=0.001 for both N and K) and also a significant quadratic response component for N (P=0.01) indicating a reduced response to the highest N applications. In practice, with yields at N_2 and K_2 not differing in practical terms from N_1 and K_1, application of fertilizer to the higher levels could not be recommended at present.

The increased yield due to N was attributable to an increased number of bunches, whilst the extra yield from K was due to increased bunch weights, indicating the complementary modes of action of the two fertilizers.

Leaf analysis result (Table 45) for February to September of plots sampled for Investigation 708 indicated that more N was being taken up by the palms subject to a "high" fertilizer regime as compared to the "low" one. Levels of P were stable and just above critical. Leaf K levels were still higher in the control plots than in fertilized plots. Levels of Mg were still below the designated "critical" level, but Mg fertilizer did not improve yield.

Table 35: Experiment 305, Nutrient levels frond 17, Feb-Sept 1986 averaged

TREATMENT	PLOT	%				
N P K Mg		N	P	K	Mg	Cl
0 0 0 0	18	2.5	0.16	0.97	0.17	0.15
2 1 2 1	20	2.6	0.16	0.84	0.21	0.55
2 1 2 1	52	2.7	0.17	0.87	0.19	0.57
0 0 0 0	61	2.4	0.16	0.90	0.20	0.17

The soil analysis results from the samples taken in August showed:

- Relatively high bulk densities (> 0.9g/ml) indicating colluvial/alluvial origin.

- pH around 6.0.

- Available P very low and possibly limiting.

- Base saturation: predominantly Ca/Mg saturated, BS figures for K were low but exchangeable figures show that added fertilizer K is increasing the labile K pool in the soil.

- Cation Exchange Capacity average to low.

- Organic Matter levels low, thus P and total N were also low especially to the north of the experiment in the ex-kunai area.

Judging by these results the yield responses to N and K fertilizers are not surprising.

Whole experiment height measurements were carried out in November. The results are presented in Table 46. No height differences due to fertilizer application were identified, but palms in the ex-forest blocks averaged 318 cm, significantly taller than the average of 285 cm for the ex-kunai blocks to the north.

Petiole cross sections for the whole experiment were measured in August. The results are given in Table 47. Both K and N fertilizer gave clear growth responses.

Table 46: Experiment 305, Height (cm) to frond 41, Nov 1986

TREATMENT	Height	TREATMENT	Height
N0	303	K0	304
N1	310	K1	306
N2	307	K2	309
P0	306	Mg0	306
P1	307	Mg1	307

Table 47: Experiment 305, Petiole cross section (cm^2), August 1986

TREATMENT	W x T	TREATMENT	W x T
N0	36.2*	K0	35.2**
N1	37.5	K1	37.8
N2	37.9	K2	38.8
P0	37.4	Mg0	36.9
P1	37.1	Mg1	37.6

Treatment effects: ** $P<0.01$ * $P<0.05$

EXPERIMENT 306: Factorial fertilizer experiment, Ambogo

Initiated in 1982 on a 1980 planting occupying an area designated as a "K" type soil: a young greyish yellow coarse sand with moderate to excessive drainage hampered by seasonally high water-tables.

Design: A single replicate of a 3^4 (N,P,K,Mg) factorial, confounded in 3 blocks of 27 plots; 36 palms per plot of which the central 16 are recorded.

Treatments: Fertilizers were applied in April, May, June and October. The treatments were as follows:

	kg/palm. year		
Level	0	1	2
Ammonium sulphate	0	1.5	3.0
Triple superphosphate	0	0.5	1.0
Potassium chloride	0	2.5	5.0
Magnesium sulphate	0	0.75	1.5

Results: Yield data for the past 12 months are presented in Table 48.

Table 48: Experiment 306, Yield per hectare, 1986 and to date

TREATMENT	No. of bunches	Wt. of bunches t	s.b.w. kg	May 1983-Dec 1986 t
NO	2745	31.1	11.3	97.4
N1	2822	33.1	11.7	101.4
N2	2731	32.5	11.9	102.9
PO	2803	31.9	11.4	100.3
P1	2785	32.4	11.6	100.9
P2	2710	32.5	12.0	100.4
KO	2771	30.1^{l**}	10.9	94.7
K1	2747	33.4^{q*}	12.2	104.7
K2	2780	33.3	12.0	102.4
MgO	2799	32.4	11.6	99.7
Mg1	2723	31.7	11.6	101.9
Mg2	2776	32.6	11.7	100.0

Regression component l=linear, q=quadratic, $^*P=<0.05$, $^{**}P=<0.01$

The only significant response detected was to K fertilizer. The form of this response is shown in Figure 2. Trend analysis identified significant linear (P=0.01) and quadratic (P=0.05) functions, indicating reduced responses at the highest fertilizer level.

In practice, the optimum response currently on Ambogo soils appears to be provided by application of muriate of potash at the rate of 2.5kg/palm year.

The soil analysis results from the samples taken in September showed:

- Bulk densities high (> 0.9g/ml) reflecting the soil's reworked colluvial origin.
- pH mostly over pH 6.5.
- Available P appreciably better than in Expt. 305, on average 10mg/ml due partly to the low P retentions (> 20%).
- Base saturation biased towards Mg to the detriment of K which is in short supply.
- Cation Exchange Capacities moderate and higher than those of Expt. 305. This was surprising considering the differences in texture.
- OM contents were low throughout. Total N also low but N fertilizer is increasing soil supplies.

These results illustrate the need for K fertilizer in the Ambogo soils.

Folier analysis results are given in Table 49. The main observable effect is that application of KCl has resulted in substantially increased Cl levels, but reduced K levels. Overall the levels do not indicate any severe inbalances. N levels are satisfactory, with K possibly marginal, and Cl low.

Table 49: Experiment 306, Nutrient levels frond 17, Jan-Sept of selected plots

TREATMENT	PLOT	%				
N P K MG		N	P	K	Mg	Cl
0 0 0 0	10	2.5	0.16	1.04	0.29	0.09
2 0 0 0	12	2.6	0.16	1.06	0.26	0.12
2 2 2 0	17	2.7	0.16	0.92	0.24	0.54
0 0 0 1	30	2.7	0.16	1.01	0.33	0.30
2 1 2 2	32	2.7	0.16	0.93	0.28	0.52

Whole experiment height measurements were carried out in November. The results are presented in Table 50. There was a significant increase in height at the high rate of N fertilizer, N_2, compared to N_0 and N_1. The N_1 applications, however, have not given rise to a significant increase in height, in comparison to N_0.

Petiole cross sections were measured throughout the experiment in August. The results are given in Table 51. The major growth response was to K, with additional responses seen to N and Mg (level 1 only).

Table 50: Experiment 306, Height (cm), November 1986

TREATMENT	Height	TREATMENT	Height
N0	205^{1**}	K0	206
N1	207	K1	215
N2	217	K2	208
P0	210	Mg0	207
P1	213	Mg1	214
P2	206	Mg2	208

Regression component 1=linear, $^{**}P<0.01$

Table 51: Experiment 306, Petiole cross section (cm²), August 1986

TREATMENT	W X T	TREATMENT	W x T
N0	32.8	K0	31.5
N1	33.2	K1	34.0
N2	34.3	K2	34.7
P0	33.1	Mg0	33.0
P1	33.6	Mg1	34.3
P2	33.6	Mg2	33.0

EXPERIMENT 307: Smallholder fertilizer trial

Initiated at the end of 1984 on smallholdings of various ages. Details are as follows:

Block Number	Area	Planting date
230039	Ahora (1-3)	11/78
251013	Soputa (4-6)	12/78 and 3/79
010182	Girua (7-9)	3/79 and 7/79
010184	Girua (10-12)	3/78 and 7/79
500619	New Warisota (13-15)	3/78 and 5/78
410021	Sakita (19-21)	11/80 and 8/81

The soils in the different locations are as follows:

Ahora (plots 1-3): Black sandy loam over yellowish brown loamy sand over greyish yellow medium sand. Parent material is reworked volcanic ash. Moderate drainage. Possesses "K" type soil characteristics.

Girua (plots 10-12): Brownish black sandy loam over dark brown sandy loam. Parent material is rock weathered in situ. Drainage is good.

New Warisota (plots 13-15): Black humic silty clay loam over a thin horizon of dark reddish brown clay loam over light brown fine sandy loam becoming more grey and coarser in texture with depth. Drainage is good. Possesses "B" type soil characteristics.

Sakita (plots 19-21): Dark brown silty clay loam over dark yellowish fine to medium sandy loam to sandy clay loam. Drainage moderate to good. Possesses "A" type soil characteristics.

Design: This experiment originally comprised 7 replicates of completely randomised blocks, however, this has now been reduced to 4 due to smallholder default. The trial replicates are confounded with sites and variation in planting date.

Treatments: These were applied in May and November as follows:

	Kg/palm. year	
Treatment	Ammonium sulphate	Triple Superphosphate
1.	0	0
2.	2	0
3.	2	0.5

Results: Yield data are given in Table 52.

Despite increases in yields in the treated plots (both for number and tonnage of bunches per ha) the response was not statistically significant, as it had been for the January to September period of 1986. As in the past, the majority of variation was between the blocks due to differences in soil type, palm age and microclimate.

Table 52: Experiment 307, Yield per hectare, 1986

TREATMENT		Nil			Nitrogen			Nitrogen + phosphate		
SITE	PLOTS	No.	Wt. t	s.b.w. kg	No.	Wt. t	s.b.w. kg	No.	Wt. t	s.b.w. kg
Ahora	1-3	1345	15.2	11.3	1271	16.1	12.7	1360	19.0	14.0
Girua	10-12	1785	19.1	10.7	1824	22.1	12.1	2506	31.6	12.6
Warisota	13-15	1009	11.2	11.2	1140	12.6	11.1	1123	12.8	11.4
Sakita	19-21	2422	30.9	12.8	2665	31.9	12.0	2685	31.7	11.8
Mean		1640	19.1	11.5	1725	20.7	12.0	1919	23.8	12.5

Table 53: Experiment 307, Petiole cross section (cm^2), December 1986

TREATMENT		Nil	Nitrogen	Nitrogen + phosphate
SITE	PLOT			
Ahora	1-3	27.9	29.2	26.2
Girua	10-12	18.6	20.5	23.6
Warisota	13-15	23.4	25.7	21.6
Sakita	19-21	23.4	23.7	25.2
Mean	-	23.3	24.8	24.2

Petiole cross section measurements were carried out in December. The data are presented in Table 53. There was no significant growth effect of the treatments, although the treated plots gave slightly higher values than the control.

Leaf sampling was carried out in August. The analysis (Table 54) indicated that ammonium sulphate was having a beneficial effect on the N nutrition of the palms in nearly all blocks. The N + P treatment also appeared to have slightly increased leaf P in most cases as compared to the control and N only plots. Leaf S in all cases was below critical. The sulphate anion appeared not to have been taken up by the palms and had possibly combined with the soil Ca which is high in all areas. Levels of Mg were variable and notably lower in the fertilized plots than in the controls.

The palms in the treated plots in Girua, Warisota and Sakita were deficient in Mg (<0.24% Mg). Levels of Cl were low throughout.

Of the micronutrients, levels of iron were slightly low in Warisota and Sakita. Mn levels were high in Warisota. This is strange because the soils do not appear to be very acid or waterlogged.

Table 54: Experiment 307, Nutrient levels frond 17, August 1986

TREATMENT		%							ppm				
SITE		N	P	K	S	Ca	Mg	Cl	Fe	Mn	Zn	Cu	B
Ahora	Nil	2.4	0.15	0.82	0.17	0.82	0.37	0.25	67	224	23	6	9
	N	2.3	0.15	0.85	0.16	0.82	0.24	0.13	76	185	20	7	11
	N+P	2.6	0.16	1.02	0.17	0.69	0.32	0.12	85	152	16	6	8
Girua	Nil	2.4	0.15	0.97	0.16	0.79	0.29	0.18	67	382	22	7	8
	N	2.7	0.16	0.94	0.17	0.89	0.23	0.20	75	329	18	6	7
	N+P	2.6	0.16	1.01	0.16	0.86	0.23	0.09	65	284	16	5	7
Warisota	Nil	2.1	0.14	0.82	0.14	0.84	0.27	0.18	40	403	11	5	9
	N	2.2	0.14	0.92	0.14	0.87	0.20	0.13	53	490	14	4	8
	N+P	2.5	0.15	0.99	0.16	0.92	0.20	0.14	56	467	17	5	8
Sakita	Nil	2.7	0.16	1.00	0.16	0.93	0.24	0.09	59	239	26	6	15
	N	2.4	0.17	1.05	0.17	0.97	0.21	0.09	53	116	14	5	8
	N+P	2.8	0.17	0.95	0.18	0.93	0.20	0.11	50	263	9	5	11

Nitrogen and phosphate fertilizers were applied in November. It became increasingly difficult to maintain consistent recording in these blocks. Two more had to be abandoned at Soputa and Girua.

EXPERIMENT 308: Mill effluent trial, Arehe

Initiated in 1984 on a 1978 planting in close proximity to the effluent ponds. The soils of this site are yellowish brown volcanic sandsoils with a thick black humic topsoil. External drainage is poor with high runoff whilst internal drainage is good to excessive.

Design: Five replicates of fully randomised blocks with 3 treatments each.

Treatments:

Treatment	Kg Raw effluent/palm
1.	NIL
2.	625
3.	1,250

The effluent was applied in June.

Results: Yields continued to vary considerably between plots, the range being from 13.7 to 24.0t/ha. Data for the past year are given in Table 55. The untreated plots gave considerably greater yield (t/ha) than the treated plots. This was not a treatment effect, the effluent only having been applied in June.

Whole experiment leaf sampling was carried out in May just prior to effluent application. Results indicated that poor N and K nutrition was widespread throughout the experiment, especially in the lower yielding blocks and this may, in part, be responsible for the variable yields in the area. Figures were as low as 1.9% N and 0.50% K, well below their respective critical values of 2.5 and 1.00%.

Very high levels of manganese were found in some samples. In particularly acid soils such as these, Mn is very mobile and thus is easily taken up by the palms, to the extent that the Mn may prove detrimental to growth.

Table 55: Experiment 308, Yield per hectare, 1986

POME per palm per year kg	No. of bunches	Wt. of bunches t	s.b.w. kg
Nil	1141	20.3	17.8
625	1157	18.4	15.9
1250	1167	18.5	15.9

It was decided to discontinue this trial. However, yield recording and growth measurements will proceed until such time as an alternative use is found for the site.

The *Calopogonium caeruleum* spp inoculation trial situated in this experiment continued to maintain only slow growth under the shade. It will be some time before it is worthwhile assessing the effectiveness of the CB756 inoculant.

EXPERIMENT 309: Bunch refuse manurial trial, Ambogo

This experiment was initiated in 1984 on a 1980 planting. The soil in this area is a dark brown to black humic clay loam over yellowish brown fine to medium sandy loam over brownish yellow medium sand. It is probably an intergrade between a "K" and an "L" type soil, but without the iron mottling. Drainage is excessive.

Design: Five replicates of randomised blocks, each with 3 empty bunch treatments and 2 nil plots. 36 palms per plot of which the central 16 are recorded.

Treatments: Empty bunch application was completed in early 1985. The Scientific Advisory Board have decided that treatments will not be reapplied. However full recording will continue for the time being.

Treatment	Wt. of EB per ha
1 + 2	NIL
3	50t
4	100t
5	100t + 1Kg SOA per palm

Results: Yield data are presented in Table 56.

There was still a highly significant yield response (tonnage per ha) to the empty bunches, particularly the 100t EB + SOA treatment. The N-fertilizer will have assisted in the microbial degradation of the OM, so increasing the speed of release of nutrients to the soil, and will have supplied additional nitrogen to the palms. The treated plots gave more and bigger bunches and also better growth as reflected by petiole cross sections (Table 57).

Leaf analysis data in Table 58 indicated that the increased yield was particularly associated with raised levels of K and Cl in the palms. N and P levels remained constant throughout the treatments.

Table 56: Experiment 309, Yield per hectare, 1986

TREATMENT per palm	No. of bunches	Wt. of bunches t	s.b.w. kg
Nil	2919	25.5 a	8.7
50 t EB	3202	29.5 b**	9.2
100 t EB	3150	30.1 b	9.6
100 t EB+SOA	3332	32.3 c	9.7

Data with different letters differ significantly **P<0.01

Table 57: Experiment 309, Petiole cross section (cm^2), July 1986

TREATMENT per palm	W x T
Nil	21.5 a
50 t EB	23.1 b(*)
100 t EB	24.1 c
100 t EB + SOA	23.7

Data with different letters differ significantly, (*)P=<0.1

Table 58: Experiment 309, Nutrient levels frond 17, May 1986

TREATMENT per palm	N%	P%	K%	Mg%	Cl%
Nil	2.5	0.16	0.83	0.32	0.20
50 t EB	2.6	0.16	0.92	0.29	0.23
100 t EB	2.5	0.16	0.91	0.30	0.25
100tEB +SOA	2.6	0.16	0.96	0.27	0.24

EXPERIMENT 310: Fertilizer frequency and anion trial, Ambogo

Initiated in March 1986 on a "K" type soil: a brown to olive brown fine to medium sandy loam overlying grey apedal sand at depth, characterized by intermittent high water tables.

Design: 5 replicates of completely randomised blocks, 7 treatments, 36 palms per plot of which the central 16 are recorded.

Treatments:

Treatment	Rates kg/palm. year
1.	NIL
2.	Mg SO_4 2.0 (2 x 1.0 kg)
3.	Mg Cl_2 1.5 (2 x 0.75 kg)
4.	K_2 SO_4 3.0 (2 x 1.5 kg)
5.	K Cl 2.5 (2 x 1.25 kg)
6.	K_2 SO_4 3.0 (1 x 3.0 kg)
7.	K Cl 2.5 (1 x 2.5 kg)

Treatments 2-5 are split (6 monthly) applications, 6-7 are applied annually as one dose. The first round of fertilizers was applied in November.

Objective: This trial was designed primarily to assess the difference in nutritional value between sulphate and chloride-anion based fertilizers. A secondary aim is to study the effect which frequency of fertilizer application has on palm growth and yields. This is tested with the two types of K fertilizers since the added K is likely to be of more benefit to the palms than Mg in this instance.

There was difficulty applying potassium sulphate and magnesium chloride. The former tended to blow about in the lightest of breezes; the latter was highly hydroscopic and was hydrating virtually as fast as it could be applied. Storage of magnesium chloride has proved particularly difficult.

MILNE BAY PROVINCE

(R.L.A.)

EXPERIMENT 501: Establishment fertilizer trial, Hagita

This experiment was established in June 1986 on an early 1986 planting. The soils of this area are "Plantation" series soils. These are characterized by a dark greyish brown clay loam topsoil over yellowish brown fine sandy loam. Drainage is moderate.

Design: A 3x2x3 (N,P,K) factorial replicated 3 times with 16 recorded palms per plot with guard rows around each row of plots, but none between plots.

Treatments:

TREATMENT (kg/palm)	Ammonium sulphate			Triple superphosphate		Potassium chloride		
Level	0	1	2	0	2	0	1	2
Months after Planting								
3	0.3	0.3	0.4	0	0	0	0	0
6	0	0.3	0.6	0	0.5	0	0.25	0.5
12	0	0.6	1.2	0	0.5	0	0.5	1.0
18	0	0.6	1.2	0	0	0.75	0	1.5
24	0	1.2	2.4	0	0	0	1.25	2.5

The first round of N-fertilizer was applied in early July. The second round of fertilizer (ammonium sulphate, triple superphosphate and potassium sulphate) was to be applied in November at which time petiole cross section would also be measured. However, this had to be postponed until the New Year.

In October, the Scientific Advisory Board concluded that because of the relative price differential, potassium chloride, rather than potassium sulphate, was more likely to be used commercially. Thus, to keep the experiment as applicable as possible to the estate's needs KCl (K equivalent) was substituted for K_2SO_4. In coming to this decision it was assumed that the effect of the chloride would be resolved by Expts. 110 and 310.

PHYSIOLOGY

(T.M.)

EXPERIMENT 102: Density trial, Dami

Planted October/November 1970; 1,756 palms (total), 1,152 (recorded); area 15 hectares.

Design: Split-plots with four replicates of four planting densities (main plots) and four levels of fertilizer (sub plots). Plots contained from 46 to 169 palms of which the central palms are recorded leaving a perimeter of guard rows around each main plot except the widest spacing where it was superfluous.

Treatments:

Density palms/ha	spacing m triangular	recorded palms per plot
56	14.40	20
111	10.23	36
148	8.82	48
185	7.88	80

Fertilizer, proportion "estate" practice*	palms/ha 56	111	148	185
	recorded palms per sub plot			
0	-	8	12	20
50	-	8	12	20
100*	10	8	12	20
150	10	8	12	20

* = 2kg muriate of potash + 1kg kieserite/palm. year

Results: Production for 1986 is given in Table 59.

Table 59: Experiment 102, Production 1986 and cumulative

TREATMENT	PER PALM			PER HECTARE		1973-1986
palms/ha	No. of bunches	Wt. of bunches kg	s.b.w. kg	No. of bunches	Wt. of bunches t	Wt. of bunches/ha t
56	9.3	246	26.2	523	13.8	194.4
110	7.0	183	26.1	772	20.1	307.7
148	4.7	110	23.3	700	16.3	294.2
186	3.6	84	23.5	670	15.6	267.8

Optimum density for current yield 122 palms/ha
Optimum density for cumulative yield 139 palms/ha

Previous Fertilizer regime	No. of bunches/ha	Wt. of bunches/ha t	s.b.w. kg
0	845	20.3	24.0
50	753	18.5	24.5
100	646	16.3	25.3
150	701	17.6	25.1

Density continued to effect individual palms as before but its effect on yield per hectare was less pronounced. The optimum density for current yield for 1986 was 122 palms/ha, which represented no change from the situation in 1985 (123 palms/ha), indeed little change for the last 4 years. For accumulated yield the optimum was 139 palms/ha, also unchanged since 1985.

The residual response to fertilizers (N,K,Mg) applied up to 1981 that was absent in the data for 1985 was again apparent with the same trends reported previously. The latter showed single bunch weight to be enhanced by the fertilizer but number of bunches to be reduced, resulting in an overall trend to reduce yield per hectare.

In November 1986 ammonium chloride was applied to the sub plots planted at 110 and 148 palms/ha at rates of 0, 2, 4 and 6 kg/palm year, in such a way as to balance out residual effects of previous fertilizers.

EXPERIMENTS 104 and 105: Thinning trials, Bebere

These two small trials were planted on a flat area of soil overlying pumice where yields had been declining over the last few years. The objective was to evaluate the result of thinning palms from the density at which they had been planted.

Expt.	Planted	Thinned	Recorded palms	Total palms	Ha
104	1970	April 1978	345	567	4.2
105	1970	April 1980	496	816	6.8

Design: Both with randomised blocks of three treatments (2 being common to both experiments), replicated three times in Expt. 104 and four times in Expt. 105. Plots were from 51 - 81 palms, the perimeter palms forming unrecorded guard rows around each plot.

Treatments:

	Palms per hectare Expt 104	Palms per hectare Expt 105
1. No thinning	143	143
2. Every third palm removed to give hexagonal spacing	95	95
3. Every third row removed	95	-
4. Every seventh palm removed to leave each palm next to 1 vacancy	-	122

Results: Field recording ceased in 1985 and conclusions were published in the Annual Report for 1985 (page 27-28). These results were also written into a paper presented at the International Oil Palm Conference in 1987. In doing this some further observations were made about differences in growth rate which are reported here.

Previous reports have shown how thinning improved Bunch Index by improving production relative to vegetative growth. One component of the latter is increase in height of the trunk and this was highly significantly reduced after thinning by a third (Table 60). Thinning by a seventh was less effective in this respect.

Table 60: Experiment 102, Annual height increment

Thinning	3/78-7/81	7/81-2/85	3/81-2/85
Expt.104	cm	cm	cm
None	94.8	52.7 a	73.0 a**
1/3 hexagonally	89.0	48.6 a	68.0 b
1/3 rows	90.4	41.2 b*	64.9 b
Expt.105			
None		50.0 a	
1/3 hexagonally		44.4 b*	
1/7		49.0 a	

Means with a different letter differ significantly, * P=0.05, **P=0.01

The pollinating weevil, *Elaeidobius kamerunicus*, was introduced during the course of these experiments. One of the benefits of better insect pollination that had been hoped for was that, by increasing the yield of bunches, it would cause a corresponding reduction in upward growth of the trunk. This could lengthen the economic life of palms in a region where vegetative growth had been rapid. During the first two and half years of Expt.104 pollination was assisted by hand because the weevil had not yet been established over the area. In Expt.105, on the other hand, only the first six months were without the weevil. Our experiments, therefore, provided an opportunity to test what effect the weevil had caused. In Expt.104 vertical growth was greater in the unthinned plots over the whole experimental period. Where there had been no thinning it was estimated to be 6cm/palm/month, whereas it was 4cm/palm/month in Expt. 105. The data also permitted the comparison of pre and post-weevil periods in Expt.104 compared to Expt.105 which was largely pollinated post-weevil. In Expt.104, trunks elongated by 7.9cm/palm/month before the insect was released but only by 4.4cm/palm/month afterwards, which was similar to the rate for similar plots in Expt. 105. The earlier rate of elongation may seem excessive, however, it is in line with contemporary growth recorded by NBPOD on palms of similar age elsewhere on the plantation. Although better pollination has slowed down height increment in the three years after the weevil was established in the field, it is uncertain the extent to which this will continue because the weevil caused such immediate and intense fruiting activity that the palms would have been unusually stressed.

INVESTIGATION 702: Effects of competition

The design of this investigation and how it was recorded were detailed in the Annual Report for 1985. Briefly, two different populations of 80 palms each were created in half the sub plots of Expt.102 that had been planted at 186 palm/ha. These populations differed in that one remained at its original density at which inter palm competition was high whereas the other had been liberated abruptly from these constraints by thinning in October 1981.

Development of bunches and flowers in successive leaf axils was studied for three years after thinning. In 1984 bunch components were also studied at all densities in Expt. 102. Developmental and morphological studies were completed in Holland on samples of apical meristems and developing inflorescences dissected from the palms felled at the beginning of the experiment, supplemented by samples from guard row palms felled later.

The objectives were to determine developmental characteristics and relate these to changes in the components of yield and components of bunch composition and to establish at what stages of development they occurred. This information would lead to a better understanding of the effects of environment (and experimental treatments) on yield in Papua New Guinea and forecasting its trends.

Originally described in three topics, intended for publication, during 1986 the presentation of this complex study evolved into four separate papers (topics). One was accepted for publication and the remaining three were all but ready for submission for publication at the end of the year. The summary from Blumea and drafts of the summaries of papers whose publication is pending are presented here.

The effect of plant density on the components of oil yield in oil palm (C.J. Breure, T. Menendez, M.S. Powell): Response of components of oil yield were studied in a spacing experiment, comparing 56, 110, 148, and 186 palms ha-1 at Dami Oil Palm Research Station, Papua New Guinea. Bunch weight components were studied under assisted pollination (5th year from planting) and under insect pollination (years 12 to 14). In both periods bunch weight decreased significantly as a function of planting density, due to an effect on frame weight (stalk and empty spikelets), and on flowers per inflorescence (spikelet number and flowers per spikelet); single fruit weight was little affected. Fruit set (the proportion of fertile fruits to total flowers) did not respond under assisted pollination but with insect pollination closer spacing increased fruit set. This resulted in an enhanced kernel and oil extraction to the extent that optimal planting density became 5 palms ha-1 higher for oil and kernel yield than for yield of fresh fruit bunches. The extent of response of flowers per inflorescence indicates that seed production per palm can be increased by 15% by any practical method of reducing shade from surrounding unselected palms. Bunch number was reduced in response of higher density planting density, due to a rise in both number of aborted and male inflorescences. Sex definition, and the flower number per inflorescence are less sensitive to increasing interpalm competition for light than floral abortion and the weight of the frame of the bunch.

The determination of the components of bunch yield in the development of inflorescences in oil palm: I Bunch number components. (C.J. Breure, and T. Menendez): The stage in oil palm inflorescence development at which abortion and sex differentiation, both determining the number of bunches produced, take place were identified by thinning a part of the 186 palms ha^{-1} treatment of a spacing experiment at the Dami Oil Palm Research Station, Papua New Guinea. The development stage at which the resulting drop in abortion rate (the proportion of aborted inflorescences to total leaves produced) and that of the gain in sex ratio (the proportion of female to total inflorescences) occurred, was established by comparing abortions and sex of the surviving inflorescences of the unthinned and thinned group against sequentially numbered leaves (L-numbers). The corresponding scale in inflorescence development was derived by dissecting a sample of felled palms.

Sex differentiation appears to occur 6 to 7 leaves prior to spikelet initiation. Abortion occurred at the onset of rapid elongation of inflorescences, about 10 leaves prior to anthesis. Initially, abortion was preferential for female inflorescences, but later on both females and males aborted in equal proportion. The initial reduction in abortion and, at an earlier developmental stage, the rise in the proportion of females differentiated as a result of thinning, caused two peaks in the load of developing bunches (fruiting activity) on the thinned palms which apparently eliminated temporarily the gain in sex ratio. The occurrence of fruiting activity provided further evidence for the developmental stage at which sex determination occurs.

Our study suggests that abortion and sex definition occur at a specific stage in inflorescence development. But considerable differences in time-lags between these critical developmental stages and anthesis may occur due to variations in environmental conditions and fluctuating levels of carbohydrate status of the palms.

The determination of the components of bunch yield in the development of inflorescences in oil palm: II Bunch weight components. (C.J. Breure, and T. Menendez): Stages in inflorescence development at which components of bunch weight are determined were unravelled by reducing the density of one group of palms from 186 to 93 palms ha^{-1} (sudden increase in light intensity). Using the unthinned palms as a reference, changes in components of remaining palms were recorded against sequential leaf (L-) numbers: main stages in inflorescence development against L-numbers were derived by dissection of a sample of felled palms.

Frame weight increased in three steps corresponding with the stage of rapid expansion of the inflorescences, with completion of meristematic development of the primary axis, and with the determination of number of flowers per spikelet. The latter component appears to be determined about 8 leaves prior to the determination of spikelet number, the determination of which in turn appears to coincide with the moment that the primary axis ceases to be meristematic.

Fruit weight is determined shortly after anthesis, but a minor modification appears possible up to 6 leaves later. The increase disappeared as soon as flowers per spikelet increased. This increase also coincided with a consistent decrease in fruit set. Due to the apparent diminishing effect of the increase in flowers per spikelet on single fruit weight and on fruit set, this component did not increase bunch weight any further. But, since at this stage frame weight attained its final increment, fruit to bunch ratio of the thinned palms became lower than the unthinned group.

There was a sudden increase in fruiting activity on the thinned palms shortly after thinning. This counteracted, for a short period, the beneficial effect of thinning, and strengthened the interpretation of our results.

The early development of inflorescences and flowers of the oil palm seen through the scanning electron microscope. (W.A. van Heel, C.J. Breure, T.Menendez): The development of inflorescences and flowers of the African Oil Palm up to anthesis is illustrated by scanning electron microscopy images. The time of origin relative to the development of the foliage leaves of the basipetalous succession of flowering rachillae is determined, as well as the time of morphological sex definition. The logical stage when sex is determined is inferred to be not before the first appearance of the spikelet primordia. Female flower groups develop acropetally as triaxial cincinni, the male units as reduced ones. A developmental diagram is presented.

INVESTIGATION 703: Study of inflorescence characteristics in relation to pollination and fruit set (P.S., T.M.)

The objective is to observe flowering and fruit set in two populations of palms, one of which was earlier typified by poor and the other by good fruit set, in order to recognise characteristics that may be responsible for differences in fruit set.

For this purpose, 18 dura palms planted at Dami in 1978 were selected from NBPOD, OPRS records taken in the post-weevil period from November 1981 to July 1985. Nine of these showed consistently better than 80% fruit set and nine were consistently poorer than 50% fruit set. Our observation of these palms in the field started in December for the following characteristics. Female inflorescences: duration of and daily percent anthesis, daily opening and colour of stigmas or developed companion flowers, degree of basal spikelet compaction, spikelet splay, peduncle length, scent and attractiveness to the pollinating weevil. Male inflorescences: splay of spikelets, duration of anthesis, scent and weevils visiting.

By the end of 1986 224 bunches had been analysed for fruit set from the eighteen experimental palms. These results are given in Table 61, together with the earlier data on the basis of which the palms had been separated into two populations. One palm (IV 639/09) did not maintain its previous record for fruit set and two palms (I644/07 and IV 638/10) performed better than previously, otherwise the two groups retained their distinctiveness. Observation of these palms during anthesis suggested that palms with poor fruit set had more abnormal stigmas and were less attractive to weevils than palms with good fruit set. Surprisingly, there was no obvious link with the duration of anthesis over the whole inflorescence but palms with inflorescences, the majority of whose flowers were receptive towards the beginning of anthesis, were those in the low fruitset category. A comparison of inflorescences scored at anthesis and their subsequent fruit set was still in progress at the end of 1986. In both populations the coefficient of variation is varying inversely with fruitset. Overall this was very highly significant with $r = -0.74$ ($P < 0.001$). Also to be analysed is whether or not assisted pollination carried out in 1986 will improve the poor fruit-setters.

Samples of stigmas continued to be collected and preserved for microscopic study of stigmatic stomata in the future, this being not possible during 1986.

Table 61: Experiment 703, Percentage fruit-set per palm selected

Rep	Progeny	Palm	Fruit-set (%) OPRS record (11/81 - 7/85)	CV%	current 12/85 - 12/86	CV%
I	652	04	81.9	8	63.1 (3)	28
II	644	04	82.2	4	64.1 (13)	19
III	635	04	80.2	10	68.2 (7)	16
IV	636	07	85.0	7	75.9 (13)	24
	639	09	80.9	3	45.5 (10)	36
	653	05	82.3	3	76.3 (11)	16
V	639	07	80.2	9	59.7 (10)	41
	653	12	80.1	7	66.7 (13)	16
VI	633	01	81.4	5	72.7 (8)	21
	Means		81.6		65.8	
I	638	02	30.2	23	30.9 (19)	42
		11	32.1	49	39.4 (17)	49
	644	05	48.2	4	50.8 (18)	40
		07	34.8	41	55.2 (13)	21
II	638	01	24.8	73	39.5 (16)	25
		06	34.6	18	28.5 (20)	52
IV	038	04	39.6	10	47.1 (14)	28
		10	35.4	39	53.8 (8)	17
	650	10	49.1	7	44.9 (11)	33
	Mean		36.5		43.3	

EXPERIMENT 705: Clonal density trial, Arehe (R.L.A.)

Planted/initiated in December 1985, occupying 5 hectares of the old Arehe nursery site. The soils of the area are characterized by a thick but variable, very dark brown to black humic clay loam to loam over yellowish brown saprolytic rock.

Design: Split plots with 3 replicates of 3 main plots each with 4 sub plots, 9 unguarded palms per sub plot, 36 recorded palms per main plot guarded on all 4 sides with double or single guard rows.

Treatments:

	palms/ha	Spacing (m)
Main plots	115	10
	143	9
	180	8
	Clone Type	
Sub-plots	UF 6	
	UF 12	
	UF 15	
	UF 18	

(UF 4 planted in guard rows)

Routine plantation practice is followed for maintenance and manuring.

The objective of the trial is to assess the growth and yield patterns of the individual clones and to assess competition between palms planted at different densities.

Results: An inflorescence survey was carried out in November because flowering abnormalities had been reported in these clones elsewhere. The majority of the abnormalities were of the androgynous type, that is morphologically male (large number of small flowers per spikelet) with some of the small flowers developing as females later to become fruitlets and of the "mantled" fruit type. The whole experiment is affected. Abnormalities appear to be most common in UF6 and also UF4, the guard row palm. UF12 and 15 are also affected with the problem being less apparent in UF18.

Three monthly petiole cross section measurements were carried out in December. The results are presented in Table 62. UF6 had the lowest average W x T for the past 12 months, but the greatest leaf area. It is unlikely that the differential spacing is having any effect on palm growth at present.

The cover in this area, *Pueraria phaseoloides and Calopogonium muconoides,* was proliferating to such an extent that it has had to be rolled. Despite the good establishment of the leguminous cover, effective nodulation appears to be limited. However, the leaf fall will provide the soil with a valuable supply of organic matter.

The possibility of abandoning the trial, in view of its flowering abnormalities, was considered. However, it was felt that such a decision would be premature.

Table 62: Investigation 705, Petiole cross section and leaf area frond 9 (cm^2)

	WxT				Frond area
CLONE	Feb'86	Jun'86	Sept'86	Dec'86	Sept'86
UF 6	0.71	1.87	2.58	3.96	3331
UF 12	0.88	2.03	2.98	4.48	2686
UF 15	0.83	2.06	2.97	4.44	2695
UF 18	0.83	2.05	2.81	4.35	2679

EXPERIMENT 706: Continuous flowering study (T.M.)

The objective is to keep records of flowering at one site on each major oil palm development to characterise and monitor the effects of the environment on components of yield. Although the localised effects of fruiting activity will complicate matters major environmental differences should, however, show up. This will help explain and predict variations in plantations' yields and reasons for differences between sites.

Observations have been or are being made at the following sites:

	Site	Planted	Period
W.N.B.P.	Expt. 102, Dami	1970	1978-1985
	Dami, Buluma	1978	Jan.'85 continuing
	Expt. 201	1973	1986 continuing
Oro Province	Expt. 305, Arehe	1978	continuing

The plan is to continue recording continuously at Buluma, Expts. 201 and 305 and, in due course, at Milne Bay. Recording involves monthly leaf marking and completing a detailed flowering census at three month intervals. From 64 to 100 palms are recorded at each site. The data will also provide accurate information about the production of male flowers which can under reduced circumstances limit pollination force.

Results: This study has not been underway long enough for a useful summary to be presented.

EXPERIMENT 707: Continuous vegetative growth study (M.H.)

Planted:	Bebere Expt. 109a	Hargy Expt. 201	Higaturu Expt. 305
Records started:	-		
Details at:	5th Annual Report page 39		

Since 1980 it has been the policy to measure growth continuously in the different oil palm areas to establish their characteristic growth curves for leaf production, leaf area and dry weight, vegetative dry matter production and bunch index. These measurements are done in selected plots within agronomic field trials. Observations are carried out every six months for leaf production, annually for leaf measurements and occasionally for trunk height and girth.

The following sites have been or are being recorded:

	Site	Planted	Period
W.N.B.P.	Expt. 103	6 plots	1980 - 1983
	Expt. 109a	6 plots	1984 continuing
	Expt. 201	5 plots	1985 continuing
Oro Province	Expt. 305	4 plots	1984 continuing

Results: The opportunity is not yet being taken to present a summary of results.

INVESTIGATION 708: Continuous variation of leaf nutrient levels

The objective is to analyse the dynamics of leaf nutrient contents, so as to assist in the interpretation of results from estate leaf sampling.

Results: Leaf nutrient levels are being studied in the various oil palm growing regions by taking monthly leaf samples (Expts. 305 and 306) or bimonthly (Expts. 109a and 201) in selected plots which are under high and low fertilizer regimes,(Tables 63-66 and Figures 3-6). Rainfall is presented as stacked bars in the figures, the black parts of the bars of which represent the amount of rain 10 days before the leaf sample was taken, the white representing the total amount of rain for the month. When no leaf sample was taken the month's letter at the horizontal axis is omitted. An open bar indicates more than 300mm of rain for that month.

The following trends were noted:-

- In periods of high rainfall K levels tend to be high, and Mg low, in the drier periods K levels are on a low and Mg high, as best seen in Expt. 306. Comparing levels for K and Mg in April 1986, however, (Expts. 306 and 109a) rainfall was still high (for both the 10 day period and the month) but K levels dropped and Mg levels increased.

- Nitrogen levels seemed to be highest around December in all experiments except for Expt. 306.

- Seasonal trends and relationships with rainfall for other elements are not clear.

- Other trends over time: Manganese increased considerably in the high fertilizer plots of Expts. 305 and 306, probably due to a decrease in pH caused by fertilization with sulphate of ammonia.

- Average phosphorus levels dropped during 1986 in Expt. 306.

Table 63: Investigation 708, Monthly leaf nutrient levels, Arehe 1986

	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
%												
N 0000	-	2.5	2.4	2.4	2.4	2.3	2.4	2.5	2.6	2.4	2.5	2.3
2121	-	2.6	2.6	2.6	2.7	2.7	2.6	2.8	2.8	2.6	2.9	2.5
P 0000	-	.17	.17	.15	.16	.16	.17	.16	.16	.14	.16	.15
2121	-	.18	.17	.15	.17	.16	.17	.17	.17	.15	.17	.16
K 0000	-	.99	.99	.91	.95	.91	.92	.91	.95	.97	.84	.88
2121	-	.75	.89	.88	.90	.82	.91	.80	.88	.89	.82	.88
S 0000	-	.20	.18	.15	.17	.18	.20	.17	.17	.16	.18	.18
2121	-	.21	.17	.16	.19	.19	.19	.18	.17	.17	.20	.20
Ca 0000	-	.95	.82	.91	.86	.86	.93	.90	.86	.89	.89	.87
2121	-	.94	.87	.83	.84	.89	.82	.86	.85	.81	.87	.78
Mg 0000	-	.17	.17	.19	.16	.18	.20	.20	.20	.19	.19	.19
2121	-	.22	.19	.20	.19	.21	.20	.20	.20	.18	.20	.18
Cl 0000	-	.18	.14	.17	.16	.14	.15	.17	.20	.15	.17	.16
2121	-	.54	.54	.59	.55	.52	.54	.59	.62	.58	.59	.57
ppm												
Fe 0000	-	63	59	57	59	54	52	60	61	54	71	52
2121	-	57	56	53	56	57	57	58	63	54	67	57
Mn 0000	-	69	76	76	73	78	78	78	75	80	84	89
2121	-	162	152	146	148	155	142	140	139	123	131	147
Zn 0000	-	21	19	20	18	18	19	17	19	13	17	19
2121	-	21	18	17	20	16	22	13	14	9	16	15
Cu 0000	-	7	6	5	5	6	6	5	6	5	6	6
2121	-	7	6	5	6	6	6	5	5	6	7	7
B 0000	-	19	23	16	16	14	19	12	12	15	11	15

2121 - 12 14 13 15 13 13 10 9 14 9 1

Table 64: Investigation 708, Monthly leaf nutrient levels, Ambogo 1986

%		Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sept	Oct	Nov	Dec
N	low	2.7	2.7	2.7	2.6	2.6	2.5	2.6	2.7	2.5	2.5	2.6	2.3
	high	2.7	2.7	2.7	2.8	2.7	2.6	2.8	2.7	2.6	2.6	2.9	2.6
	nil	2.6	2.7	2.8	2.6	2.6	2.6	2.6	2.8	2.6	2.8	2.9	2.5
P	low	.16	.17	.16	.15	.17	.16	.17	.17	.15	.15	.16	.15
	high	.17	.18	.16	.15	.16	.16	.16	.16	.16	.16	.17	.15
	nil	.15	.17	.16	.15	.16	.16	.17	.16	.15	.14	.16	.15
K	low	1.04	.99	1.03	1.04	1.05	.98	1.06	.97	.99	1.01	1.02	1.11
	high	.90	.94	.95	.87	.98	.92	.93	.87	.90	.98	.90	.97
	nil	1.07	1.10	1.07	1.02	1.10	1.05	1.04	1.05	1.05	1.12	1.00	1.12
S	low	.18	.18	.16	.16	.18	.18	.18	.18	.17	.16	.19	.17
	high	.19	.19	.17	.17	.18	.18	.18	.18	.18	.18	.20	.18
	nil	.17	.18	.17	.16	.18	.19	.18	.17	.16	.17	.19	.18
Ca	low	.73	.78	.70	.71	.70	.71	.74	.68	.65	.70	.68	.69
	high	.88	.76	.79	.79	.72	.80	.80	.78	.73	.80	.80	.84
	nil	.80	.80	.79	.75	.75	.73	.69	.73	.71	.81	.78	.77
Mg	low	.28	.30	.34	.31	.32	.32	.31	.30	.28	.32	.28	.27
	high	.24	.30	.25	.25	.25	.27	.27	.27	.25	.28	.24	.25
	nil	.23	.24	.27	.27	.25	.26	.31	.27	.28	.31	.26	.27
Cl	nil	.06	.08	.12	.15	.09	.07	.09	.10	.05	.05	.07	.08
	high	.62	.45	.51	.54	.60	.53	.43	.64	.56		.59	.55
	nil	.11	.12	.14	.15	.13	.12	.06	.15	.12	.11	.13	.11
ppm													
Fe	low	68	91	82	86	71	68	65	67	71	58	63	69
	high	83	72	90	95	92	81	69	86	75	84	77	85
	nil	56	69	71	86	87	72	57	68	62	70	65	64
Mn	low	46	38	37	36	40	40	44	46	46	46	47	55
	high	93	86	100	95	87	106	114	116	104	104	104	110
	nil	56	54	58	58	67	64	72	75	67	73	68	72
Zn	low	16	20	22	18	23	18	15	18	19	14	18	17
	high	14	20	17	16	16	16	14	16	16	10	14	13
	nil	13	16	14	15	25	17	16	15	15	7	13	11
Cu	low	9	7	6	6	6	7	6	6	7	7	7	6
	high	5	7	5	5	4	6	6	6	6	6	6	5
	nil	9	4	3	3	3	3	6	2	3	3	3	3
B	low	11	13	14	14	14	15	14	9	12	11	7	13
	high	13	11	15	15	14	12	12	9	12	12	4	14
	nil	9	14	16	14	15	12	13	10	9	11	10	13

Table 65: Investigation 708, Bi-monthly leaf nutrient levels, Bebere ,986

%		Jan	March	May	July	Sept	Nov
N	nil	2.4	2.3	2.6	2.5	2.4	2.7
	10001	2.3	2.4	2.6	2.6	2.5	2.7
P	nil	.16	.15	.16	.15	.15	.17
	10001	.15	.15	.15	.15	.16	.16
K	nil	1.06	1.07	.95	1.08	1.05	.97
	10001	.99	1.07	.85	1.02	1.00	.92
	nil	.16	.15	.17	.16	.16	.17
	10001	.16	.16	.17	.17	.16	.17
Ca	nil	.91	.96	1.05	.99	.90	.91
	10001	.85	.89	.98	.91	.89	.89
Mg	nil	.14	.15	.19	.16	.17	.18
	10001	.17	.18	.22	.20	.20	.13
Cl	nil	.14	.13	.16	.15	.15	.12
	10001	.21	.21	.24	.24	.24	.20
ppm							
Fe	nil	45	56	51	65	66	62
	10001	47	57	55	58	67	66
Mn	nil	37	38	38	38	38	37
	10001	40	37	35	35	39	40
Zn	nil	17	21	20	22	20	15
	10001	20	23	20	21	19	16
Cu	nil	5	5	6	5	4	7
	10001	4	5	6	5	3	7
B	nil	13	14	16	14	13	12
	10001	12	13	13	13	12	9

Table 66: Investigation 708, Bi-monthly leaf nutrient levels, Hargy 1986

%		Jan	March	May	July	Sept	Nov
N	nil	2.5	2.4	2.4	2.4	2.5	2.6
	P only	2.4	2.3	2.3	2.3	2.3	2.5
	NP only	2.4	2.3	2.4	2.5	2.4	2.5
	NPK Mg	2.4	2.4	2.5	2.5	2.3	2.5
P	nil	.16	.15	.15	.15	.15	.17
	P only	.17	.16	.15	.21	.16	.16
	NP only	.17	.15	.15	.16	.15	.16
	NPK Mg	.16	.16	.15	.16	.15	.16
K	nil	1.05	1.07	.95	1.02	.95	.94
	P only	1.04	1.05	1.01	1.05	1.00	.99
	NP only	1.04	1.03	.88	1.03	.86	.94
	NPK Mg	1.02	1.05	.95	1.08	1.00	.88
S	nil	.18	.17	.16	.17	.17	.19
	P only	.19	.18	.16	.24	.16	.18
	NP only	.18	.17	.16	.18	.17	.17
	NPK Mg	.19	.17	.17	.18	.17	.17
Ca	nil	.92	1.03	1.02	1.07	.97	1.07
	P only	1.00	1.11	1.05	1.19	1.08	1.04
	NP only	.89	.96	.88	1.00	1.00	.89
	NPK Mg	.98	1.06	1.04	1.04	1.04	1.04
Mg	nil	.14	.12	.14	.15	.20	.12
	P only	.15	.15	.15	.14	.13	.14
	NP only	.16	.16	.18	.14	.17	.17
	NPK Mg	.14	.15	.14	.14	.15	.15
Cl	nil	.29	.25	.20	.19	.23	.21
	P only	.18	.24	.18	.14	.13	.16
	NP only	.26	.22	.18	.20	.17	.20
	NPK Mg	.28	.28	.23	.24	.24	.28
ppm							
Fe	nil	53	60	60	51	50	58
	P only	55	53	63	97	57	59
	NP only	68	66	66	51	48	61
	NPK Mg	48	63	57	53	56	48
Mn	nil	65	75	75	78	77	77
	P only	62	72	74	89	77	72
	NP only	53	67	62	66	68	62
	NPK Mg	56	67	66	70	70	67
Zn	nil	22	30	27	27	26	21
	P only	24	31	30	40	27	30
	NP only	20	24	25	21	23	22
	NPK Mg	20	24	27	29	26	24
Cu	nil	6	6	7	5	6	6
	P only	6	8	7	8	5	8
	NP only	6	7	7	5	3	6
	NPK Mg	6	7	6	5	5	5
B	nil	14	25	15	21	14	21
	P only	15	31	13	46	12	20
	NP only	14	24	13	18	12	15
	NPK Mg	15	24	15	19	15	18

Figure 3: Investigation 708, Monthly leaf nutrient levels in Expt.109a (line graph) and rainfall, monthly (white bar) & over 10 days preceding leaf sampling (black bar)

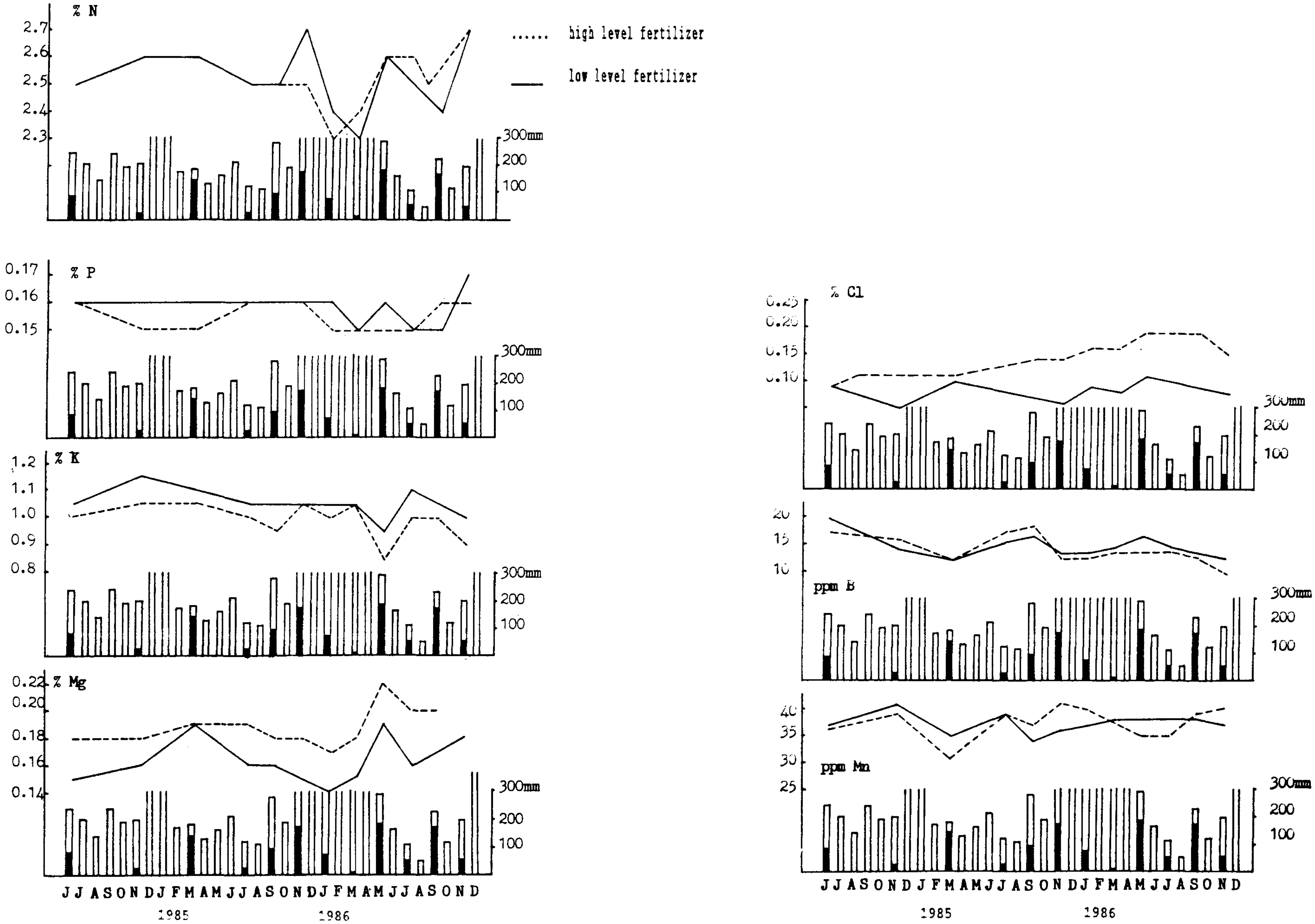


Figure 4: Investigation 708, Monthly leaf nutrient levels in Expt.201 (line graph) and rainfall, monthly (white bar) & over 10 days preceding leaf sampling (black bar)

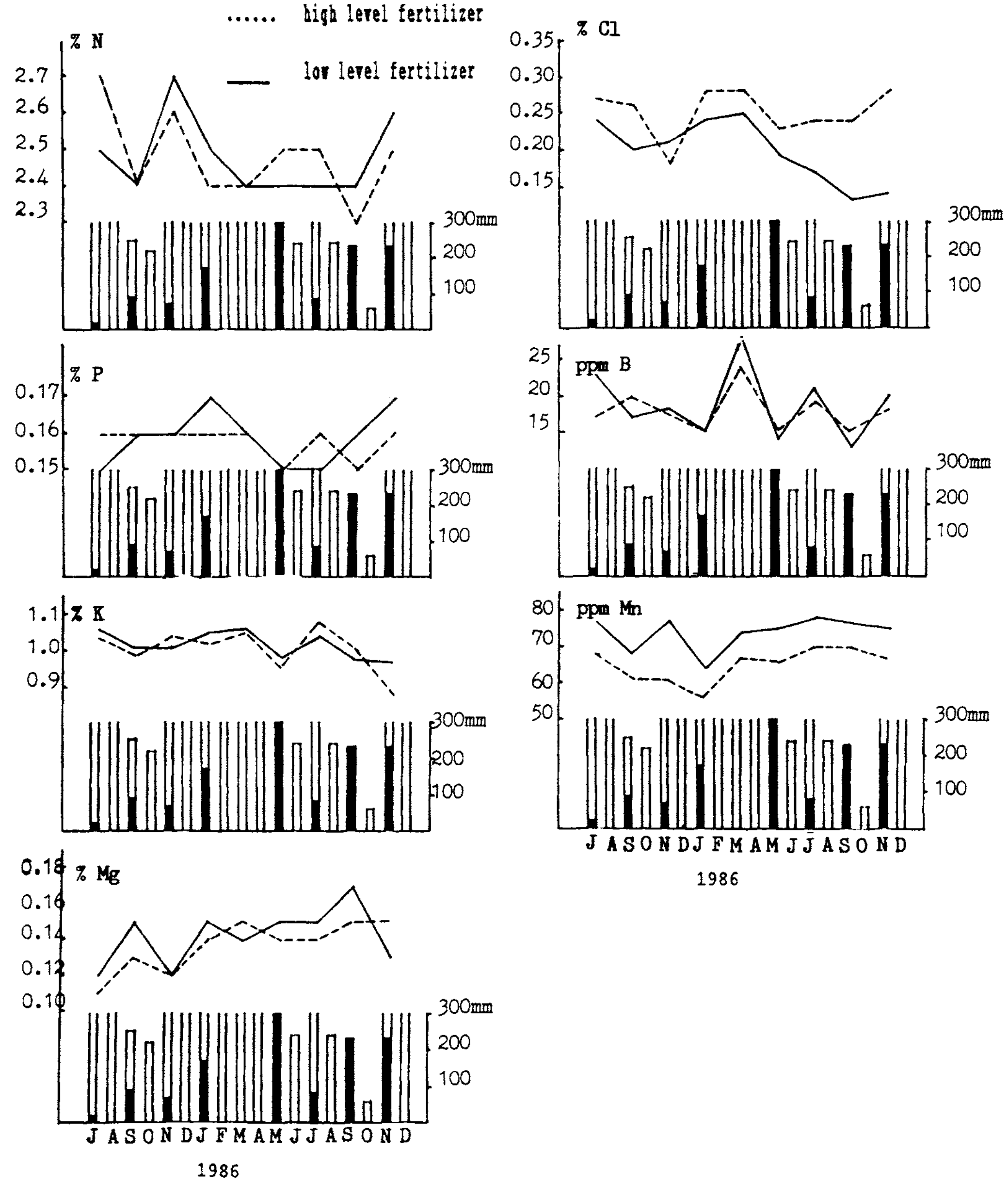


Figure 5: Investigation 708 Monthly leaf nutrient levels in Expt.305 (line graph) and rainfall, monthly (white bar) & over 10 days preceding leaf sampling (black bar)

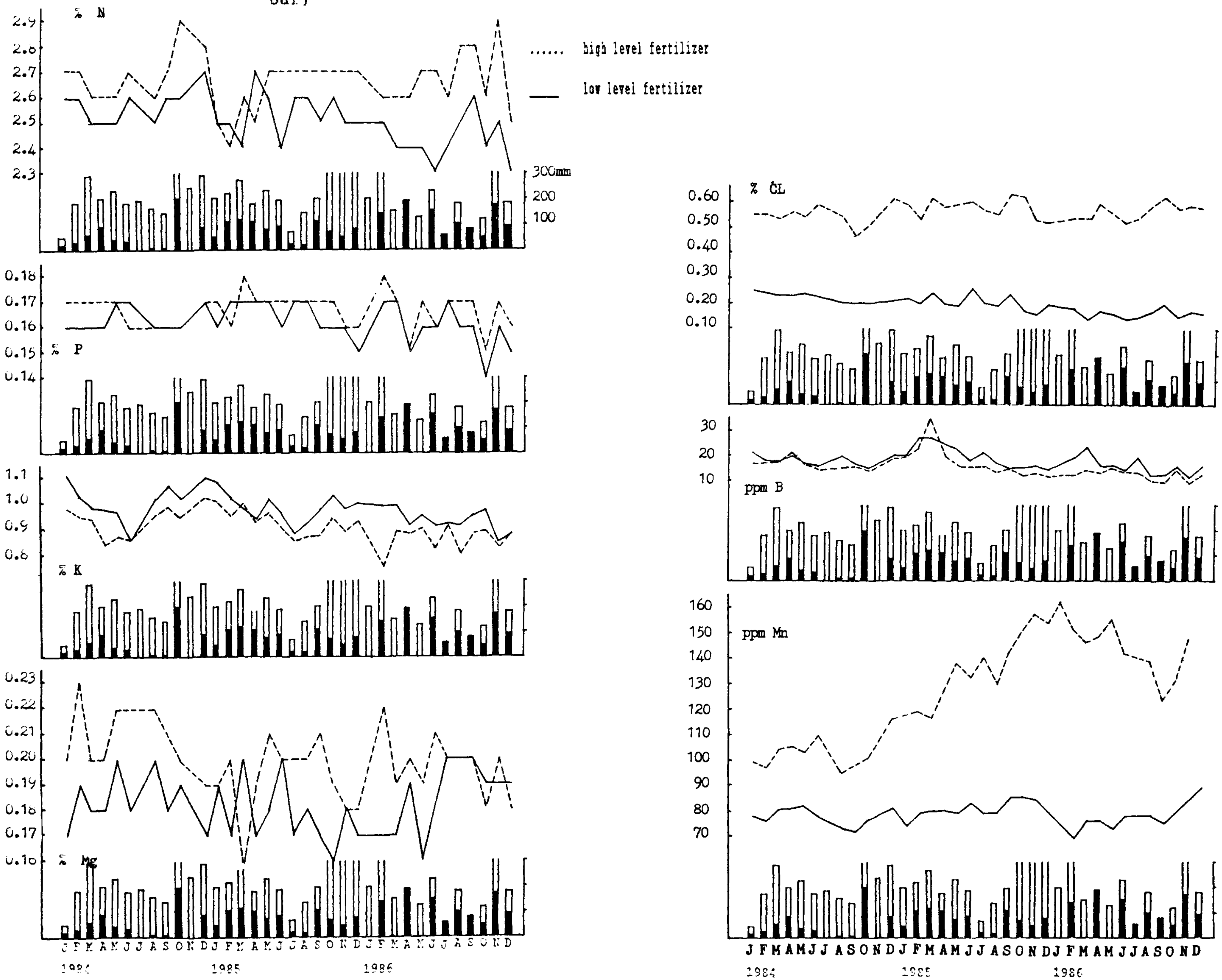
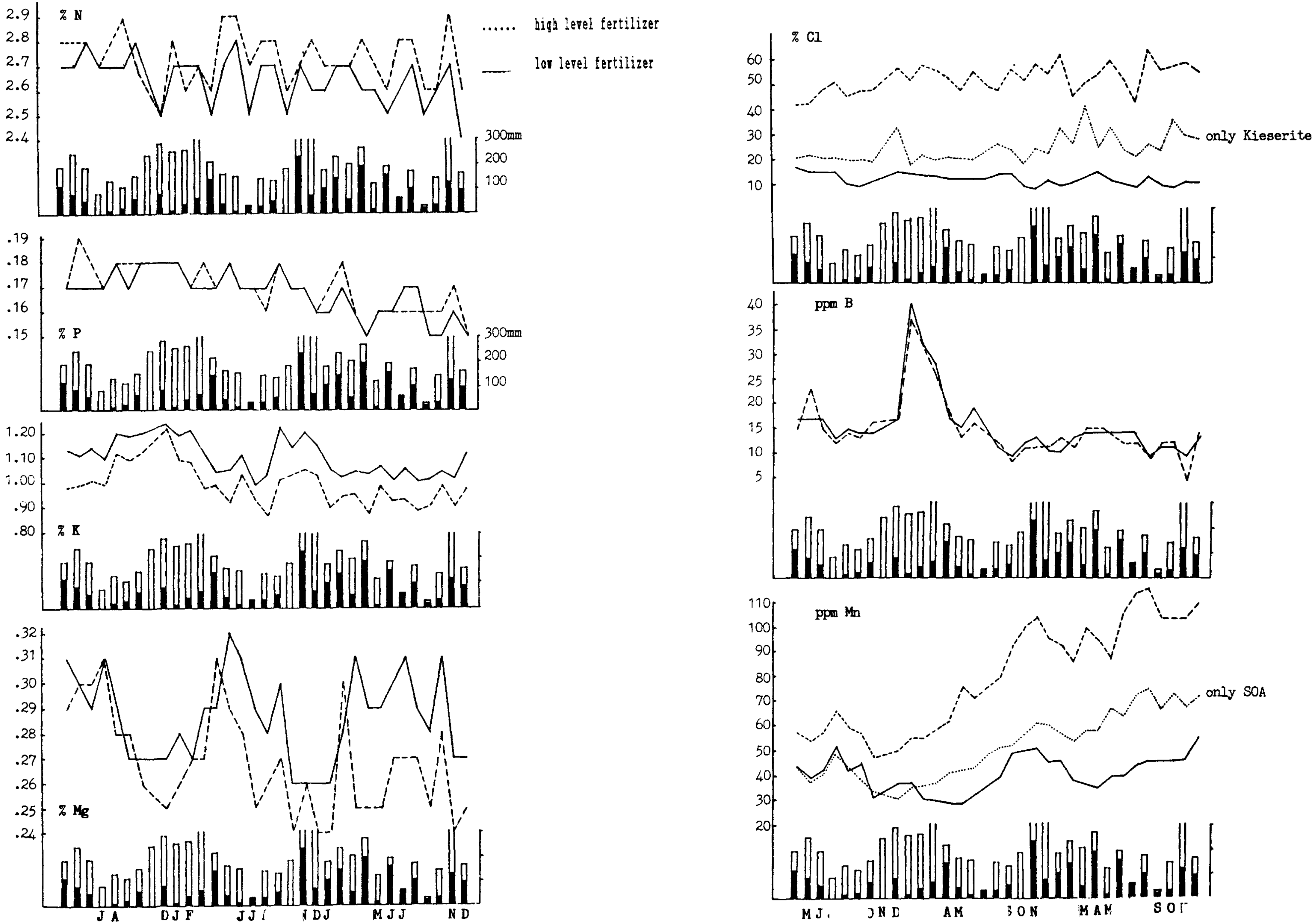


Figure 6: Investigation 708, Monthly leaf nutrient levels in Expt.306 (line graph) and rainfall, monthly (white bar) & over 10 days preceding leaf sampling (black bar)



ENTOMOLOGY

(R.N.B.P.)

Investigation 602: Pollinators: Introduction

Following the visit of the entomologist to South America and data supplied by Dr. P. Genty of Indupalma Colombia and Dr. F. Luchinni of E.M.B.R.A.P.A. Belem, Brazil, the decision was taken to import *Mystrops costaricensis* sub species *pacificus* from Ecuador.

There is no published information on the host range of *M.c. pacificus* but Dr. Genty and Dr. Luchinni had been studying pollination of palms, both native and cultivated, for some years and had recently focused their attention on pollination of *Elaeis oleifera* and *guineensis* and their hybrids. In their opinion *M.c. pacificus* was found only on *Elaeis oleifera* and *guineensis*. They knew of no other records of it being found on other plants nor causing damage to plants including the two *Elaeis* species.

One species of *Mystrops*, *fryi* (syn. *palmarum*) is recorded as damaging *Cocos* in South America but the description does not fit *M.c. pacificus* and it appears as though the biology is different.

The identification of sub species of *Mystrops* by Dr. Genty and colleagues goes some way to explain the very variable fruitset recorded in the different regions. They suggest that three sub species of *Mystops costaricensis* have developed through geographical isolation by the Andean ranges (Genty 1986).

Genty's data (Figures 7 and 8) give different levels of fruitset and population dynamics with two sub species from which *M.c. pacificus* is considered to be an effective pollinator.

In an area where *M.c. pacificus* was apparently the only pollinator and *E. subvittatus* virtually absent, the average fruitset for nine months was for 1974 planting:- 72 percent; 1976:- 69 percent and 1977 planting:- 69 percent.

At all times of the year fruitset was not a problem on a small plantation near La Concordia, Ecuador, where *Mystrops* appeared also to be the only pollinator.

Table 67 gives a range of natural fruitset on 3 stations in Nigeria which is very similar to fruitset at Hargy plantation, West New Britain, and is probably the best one can expect under any combination of natural pollinators.

Mystrops was reared initially in England and checked by the Commonwealth Institute of Biological Control and the Commonwealth Mycological Institute. Quarantine facilities were made available at the Ministry of Agriculture's A.D.A.S. Plant Pathology Laboratory. Prior to *Mystrops* arrival from Colombia, constant temperature and humidity chambers were set up by the entomologist to the required tropical regime. To prepare food and breeding sites for the insect, 50 spikelets airfreighted to England 3 times a week via Sydney and Singapore, a journey of 4 or 5 days. The condition of the spikelets

Figure 7: Daily activity of *Mystrops* on male inflorescences in Colombia (after Genty)

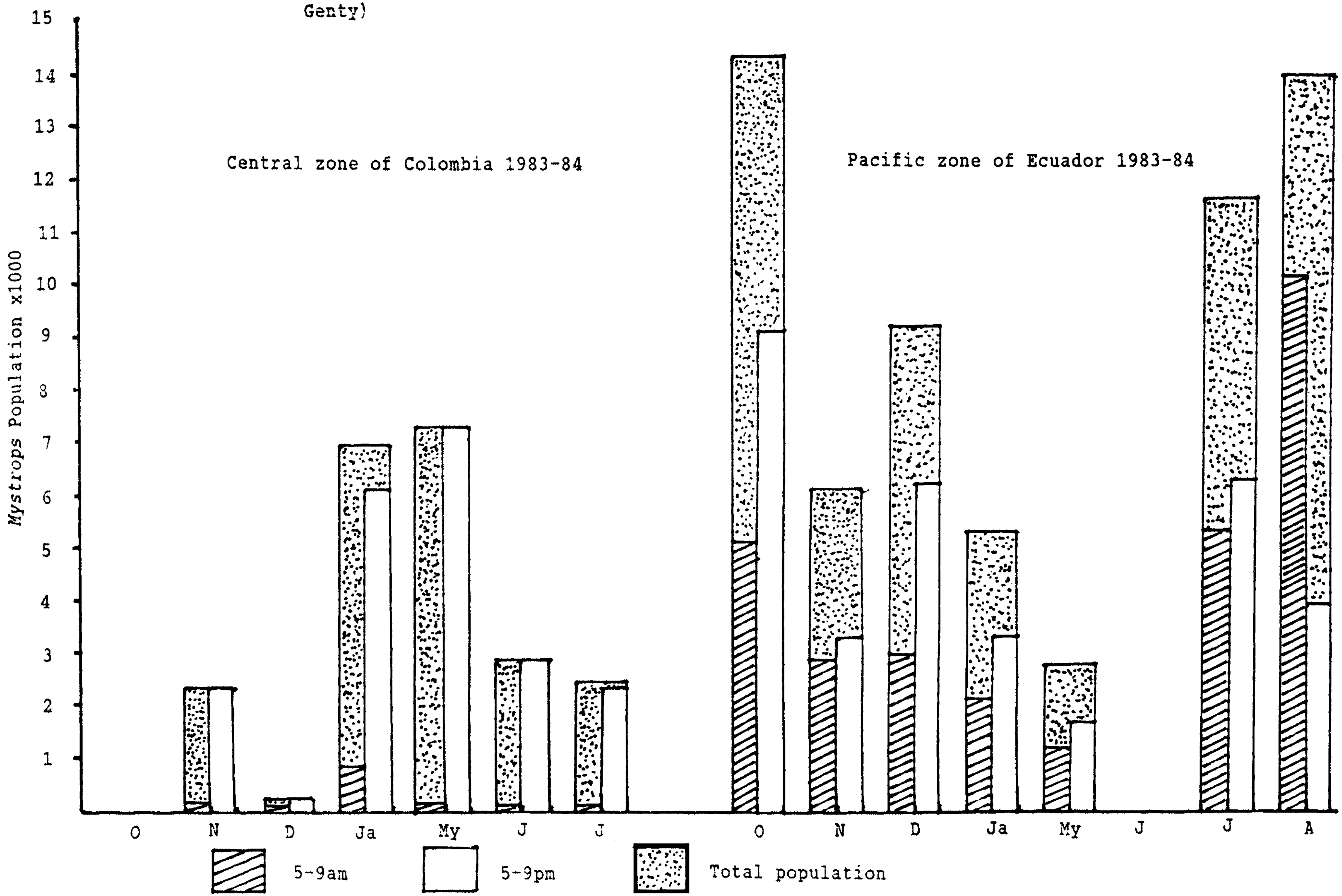
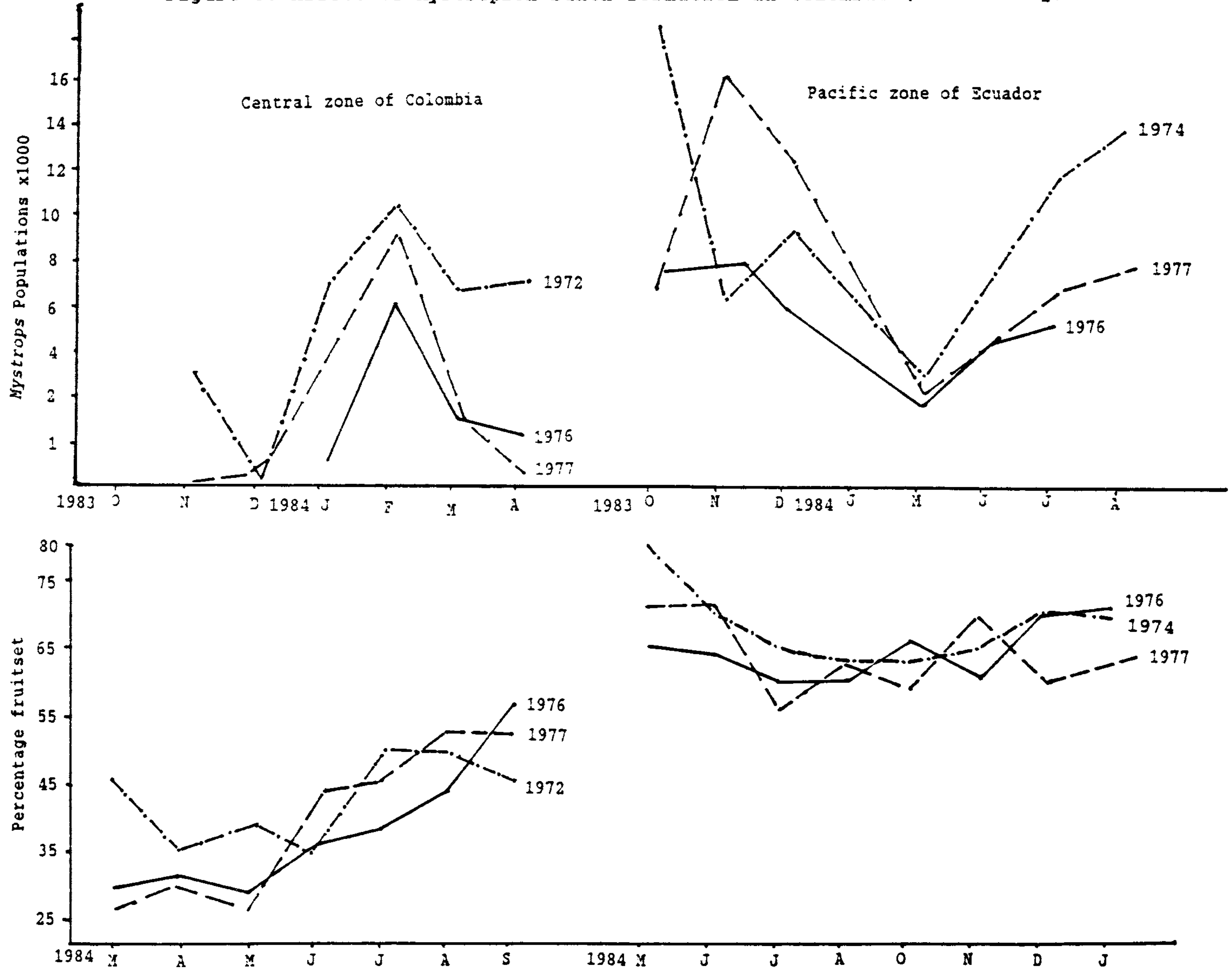


Figure 8: Affect of *Mystrops* on bunch formation in Colombia (after Genty)



was generally excellent and it would be practical to use the same technique for quarantine of other oil palm insects or checking pathogens on living oil palm tissues in London. The following describes the quarantine and testing procedures and results in England and Papua New Guinea.

Table 67: Fruitset data from Nigeria, West Africa (after Broekmans)

Year	1942	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952
A. Percentage fruitset (controlled pollinated bunches											
Ogba Farm, Benin	41.3	46.9	39.3	47.3	66.2	66.0	58.8	57.9	53.0	55.6	53.9
Nkwele Farm, Onitsha	37.2	33.4	32.8	30.0	28.8	33.9	41.9	39.8	52.2	40.6	47.8
Umudike Farm, Umuahia	-	-	66.8	57.0	65.2	67.0	65.1	67.9	65.1	61.6	61.2
B. Percentage fruitset (naturally pollinated bunches)											
Ogba Farm, Benin	64.7	67.5	70.8	70.3	64.9	63.8	62.4	69.4	72.6	82.5	68.6
Nkwele Farm, Onitsha	56.8	54.3	65.0	58.3	59.4	64.2	52.5	67.1	67.8	73.5	69.9
Umudike Farm, Umuahia	-	-	-	68.8	72.9	74.5	75.7	72.0	80.4	71.9	73.3

Each figure represents the average percentage set of 100-200 bunches

In London, the material of *Mystrops costaricensis* sub species *pacificus* originally from Ecuador, arrived safely from Colombia where it had been reared in a laboratory at Buccamaranga.

The material contained mites which appeared to be commensal with the *Mystrops* and were often seen attached to the adult *Mystrops* body. Establishment of a mite free culture was achieved by removing mites from adult *Mystrops* prior to their transfer to a different environmental chamber. In England, it appeared that the mite free cultures were not so vigorous as those containing mites.

It was observed that, particularly where the *Mystrops* larvae were feeding, the mites were delaying the growth of fungus which rapidly overtook the pollen bearing areas of the oil palm spikelets. The mite was provisionally identified by Dr. D. Macfarlane of C.I.E. as *Proctolaelaps* near *cubanus*. Dr. Evans of C.I.B.C. was asked to check the gut content of both *Mystrops* and mites for pathogenic contaminants, he reported digested fungal spores in the gut of the mite.

No other contaminants or pathogenic organisms were recorded from material reared in England and checked by both the Commonwealth Mycological Institute and the Commonwealth Institute for Biological Control.

Both clean and mite infested material was taken to P.N.G., where more vigorous cultures could be built up with fresher oil palm material available. The difference between mite infested and mite free cultures became less apparent under these new conditions. In the time available it was not possible to reach a conclusion on the necessity of having mites in association with *Mystrops* However, it is known that *Mystrops* populations do not favour wet conditions. It is likely,therefore, that under such adverse climatic conditions or when the population is reduced, the mites could assist in the survival of the *Mystrops* larvae against fungal growth. Where large numbers of *Mystrops* adults are found, their activity on the spikelet, in a similar way to *E.k.*, continuously disturbs the surface and removes pollen which reduces the growth of fungae. The feeding on fungal spores by the mites would also reduce the number able to germinate among the *Mystrops* larvae.

In Port Moresby, P.N.G., the cultures of *Mystrops* from London were divided up into six sub cultures which had mites present and fourteen which were started free of mites. After two weeks, sufficient material was available to run a preliminary test on coconut flowers to see if *Mystrops* could survive and develop on coconuts.

Table 68 gives the results of the test started on 17th May. This demonstrated the difficulties in counting small active insects, the adults of which were often hidden inside half opened flowers. The adults used in this first test had been collected from oil palm material in the laboratory and a certain amount of pollen was unavoidably transferred with them to the coconut test jars.

Coconut flowers absciss within 12 hours of opening and the survival of both adults and larvae depended on the condition of the dropped flowers. Fresh flowers were added to the test jars every day or so, creating what was a very unnatural situation. However, given a continuous supply of fresh flowers in a confined space, this test indicated that eventually eggs could be laid on coconut which could hatch and some larvae complete development. In relation to the number of progeny produced in the oil palm control jar, the progeny from coconuts was small.

Table 69 gives the results of the second test started on 20th May and showed clearly that *Mystrops* could complete its development in the same time scale on coconuts as on oil palm. The difference between the total number of progeny produced in the coconut tests and the higher number on oil palm was large but difficult to compare quantitatively because of differences between the test material.

Table 70 gives the results of a test designed to examine the development and production of progeny using a small definite number of insects. Adult insects were freshly emerged for use in this test and collected on moist filter paper wrapped around an anthesing spikelet in the top of the emergence cage. The adult *Mystrops* settled in crevices in the paper and could be collected with a pooter with no contact or contamination with the spikelet material. In order to handle the insects and count them , they were placed in a fridge at 10°C for a few minutes. Many did not survive the cold treatment. It is apparent from the effect of slight chilling that *Mystrops* is rather fragile.

Of interest is the longevity of the few surviving adults (26 days) and the formation of *Mystrops* pupae inside dried coconut flowers. In some cases, the *Mystrops* pupa was in a cell immediately above the pre pupal larva of the coconut weevil *Derelomus* which pupate in tissue beneath the flower stigma. The *Mystrops* pupa was formed in a cavity of fungal hyphae and detritus from larval feeding.

Table 71 gives the results of 10 replicates using 10 adult *Mystrops* per tube on coconut male flowers. It was decided not to try and immobilize the insects, which would have been necessary to determine their sex. A check was run on random samples as well as sexing the recovered adults in the tests as they died, in most cases a 50:50 sex ratio was normal. The adults were freshly emerged from the peat soil and had no contact with plant material prior to their release into the test tubes.

As well as confirming the development time for the progeny of the test insects of approximately 15 days from egg to emerging adults, the longevity of the test insects was much longer than expected. 67 percent of the test insects remained alive on coconut flowers twenty six days from the start of the test. The presence of first instar larvae in several cultures after the same period of time would indicate that the surviving adults were still reproducing. Ideally, this test should have been repeated and run until the test insects have all died, but it was not practicable to do so.

Table 68: First series coconut test 1 started on 17 May 1986

	Coconut Jar 1	Coconut Jar 2	Coconut Jar 3	Oil palm Jar 4
No of Adults	30	30	30	30
Date Examined				
May 18	35	30	30	30
20	35	28	30	30
21	3 observed	1 observed	0 observed	6 observed & many small larvae
22	several adults & no larvae	several adults & no larvae	several adults & no larvae	20 adults & many larvae last instar
23	1 observed & 1 dead, no larvae	A few adults alive, no larvae	A few adults alive, no larvae	Many adults observed and many larvae
25	6 observed alive, no larvae	3 observed alive, no larvae	1 observed alive, no larvae	Four adults observed alive and some larvae
27	2 observed, no larvae	2 observed, no larvae	2 observed, no larvae	20 adults observed alive many larvae
29	15 adults recovered alive & 16? larvae	13 adults recovered alive & 4 larvae	4 adults recovered alive & 4 larvae	40 adults (some F2) alive & many larvae
NB:	no fresh flowers added from this date. Peat put in jars for pupation			
30	"	"	"	"
31	"	"	"	"
June 1	oil palm added	oil palm added	oil palm added	oil palm added
	Progeny	Progeny	Progeny	Progeny
2	0	0	2	38
3	0	0	0	49
4	0	3	0	37
5	0	0	0	32
6	0	0	0	10
7	11	0	2	1
8	10	0	3	2
10	8	0	3	0
11	4	2	2	1
12	0	0	0	0
13	0	0	0	0
Total Progeny	33	5	12	170

Table 69: First series coconut test 2 started on 20 May 1986

	Coconut Jar 1	Coconut Jar 2	Coconut Jar 3	Coconut Jar 4	Oil Palm Jar 5
No of Adults	50+	50+	50+	50+	50+
Date Examined					
May 23	several adults observed alive	one or two adults observed alive	several adults observed alive	Several adults observed alive	Many adults observed alive
25	3 adults observed	2 adults observed	4 adults observed	4 adults observed	Many adults observed
26	-	-	-	-	Many adults and larvae
27	5 adults observed alive + 12 insect larvae	5 adults observed alive. No larvae	12 adults observed alive. No larvae	10 adults observed alive. No larvae	40 + adults alive + many larvae
28	No fresh flowers added from this date. Peat put in jars for pupation.				
29	"	"	"	"	"
30	"	"	"	"	"
31	"	"	"	"	"
June 1	"	"	"	"	"
2	Oil palm added to each jar to collect emerging progeny				
	Progeny	Progeny	Progeny	Progeny	Progeny
3	24	38	98	59	132
4	10	4	17	36	124
5	0	0	6	3	329
6	2	2	0	0	206
7	0	0	3	0	224
8	0	0	6	7	264
10	4	0	51	15	153
11	2	0	15	9	16
12	2	0	1	0	6
13	0	0	0	1	0
15	0	1	4	2	1
16	0	1	3	1	0
18	0	0	3	3	0
Total Progeny	44	46	207	136	1445

Table 70: First series coconut test 3 started 30 May 1986

10 Adults in each Tube except Tube 3 which had 20

Date of Observation	Tube 1	Tube 2	Tube 3
May 31	8 alive, 2♀♀ dead	5 alive 5♂♂ dead	5 alive, 7♂ + 6♀♀ dead
June 1	8 alive	5 alive	5 alive
2	4 alive, 1♂ dead	4 alive	3 alive
3	4 alive	2 alive	5 alive
4	1st instar larva dead	Fresh flowers added	Fresh flowers added
5	2 larvae	Fresh flowers added	Fresh flowers added
6	At least 3 adults alive	1 adult alive + 1 larva	At least 2 adults alive
7	6 adults alive + 1 egg + two 3rd instar larvae	2 adults alive + 2 larvae	5 adults alive + one 2nd instar larva + one 1st instar larva
8	Not checked F.F.A.	F.F.A.	3 adults + 2 larvae observed, F.F.A.
11	1 adult observed not checked F.F.A.	F.F.A.	3 adults + larva F.F.A
13	Peat added for pupation of larvae		
	4 alive, 1 ♂ dead + 6 larvae	2 alive 1 ♀ dead + 1♂ escaped + 2 larvae	4 alive 1♂ dead no larvae observed
16	3 alive + four 1st instar larvae + two 2nd instar larvae	2 alive, no larvae seen	4 alive + three 1st instar larvae
June 18	F.F.A.	F.F.A.	F.F.A.
20	F.F.A. + 1 Adult progeny	F.F.A	F.F.A.
22	F.F.A.	F.F.A.	F.F.A.
24	F.F.A.	F.F.A.	F.F.A.
25	All dead (1♀ + 2♂ dead) Progeny: 1 adult + 3 pupae inside old flower	1 adult alive (3 ♀ dead) 4 instar larva progeny 2	3 adult (1 ♂ dead) Progeny, 4 4th, 3 fourth prepupal larvae + 4 pupae inside old flower.
Progeny and F1 adults kept in separate tubes from June 10			
Total	1 Adult + 3 pupae	2 4th instar larvae	8 4th instar larvae + 4 pupae
Surviving adults	0	1 (26 days)	3 (26 days)

Table 71: Second series coconut test

10 cultures set up June 1st with 10 adult *Mystrops* per jar. Subculture jars with peat plus old flowers and larvae were set up on 10th June.

Date of Observation	TUBE 1	TUBE 2	TUBE 3	TUBE 4	TUBE 5	TUBE 6	TUBE 7	TUBE 8	TUBE 9	TUBE 10
June 3	F.F.A.	F.F.A.	F.F.A	F.F.A. 1♂ Dead	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
4	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A	F.F.A.	F.F.A.	F.F.A	F.F.A.	F.F.A.
5	10 Alive	10 live +1 egg	11 live	4 live 6 Dead	10 live	10 live	7 live ? larva	9 live	8 li	9 live +1♀ dead
6	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
8	F.F.A.	F.F.A	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
9	9 live +12 larvae	10 live +2 larvae	10 live +1 dead ♂	7 live	9 live +1♂ dead +1 larva	8 live	7 live	9 live +1 larva	9 live +2 larvae	9 live
10	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
11	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.	F.F.A.
13	9 live larvae	8 live +9 larvae	10 live +3 larvae	8 live +5 larvae	8 live +5 larva	10 live +6 larvae	7 live +3 larvae	8 live +4 larvae	8 live +3 larvae	7 Alive +1♂ dead +5 larvae
14	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
16	9 live +7 larvae	8 live +3-larvae	9 live +9 larvae	8 live +8 larvae	8 live +6 larvae	10 live +1 larva	5 live +9 larvae	6 live +6 larvae	7 live +4 larvae	8 live +8 larvae + prepupa inside flower
	F.F.A.	F.F.A.	F.F.A	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
18	8 Alive 1♀ dead 2 pupa in peat	8 live 3 fourth 1 first instar larvae	9 alive 3 fourth instar larvae 1 prepupa	8 Alive 1 pupa in peat	6 live 2 escaped 2 fourth instar larvae	10 Alive 2 fourth 2 first instar larvae	5 live 3 fourth instar larvae	6 live 1 fourth instar larva 2 pupae in peat	7 live 1 fourth instar larva 1♂ progeny killed	7 Alive 1 escaped 2 fourth instar larvae
	PROGENY	PROGENY	PROGENY	PROGENY	PROGENY	PROGENY	PROGENY	PROGENY	PROGENY	PROGENY
20	10	3	0	0	1	0	0	0	0	0
22	6	2	1	2	6	3	0	5	0	1
23	4	1	4	8	7	3	2	3	0	1
25	8	5	3	8	5	4	2	4	0	1
26	1	2	3	10	1	0	4	0	0	4
Total progeny	34	13	11	31	20	11	9	13	1	7

At the conclusion of this test on 26th June the following were still alive in each culture.

JAR	Live adults +		larvae
1	4	3	fourth instar
2	8	5	fourth instar, 2 first instar
3	9	5	fourth instar, 1 first instar
4	8	1	fourth instar, 1 third instar
5	6	1	third instar
6	9	4	fourth instar, 1 prepupal (fourth instar) in base of flower
7	4	3	fourth instar, 1 first instar
8	6	2	fourth instar
9	7	1	fourth instar, 1 third instar
10	6 +1 dead♀	1	fourth instar

A second plant to be tested was betelnut (*Areca catechu*) Table 72 gives data from 10 replicates using 10 adult *Mystrops* per tube on betelnut male flowers. Although only two of the ten replicates produced positive evidence of development on this material, this test was done under great difficulties with regard to obtaining really fresh flowers for the insects to feed on. Betelnut male flowers, as with coconuts, open and fall the same day. Furthermore,the male flower of the betelnut is extremely small and contains insufficient pollen to nurture a *Mystrops* larva to maturity. When the flowers fall, unlike coconuts with wide sheathing leaf bases into which the falling flowers can collect, the betelnut male flowers are scattered thinly over the ground below with little chance for an emerging larva to move onto a new flower. The possibilty of *Mystrops* larvae developing to maturity in a natural state is, therefore, remote. However, in tests where fresh flowers were added , larvae were seen and a few progeny emerged. There was about 50 percent mortality of the test insects in the first six days of the test although one test insect remained alive for 19 days. These results really required confirming and conducting in an area where fresh betelnut flowers were more readily available.

Table 72: Second series betel nut test 1st June 1986

10 adult *Mystrops* per tube

Date of Observation	Tube 1	Tube 2	Tube 3	Tube 4	Tube 5	Tube 6	Tube 7	Tube 8	Tube 9	Tube 10
June 3	1♂ dead F.F.A.	F.F.A.	1♂ dead F.F.A.	1♂ 1♀ dead F.F.A.	2♀ dead F.F.A.	F.F.A.	1♂ 1♀ dead F.F.A.	F.F.A.	1♂ dead F.F.A.	1♂ 1♀ dead F.F.A.
4	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
6	1 live 3♀ 1♂ dead F.F.A.	7 live 3♂ 1♀ dead F.F.A.	5 live 3♀ 2♂ dead F.F.A.	6 live 3♀ 1♂ dead F.F.A.	6 live 1♀ 1♂ dead F.F.A.	5 live 3♀ 2♂ dead F.F.A.	2 live 3♀ 2♂ dead F.F.A.	4 live 6♀ 1♂ dead F.F.A.	8 live 2♀ dead F.F.A.	7 live 1♀ 2♂ dead F.F.A.
8	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
10	A few adults observed alive in each tube but not counted									
11	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
	Peat added to all tubes									
12	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
14	1♀ live 2♀ 3♂ dead	4♀ 4♂ all dead	1 live 2♀ 2♂ dead	4 live 1♀ 1♂ dead 3 LARVAE	1 live ♂ 5♀ live	4♀ 1♂ all dead	2 live	1♀ 3♂ dead all dead	1 live 2♀ 4♂ Dead	2 live 3♀ 2♂ dead
15	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
17	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
19	1♀ live NO PROGENY	NO PROGENY	1♀ all dead 1♂ PROGENY fresh emerged	2♂ 1♀ all dead NO PROGENY	1♂ all dead NO PROGENY	NO PROGENY	2♀ all dead NO PROGENY	NO PROGENY	1♀ all dead NO PROGENY	1♀ 1♂ all dead NO PROGENY
20	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
22	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
23	1♀ dead Nil	Nil	Nil	PROGENY 3♀ 2♂	Nil	Nil	Nil	Nil	Nil	Nil
24	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
26	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Total Progeny	0	0	1	5	0	0	0	0	0	0

Table 73 gives data from the five replicates of test insects on oil palm. The greatest difficulty here was observing and recording the insects once they had disappeared beneath the anthers on the spikelet - hence the appearance of a slightly larger number of adults in some subsequent counts. The initial tests also demonstrated that, with only a small number of *Mystrops* present on the spikelet, mould growth could quickly swamp the insects, particularly inside small closed containers. However, the results from this series amply demonstrates *Mystrops* ability to develop rapidly even under sub optimum conditions. Again, development time could be judged at approximately 15 days or less from the time the first eggs were seen to the emergence of the first adults.

Table 73: Second series oil palm test (controls) 1 June

10 adult *Mystrops* per tube

Date of Observation	Tube 1	Tube 2	Tube 3	Tube 4	Tube 5
		1o dead		2o 1o dead	
June 3	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
4	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
5	7 live 3 missing	7 live 3 missing	4 live,1o dead 5 missing	2 live,2+ 1o dead 5 missing 6 ova observed	5 live 5 missing
7	F.F.A	F.F.A.	F.F.A.	F.F.A.	F.F.A.
10	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
11	6 live 20+ larvae	6 live 20+ larvae	3 live 10+ larvae	3 live 10+ larvae	6 live 20+ larvae
	Peat added to all tubes				
12	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
13	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
15	8 live	6 live	3 live	2 live +	6 live +
	All tubes many 4th instar lavae				
16	F.F.A.	F.F.A.	F.F.A.	F.F.A.	F.F.A.
18	F.F.A	F.F.A	F.F.A	F.F.A	F.F.A
19	10+ Adults	5 live	9 live	5 live	5 live
	Adults removed, larvae left to develop				
20	F.F.A	F.F.A	F.F.A	F.F.A	F.F.A
	Progeny	Progeny	Progeny	Progeny	Progeny
21	138	115	47	49	125
22	47	27	21	23	32
23	29	20	23	20	36
25	20	34	22	17	54
26	5	10	4	8	18
Total Progeny	239	206	117	117	265

Table 74 gives the results of a test of longevity on adult *Mystrops* freshly emerged and placed on moist filter paper without access to plant material. The majority were dead three days later and all test insects had died 5 days from the start of the test. This test was designed to provide as comparative data for mortality in the other experiments where the insect might have survived without feeding on the test plant.

Table 74: Longevity of adult *Mystrops*

Date of observation	Tube A		Tube B
May 26	Cultures started 20 freshly emerged adults on moist filter paper without plant material		
May 28	19 live	1 missing	10 live + 10 dead
May 29	2 live	17 dead	3 live + 17 dead
May 30	1 live	18 dead	2 live + 18 dead
May 31	19 dead		20 dead

The result of four multiple choice tests indicated that *Mystrops* preferred oil palm to both coconut and betelnut (Table 75). However, it is considered that in the confines of a small cage the smell of the oil palm could swamp the scent of the other two plants.

Table 76 gives the results of a test of compatibility between *Elaeidobius kamerunicus* and *Mystrops* which were fairly conclusive although this experiment requires repeating to confirm that there is little or no interference by *Mystrops* with the reproduction of *E.k.*

Table 75: Settled adults recovered in multiple choice tests from initial populations of approximately 200-300 *Mystrops* after 2 periods of activity from 1500 to 0900 hrs

	Test 1 June 7	Test2 June 11	Test3 June 18	Test 4 June 22
	Percent recovered			
COCONUT	16	21	4	15
BETEL NUT	14	26	7	4
OIL PALM	70	53	89	81

Table 76: Development of *Elaeidobius kamerunicus* on oil palm spikelets with and without *Mystrops costaricensis* sub sp. *pacificus*

	Without *Mystrops*		With *Mystrops*		
	Jar 1	Jar 2	Jar 3	Jar 4	Jar 5
June 12	20♀ 20♂ *E.k.*		20♀ 20♂ *E.k.* plus 200 *M.c.p.*		
23	- 40 adults removed from each jar -				
	Progeny	Progeny	Progeny	Progeny	Progeny
24	33	29	42	14	35
26	38	15	5	3	10
July 3	222	205	191	233	236
TOTAL	293	249	238	250	281
Mean	271[1]			256[1]	

[1] t,3 df = 0.57 ns

Conclusions: In so far as the host specificity of *Mystrops costaricensis* sub species *pacificus* is concerned, the results were disappointing but not conclusive. They indicated the possibility of *Mystrops* completing its development both on coconut and betelnut, mainly because the insect is a pollen feeder with no specialised requirements for other areas of plant tissue to complete its development. Whether or not *M.c. pacificus* is naturally a polyphagous insect requires validation in South America. Information from Drs' Genty and Lucchini indicated that they had only collected it from oil palms , both American and West African, and that it had not been recorded from other plants, including coconuts.

The main criticism of laboratory techniques used for both *Mystrops* and *E. kamerunicus* host range tests was that they were carried out in an unnatural environment and using excised plant material. However, although negative results on excised plant material can only be regarded as inconclusive, positive feeding and breeding results are not and are that much more likely to be reproduced on the growing plants in the field. Therefore, immediately eggs and larval development of *Mystrops* were observed on excised coconut in the laboratory, the chance that this could occur in the field with possible damaging effects had to be accepted.

Taking these results to the next stage planned, (field tests) obviously involved too great a risk in that escape of material into the environment might take place. The decision was taken by DPI and PNGOPRA to destroy the cultures after the completion of the tests in the quarantine laboratory because it was not practical to hold them in isolation indefinitely.

The set-back with *Mystrops* was regarded only as such, pending information from South America which would substantiate its feeding on and damaging coconuts or other evidence of polyphagy.

Because we did not wish to risk *Mystrops* in the field in PNG in case it damaged coconuts, it will be necessary to study coconuts in the Quininide area of Ecuador where *M.c. pacificus* occurs in the plantations of *E.guineensis*. In the same area, tests on other economic crops should be carried out as well as observing the beetle on these crops in the field. Further data on its pollination efficiency should be obtained and data to substantiate that no other pollinator exists in the Quininde area.

Research is currently in progress by other scientists in South America, Colombia and Brazil in particular, and comment on our results and information on other introduced pollinators is being sought.

The only other pollinators which could immediately be considered for introduction to Popondetta are either other species of *Elaeidobius* or *E.kamerunicus* from zones where it is adapted to dry conditions similar to those at Popondetta. An advantage of introducing another *Elaeidobius* species would be primarily the relatively quicker period of quarantine and testing required because all species of *Elaeidobius* are host specific. A disadvantage is that it would be expected to be equally prone to any pest or disease that affects our current strain.

The data obtained from the testing of *Mystrops* with *E.k.* which indicated little or no competition or adverse affect on *E.k.*'s development by *Mystrops*, will not be wasted as it has added to our knowledge of this insect and will make a second attempt that much easier for this species or a nitidulid from West Africa. It is re-emphasised that in the parts of P.N.G. where pollination is good, it is dependent on a single potentially vulnerable species of insect and it will not pay to be complacent. The introduction of alternative pollinators should continue to be given a high research priority because of this.

Investigation 603: *Elaeidobius kamerunicus*: field studies

Fruitset: Results and rainfall data are given in Figure 9. Of principal interest was the general decline of fruitset at West New Britain in the 1979 Buluma study area where, although a level at or slightly above fifty percent was maintained for eight months of the year, it dropped to between 39-44 percent for the rest. This was difficult to explain because the lowest fruitset corresponded with previously high male flower counts and weevil populations (Figure 10) and, although rainfall was high, it would not have prevented weevil activity. Hargy, on the other hand, continued to produce above average fruitset which did not fall below 60 percent at any time during the year. The extremely high rainfall in April at Hargy may have slightly depressed the fruitset as seen expressed in the fruitset graph, five to six months later. Otherwise, the overall rainfall distribution was similar for both Buluma and Hargy.

In Oro Province, the main problem area remained on Ambogo plantation where average fruitset was below or about 40 percent for eight months of the year and ranged from between 45 to 51 percent for the rest. Fruitset monitored on the oldest (1976/77) planting at Arehe produced the best fruitset which was between 50 and 60 for nine months of the year and ranged from 63-70 percent for the rest. Six other sites in the area were also recorded and fluctuated alternately between 46-50 one month and 52-55 the next.

Rainfall is known to vary considerably from area to area in the Province but comparison of the wettest and driest zones showed a strong correlation between fluctuations in monthly rainfall between the three sites and generally followed the known wetter or drier characteristics of each site. No positive correlation could be seen between fluctuation in rainfall and subsequent fruitset.

Figure 9: Average monthly fruitset and rainfall 1986

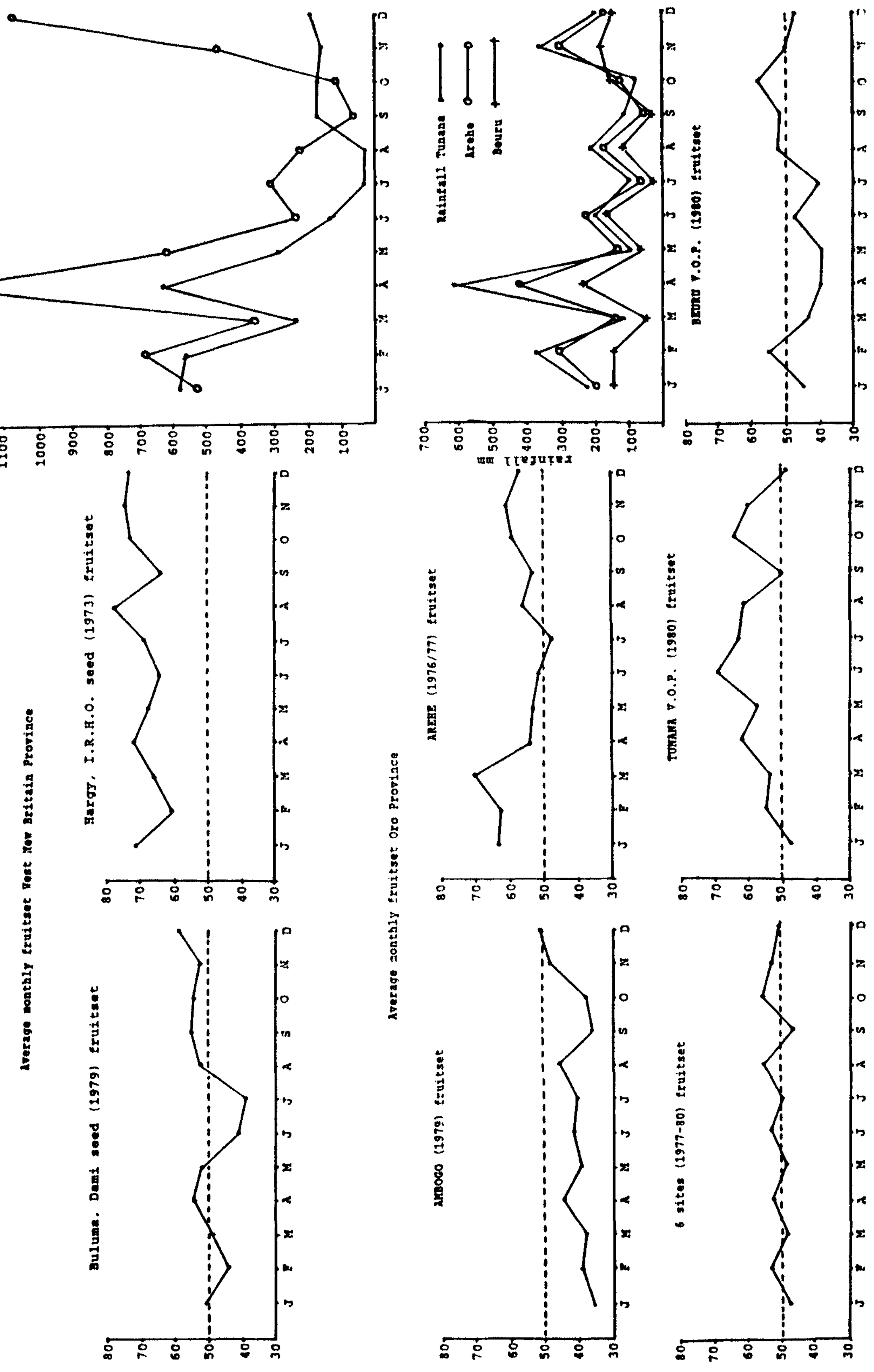
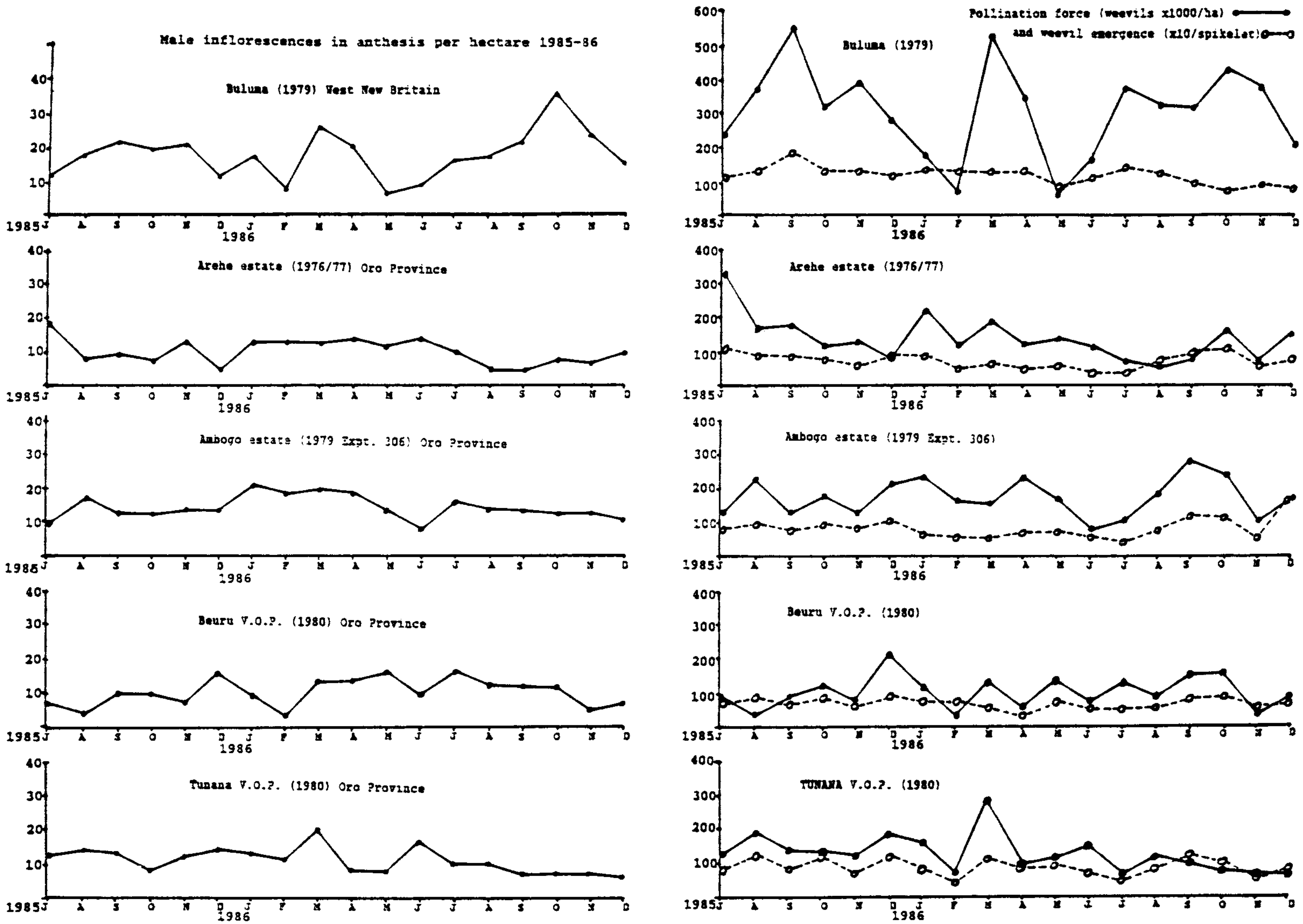


Figure 10: Monthly male inflorescence production and weevil populations 1985 and 1986



Investigation 601: Sexava: chemical control

Preliminary tests with an insecticide that kills immature stages of insects by interfering with chitin production, were encouraging. The product, trade name Dimilin, gave a hundred percent kill of all immature stages of Sexava tested.

In the laboratory, Dimilin was mixed at the rate of 8g in 1 litre water plus 5mls Orthospray sticker and then sprayed to run off on the test plants, seedling oil palms in polybags. After 12 hours, when the surface of the plants was dry, immature Sexava at different nymphal stages were put into cages containing the sprayed plants. After four days the first Sexava nymph to be killed was observed hanging upside down in a characteristic way, attached still by the tarsi to the plant, although quite dead. Table 77 gives the details of the kill in three separate tests. In Tests A and C last instar nymphs were able to moult to adults where they remained unaffected by the Dimilin to the end of the tests. Apart from the adults which survived, the result was 100 percent kill after 22 days.

In the field on November 5th, the same concentration of Dimilin was used to spray oil palm seedlings recently underplanted in mature 10-15 metre high palms which had an infestation of Sexava that had moved down onto the younger palms. Four days after treatment three affected nymphs were found. Accurate assessment in the field was not possible because most affected Sexava fell to the ground and were lost. However, three weeks later only a few adults could be found which were unaffected.

Table 77: Laboratory Tests of Dimilin 25 W.P. against Segestidea defoliaria.

No. of dead insects first instar to adult

Date of Observation	Test A 24 nymphs Test started 4 Nov — INSTARS:- 1	2	3	4	5	6	7	Adult	Test B 15 nymphs Test started 4 Nov — INSTARS:- 1	2	3	4	5	6	7	Adult
5th November								1 Alive								
6th November								1 Alive								
7th November						1					1					
8th November				2												
11th November				1					1	1						
12th November					1	1	1			2	1					
13th November									2							
14th November									1							
15th November									1							
16th November									1	1	1					
17th November					2				2							
18th November				4												
19th November						3										
26th November						1										
End totals	17 dead, 5 escaped,2 adults live								15 dead							

Date of Observation	Test C 19 nymphs Test Started 2 Dec — INSTARS:- 1	2	3	4	5	6	7	Adult
3rd December				2				2 Alive
4th December							1	
5th December								
6th December								
7th December							1	
9th December				1	1		2	
12th December	1							
16th December					2			
18th December							4	
22nd December							1	
End totals	17 dead, 2 adults live							

Treatment of Sexava by trunk injection with 10cc monocrotophus is the only system of pest control employed by this industry. This year, in West New Britain, New Britain Palm Oil Development treated 177 smallholder blocks (708 hectares) and 489 hectares of plantation oil palm at an approximate cost of K50,000.00. The treatment of the smallholdings remained similar in scale to previous years and has to be regarded as an essential on going cost to prevent loss of crop. The plantation treatment is considerably increased from previous years with both Bebere and Kumbango requiring large areas treated. Palm census rounds were introduced in an effort to prevent widespread damage before detection. On Hargy, damage occurred on about 120 hectares of the estate in May-June. Treatment was carried out and continued to the end of the year resulting in a total of 200 hectares requiring treatment. No damage was reported on smallholdings in the area. In Oro Province, about 10 hectares on Arehe plantation and 15 smallholder blocks were treated.

Investigation 607: Sexava: biological control

In West New Britain, Sexava egg parasites, *Leefmansia bicolor* and *Diorania leefmanii*, continued to be mass reared in the laboratory at Dami and released. A summary of releases during the year is given in (Table *) Attempts to confirm establishment of the parasites by exposing healthy Sexava eggs in cages placed in the fields where releases have been made, were so far negative.

In Oro Province, the Tachinid fly parasite *Exorista notabilis* (Wlk) was found in 89 out of 102 *Segestidea nouvaeguineae* collected on a smallholder block in Iseveni sub division. Thirty parasite pupae were sent to Dami, West New Britain, where unsuccessful attempts were made to infest *S.defoliaria* in the laboratory.

Table 78: Number of eggs parasitised by *Leefmansia bicolor* and *Doirania Leefmansii* release in the field.

Locality	Date	*Leefmansia bicolor*	*Doirani Leefmansii*
Bebere	17 Jan-2-30 June'86	3613	688
Kapore	3 Dec 1985-7 June'86	1585	266
Buvussi	Nov 1985-27 June'86	3434	
Kumbango	Nov 1985-25 June'86	1457	
Kavugara	26 June'86	370	
Dami	30-31 July'86	388	180
Kavugara	1 July'86		140
Dami	4 Aug'86	266	
Hargy (Bialla)	19 Aug'86	367	
Dami	2-5 Sept'86	912	
Banaule V.O.P.	2-5 Sept'86	334	150
Kapore	5-10 Sept'86	576	
Kavui	29 April-29 Sept'86	2355	
Kavui	1-11 Oct'86	1465	330
Walindi	9 Oct'86	472	235
Bebere	14-27 Oct'86	2196	340
Popondetta	5 Dec 1985-25 Oct'86	1679	
Gasmata	12 Nov'86	340	100
Bebere	19-24 Nov'86	515	845
Kumbango	19 Nov'86	220	
Popondetta	20 Nov'86	791	90
Hargy (Bialla)	22 Nov'86	540	
Tamba	31 Jan-5 Dec'86	748	180
Total (Eggs)		24,623	3544
Estimated number of parasites:-		984,920 (40 per egg)	886,000 (250 per egg)

Investigation 604: Sexava: field studies

In December, a survey of smallholders' blocks in the Tamba Subdivision, W.N.B., revealed one block with a mixed population of *Segestidea defoliaria* Uvarov and *Segestes decoratus* Redt. This was the first record of *S.decoratus* on oil palm in West New Britain, previously recorded on an oil palm block at Bubia, Morobe Province, adjacent to infested coconuts. On the Tamba block, two factors emerged which could account for its emergence here. The block holder also owned a block of coconuts at Pangalu, Talasea, which had suffered severe damage by *S.decoratus* last year. A feature of the Pangalu outbreak was that all the specimens examined were female and many hundreds killed by the injection treatment revealed no males in the population. To date all the specimens of *S. decoratus* at Tamba are also female.

Immature specimens kept in isolation in the laboratory matured but appeared at first to lay no eggs. However, after three to four weeks oviposition began and these eggs were kept and subsequently hatched to confirm the parthenogenetic reproduction of this population.

Treatment of the block containing both Sexava species was carried out but their presence also on a number of coconuts in the adjacent blocks could lead to re-infestation. This is a good example of how pests can be transferred from one area to another. The block holder informed me that he had taken young coconuts from Pangalu to his oil palm block last year. As this population is parthenogenetic it would only require one female insect from Pangalu to survive the journey to start the infestation at Tamba.

Investigation 606: Bagworm (*Lepidoptera Psycididae*): control

In W.N.B., only one 5 hectare block on Kumbango plantation was treated by trunk injection of monocrotophus where very large numbers of small *Mahasena corbetti* were found. On Togulo plantation, a widespread infestation of *M. corbetti* died out by the end of the second quarter due to the high level of parasitism by Tachinids and other natural mortality. Bebere plantation had a small outbreak in August but sampling revealed a 40-50 percent natural mortality and no treatment was carried out. In the smallholdings, Sarakolok subdivision reported an outbreak on 5 blocks in October - samples revealed 69 percent natural mortality of which 26 percent was due to Tachinid parasites - no treatment was carried out.

In Oro Province, no bagworm outbreaks were recorded during this year, and very few specimens could be collected and reared for parasite determination.

Investigation 605: Other Pests

In Oro Province in June, rat damage was recorded on Arehe estate where both male inflorescence were stripped, and black bunches attacked in both 1976 and 1983 plantings. Slight to moderate damage to V.O.P.'s at Beuru and parts of the Ambogo estate occurred and persisted until September.

The unidentified stick insect (*Phasmatodea*), which was first recorded damaging oil palm in October 1985, re-appeared in October this year in Iseveni sub-division. In conjunction with Sexava damage the block was treated to prevent serious defoliation.

In West New Britain Province, damage to recently planted oil palms on Kapiura plantation occurred in August caused by a large unidentified rat or marsupial.

PATHOLOGY

(T.M.)

EXPERIMENTS 801,803, Incidence of Ganoderma disease and tests of pathogenicity of *Ganoderma* isolates

The experimental treatments were decsribed on pages 42-44 of the Annual Report for 1983 and discussed fully on pages 56- 58 of the Report for 1985. The Pathologist's work for the Association unfortunately ended at that time.

During 1986 seedlings underplanted in 1982 around stumps of poisoned oil palm as bait to trap Ganoderma disease were uprooted and dissected. No evidence of infection by *Ganoderma* spp was seen. At least one seedling was left in the ground around the site of each experimental stump for study when the palms overhead are ready to be replanted.

No visual symptoms of disease were observed in any palms that had been inoculated with cultures of *Ganoderma* spp isolated from poisoned oil palms on Bebere plantation.

The results to date do not suggest that Ganoderma disease is inherently a risk on this plantation. However, as negative results of this kind are by their nature inconclusive and the disease could take eight years to become manifest, it should not overly be assumed that it could not be one in the future.

WEED CONTROL PROJECT

(M.M., M.S.)

Two postgraduate students from the Cranfield Institute of Technology, who had completed their M.Sc. course work, were engaged in this project. Mr. M. Muncey worked at Dami from May to July and Miss. M. Shearer from July to December.

Introduction. The objectives of this project were to investigate the potential of new chemical additives, application methods and areas to herbicides for chemical control, to produce guidelines for future research and to train staff into methods appropriate to this kind of investigation. In the time available the project would be unlikely to produce practical recommendations and this was not, therefore, a primary objective at this stage of the programme.

Weed control in oil palms may be broadly categorised into four sections;

Routine maintenance of inter row paths and circles to facilitate collection of the fruit, inspection and management operations.

Keeping cover crop off young palms

Control of weeds in the nurseries

Spot weeding against harmful weeds

Mostly weeds are adequately controlled with chemicals and by hand, but with narrowing profit margins interest in more economic weed control practices has increased. New combinations of chemicals and methods of application are being assessed to minimize the use of herbicides and improve their effectiveness and longevity. Recently a new interest has developed chemicals that may be added to a herbicide at mixing to improve performance. Additives are available, some formulated for use with a specific herbicide and others for more general purposes, but their potential is not yet fully known, expecially in the humid tropics.

Additives fall broadly into two categories: surfactants and adjuvants. Their action may be physical by preventing separation of an emulsion reducing evaporation, increasing spreading and retention on the leaves of a target, thereby, increasing uptake and reliability in adverse conditions, or chemical by facilitating entry and movement within a plant.

Many herbicide formulations include 'stickers' emulsifiers and surfactants. The intrinsic advantage of additives is that there is an option to use them; indeed, many additives have no or negative effect on herbicides unless used in adverse conditions. Since this is the case, and because the additives may be bulky or corrosive (e.g. ammonium sulphate) or disallowed under specific patents or licenses for a particular herbicide, they are not included at formulation.

Application methods have remained, on the whole, static since chemicals were first used for pesticide control. Efficiency was not a high priority when agrochemicals could be cheaply produced, new formulations were frequently available and when adverse consequences of spraying were not realised. Currently, technology has had to improve so that chemicals may be applied in the right place, time and dose. "Controlled Droplet Application" (C.D.A.) was a pioneer in this respect, moving pesticide spraying away from being a less than 1% efficient process. Different application techniques such as wick-wiping, C.D.A. and "Very Low Volume" (V.L.V) spraying are compared in these trials.

With increasing cost of labour, interest has developed in the use of chemicals for control in areas currently weeded by hand, in this instance, the weeded circles around young palms.

The final area for research was to investigate pre-emergent herbicides in the nursery for longer term and broader spectrum control than the chemicals currently in use.

Experiments 901a-c

Objective: To assess the effects of various additives to a range of herbicides in the control of weeds along harvest paths in plantations.

Methods: Each trial consisted of three completely randomised blocks. All treatments were applied using a Micron Herbi to plots 10m and 1.2m, wide. At the time of spraying, note was taken of the soil and meteorological conditions and of the flora present in each plot.

Visual assessments of percentage kill were made for each plot at 20, 40, 60, 90 and 120 days after treatment (D.A.T.), and were coded on a 1-10 scale where 1 = no kill 10 = 100%. At each assessment a note was made of species present in each plot and of flora killed. Two-way analysis of variance tests were used to assess the relative merits of replication, chemical, rate and additive. If significant differences were shown between chemicals or additives Duncan's "Multiple Range" test was used to analyse the results further.

The record of flora served to illustrate specific kill of treatments as well as high-lighting broad immediate ecological effects of chemical weed control.

Experiment 901a: Comparison of the efficiency of herbicides, rates of application and additives in the control of mixed grass weeds (excluding Imperata), Kumbango

Treatments:

Chemicals	Rates	(litres/ha)
Round up	1	0.5
Taiwanese Glyphosate	2	1
Nabu	3	2
Fusilade		

Additive

0 None
1 Ethokem T25 at 2%
2 Ethokem C12 at 2%
3 Sulphate of ammonia (S of A) at 5%
4 C12 at 2% + S of A at 5%
5 Mixture B at 2%
6 Mixture B at 2% + S of A at 5%

Number of treatments = 84.

All combinations of chemicals, rates and additives were sprayed through a C.D.A. blue nozzle giving an application volume of 12-13 l/ha.

Site: Kumbango Plantation Division II under palms planted in 1980. The area had not been sprayed for 2 months prior to the trial and the weed cover was mixed with broad leaves and annual and perennial grasses. Spraying took place on the 4th-6th June, one replication each morning. The mornings when replicates 1 and 3 were applied, were clear, warm and sunny with no rain for at least 16 hours after treatment when replicate 2 was sprayed it was damp and cloudy with light drizzle and a rainstorm at 3am the following morning.

The whole area consisted of mixed weeds rather than the mixed grass cover. The domininant grass was *Paspulum conjugatum, Calopogonium* and *Pueraria* spp made up the cover crop which was patchy but dominated in the shadier areas.

Results: The following mixtures could not be sprayed because of coagulation and thickening: Fusilade + S of A + Ethokem C12, Fusilade + S of A + mixture B, Nabu + S of A + Mixture B. Other combinations with Nabu and Fusilade tended to settle out but could be sprayed after agitation. No problems were noted with mixes including Round-up and Taiwanese Glyphosate.

Because mixed grasses did not dominate Nabu and Fusilade gave poor kill overall, broad leaves being unaffected, as would be expected. Hardy grasses such as *Paspalum conjugatum* were not readily killed, though chlorosis was noted in most cases. Since the effect of these chemicals was small it was impossible to distinguish possible influences of the various additives. 40 D.A.T., therefore, assessment of these treatments was discontinued.

Generally the site consisted of mixtures of grasses, *Ageratum* and *Pteridium* with little leguminous cover in the lighter areas, whereas, in the more shaded ones a mixture of *calopogonium* and *Pueraria* spp, dominated.

In all plots that were successfully sprayed, *Ageratum* and other soft weeds invaded quickly the bare ground left after treatment. In the shadier plots the cover crop, which was in most cases killed initially, started to encroach back onto the paths 40 D.A.T. and continued ingressing until 90 D.A.T. the paths were thickly covered.

120 D.A.T. it was difficult to walk through these patches where *calopogonium* dominated and these plots needed re-spraying. Although there was no further kill in plots where soft weeds grew back to form about 90% cover over the ground, these spp did not obstruct harvesting paths. The nature of the invasion of the bare ground created by spraying appeared more a result of the back-ground vegetation than the type of spray.

Table 79 gives the results of treatments, 90 D.A.T. grouped by chemical and additive. There was no significant difference between either treatments or additives. The considerable differences between replicates were largely the result of the weather, especially the high rainfall after replicate 2 was sprayed.

There was no significant difference between rates of 0.5 to 2 l/ha of Round-up. However, with Taiwanese Glyphosate 1 and 2 l/ha were significantly better than 0.5 1/ha, though no discrimination could be made between the two higher rates.

Table 79: Experiment 901a, Effects on mixed grasses and broad leaved weeds of herbicides at different rates and with different additives, Kumbango

HERBICIDE	C.p 1/ha	Mean score[1] D.A.T. 20	40	60	90	Total
Round-up	1.0	9.0	8.2	6.6	3.3	27.1
Round-up	2.0	9.2	8.2	6.1	2.7	26.2
Taiwanese glyphosate	2.0	8.7	8.1	6.0	3.4	26.2
Taiwanese glyphosate	1.0	8.6	7.8	5.7	2.6	24.7
Round-up	0.5	7.0	6.5	5.5	3.6	22.6
Taiwanese glyphosate	0.5	6.9	6.2	5.6	3.2	21.9
ADDITIVE	%					
Sulphate of Ammonia	5	8.3	7.7	6.6	3.9	26.5
Mixture B + S of A	2+5	8.5	7.9	6.7	3.2	26.3
Ethokem T25	2	8.2	7.7	6.0	3.6	25.6
Ethokem C12	2	8.4	7.7	6.1	3.4	25.6
Nil		8.3	7.6	5.6	2.4	23.9
Ethokem C12 + S of A	2+5	8.1	7.2	5.1	2.6	23.0
Mixture B	2	7.9	6.8	5.2	2.8	22.7

[1]Where 10= total and 1= no kill

Experiment 901b: Comparison of the effects of additives on herbicides used in the control of mixed weeds along harvest paths under closed canopy, Bebere

Treatments:

Chemical and Rates	C.D.A. Nozzle used
1. Round-up at 0.5	blue
2. Round-up at 1 1/ha	blue
3. Paracol at 1.5 1/ha	yellow
4. Paracol at 2 1/ha	yellow
5. MSMA at 2 1/ha	blue
6. MSMA, (2 1/ha) + 2,4-D amine (1 1/ha) + Diuron (0.75 1/ha)	yellow
7. Round-up (0.5 1/ha) + 2,4-D (1 1/ha)	blue
8. Round-up (0.5 1/ha) + Simazine (1.5 1/ha)	blue
9. MSMA (2 1/ha) + Simazine (1.5 1/ha)	blue
10. Gesatop Z (2 1/ha)	blue

Additives
0 Chemical only
1 Ethokem T25 2%
2 Ethokem C12 2%, + Ammonium Sulphate 5%
3 Ammonium Sulphate 5%
4 Mixture B 2%

Total number of treatments=50. Blue nozzle gave application volume of 12-13 1/ha. Yellow nozzle gave application volume of 22-23 1/ha.

Site: Bebere plantation, block D3 planted 1970. The trial was sprayed on 18th, 19th & 20th June. All spray mornings were hot, clear and dry. The vegetation was damp and there was no rain for at least 5 hours after spraying.

Results: Dominant weeds were *Nephrolepis Pteridium, Axonopus affinisa, Paspalum conjugatum, Eleusine indica, Centrothecea lappacea,* and oil palm seedlings.

The herbicides took about 10 days to show effects. This almost certainly was the result of the cool and shaded conditions under the palms. Significant differences were recorded between treatments when the results were grouped (P= 0.01) and analysed separately (P= 0.05). These results are given in Table 80 with costs. Parocol @ 2 l/ha, Round-up @ 1 litre/ha and the MSMA, 2,4-D and diuron mix performed well and significantly better than the other treatments. Paracol @ 1 l/ha had a greater effect than Round-up and 2,4-D amine, or Round-up @ 0.5 l/ha, but Gesatop Z was consistenty worse than any other treatment. Round-up at 0.5 l/ha was especially poor against *Nephrolepis*. Combinations with flowable Simazine performed moderately well. However, since this herbicide enters weeds mainly through their roots, its effectiveness depends on rainfall to move it down into the soil. There was no immediate rainfall after treatment and this may account for the moderate control recorded for these treatments.

Table 80: Experiment 901b, Herbicidal effects on mixed weeds and costs at different rates and with different additives, under closed canopy, Bebere

TREATMENT	Mean score[1] D.A.T.					Chemical cost
Herbicide (litre/ha c.p.)	20	40	60	90	Total	kina/ha
Paracol (2)	8.7	6.8	4.7	3.5	23.7a	16.00
MSMA (2)+2,4-D (1)+diuron (0.75)	8.3	6.9	4.9	3.1	23.2a	15.25
Round-up (1)	6.2	6.2	5.0	3.7	21.1a	13.00
Paracol (1)	7.7	5.2	3.3	1.6	17.9b	12.00
MSMA (2)	7.2	4.5	3.0	2.0	16.7bc	9.00
Round-up (0.5)+ simazine (1.5)	4.3	4.2	4.6	3.5	16.5bc	13.55
MSMA (2) + simazine (1.5)	6.3	4.4	3.4	2.0	16.1bc	16.05
Round-up (0.5)	3.8	3.1	4.1	3.0	14.0c	6.50
Round-up (0.5)+2,4-D (1)	4.1	3.5	3.7	2.5	13.7c	13.50
Gesatop Z (2)	1.9	1.6	1.7	1.3	6.5d	9.00
Additive (%)						
Chemical only	6.4	5.2	4.6	3.4	19.6	0
Ethokem T25 (2)	5.7	4.6	3.8	2.5	16.5	1.38
Ethokem C12 (2)+S of A (5)	6.3	4.4	3.5	2.3	16.4	2.01
S of A (5)	5.4	4.5	3.6	2.7	16.2	0.13
Mixture B (2)	5.4	4.5	3.6	2.3	15.9	

[1]Where 10=total and 1= no kill
Data with different letters differ significantly at 1%.

The costs indicate that the three most successful treatments were among the most expensive purely in terms of cost of chemical per hectare. The complication of mixing MSMA, 2,4-D amine and diuron would further increase the relative cost of this treatment. The mix of Round-up (0.5 l/ha) + 2,4-D (1 l/ha) was an approximation of a formulation sprayed as standard control of mixed weeds in plantations. This treatment performed significantly worse than many of the others under the conditions of the trial, and its relative cost was high. Further trials are necessary to validate this result.

There was no significant difference between the effects of additives, though the best results were recorded for treatments with no additives. At the time of treatment good spraying conditions prevailed.

Experiment 901c: Control of mixed weeds in an open situation, Ponini

Treatments:

Chemicals
A Round-up @ 1 l/ha
B Paracol @ 1.5 l/ha
C MSMA @ 2 l/ha
D Round-up @ 0.75 l/ha + Garlon @ 0.05 l/ha
E MSMA @ 2 l/ha + Simazine @ 1.5 l/ha
F Round-up @ 0.75 l/ha + 2,4-D amine @ 1/ha
G Round-up @ 0.5 l/ha + 2.4-D amine @ 1/ha
H MSMA @ 2 l/ha + Gesatop Z @ 1 l/ha

Additives
0 Chemical only
1 Ethokem T25 @ 2%
2 Ethokem C12 @ 2% + S of A @ 2%
3 Sulphate of Ammonia @ 2%
4 Mixture B @ 2%

Total number of treatments = 40

All treatments sprayed through Herbi blue nozzle giving application volume of 12-13 l/ha.

Site: The experiment was first sprayed in an open situation at Bebere plantation but this site had to be abandoned. The trial was repeated at Ponini Agricultural College under palms planted in 1982. No chemicals had been used on this site previously, paths were hand weeded and left for two months before treatments. The most commonly occurring species were *Cyperus rotundus, Digitaria ischaemum, Eleusine indica, Pasiflora foetida* and *Euphorbia thymifolia* with *Pueraria, Paspalum conjugatum* and *Imperata cylindrica* variously dominating.

The trial was sprayed on August the 13th (Rep 1) and 14th (Rep 2, Rep 3,) 1986. Weather on both mornings was sunny, clear and dry with light to moderate wind. No rain was noted for at least 8 hours after application.

Results: Knockdown 10 D.A.T. was good; *Pueraria* and other weeds wilting and becoming chlorotic, but the kill 20 D.A.T. was generally less good than that obtained in Expt. 901b under closed palms. Forty days after treatment effective weed control had been lost and regrowth covered the sprayed inspection paths. 60 D.A.T. effects had disappeared. Results are presented in Table 81. There were very highly significant differences between replicates and between herbicides up to 40 D.A.T. but none between the four additives tested. Round-up alone was significantly the best herbicide. Round-up mixed with Garlon, or 2,4-D gave similar control and the usual plantation cocktail of Round-up + 2,4-D came last in this group. This could be because of antagonism of 2,4-D with Round-up. The makers suggest that, to be effective, all mixtures with Round-up must include at least 2% ammonium sulphate, of technical and not fertilizer grade, because of the adulterating presence of heavy metals in the latter. Sulphate of ammonia was used alone and with Ethokem C12 in this trial but it was of fertilizer grade. MSMA by itself or in mixtures did poorly and Paracol had very little lasting effect.

Table 81: Experiment 901c, Control of mixed weeds with different herbicide mixtures and additives, Ponini

TREATMENT	Mean score D.A.T. 20	40	60
Herbicides			
Roundup 1L/ha	7.0a	4.6a	1.1
Roundup+Garlon .75+.5L/ha	6.5ab	4.3b	1.2
	6.5ab	4.5b	1.4
Roundup+2,4-D 5+1.06L/ha	5.6abc	3.9bc	1.2
Paracol 1.5L/ha	3.1c	1.8bc	1.3
MSMA+Gesatop 2+1L/ha	4.8abc	1.8bc	1.1
MSMA+Simazine 2+1.5L/ha	3.5c	1.7bc	1.2
MSMA 2L/ha	4.1bc	1.3c	1.0c
Additives			
Nil	5	2	1
Ethokem T25	6	3	1
Ethokem C12+SOA	4	3	1
Sulphate of ammonia	4	2	1
Mixture B	5	2	1

[1]10=total and 1= no kill
Means with different letters differ significantly P <0.05

Experimental techniques Experiments 901 a,b,c

As experience was gained, limiting features which should be avoided in future trials were identified. These are classified below.

Variation in flora: The trials were aimed at provisional screening of treatments, therefore, the number of treatments had been given a higher priority than the amount of replication. There was much variation in the flora in each plot before the trials began, the shaded areas being dominated by leguminous cover which appeared to smother other species, and the lighter areas having a generally more diverse range of weeds. Because different species may be more or less easily killed by any one herbicide, a given chemical may give 100% initial kill when applied to a susceptible weed, or have no effect at all on one for which it is not selective. Since the assessment in these trials was by overall kill (though note was made of dominant flora), no account was taken of this factor. Such interplot variation tended to desensitize comparisons between experimental treatments. Alternatively, treatments could be applied to uniform stands of vegetation. A combination of both approaches is obviously desirable. This variation would be reduced by greater replication.

Assessment: Treatments were assessed visually for percentage kill which, in the case of 10m plots, was possibly the simplest effective method as they were rather small for quadrats. A visual assessment also had the advantage of speed which was important in such large trials. However, the method of assessment employed had several intrinsic disadvantages.

In many cases it was difficult to assess percentage kill in plots where weeds were sparce before treatment. It proved difficult, for example, to allocate a low score to a plot containing 70% bare ground, even when little evidence was found of treatment effect. It would be more accurate to score percentage cover immediately pre-treatment and subtract from this score later assessments so that a relative score is generated. It would be possible to generate such relative scores for total cover or for individual species.

These trials were conducted primarily to assess the value of certain additives, some of which are known to be beneficial only in adverse conditions. It would, therefore, be useful to investigate again the benefits of an additive for before real or simulated heavy rain. These are conditions where additives hold the most promise rather than in the generally dry weather which prevailed during the trials reported here.

A more thorough examination and record of species present and their abundance should prove useful in discussion of the ecological effects of chemical control. In these preliminary investigations it appeared that emergence in the plots of soft herbage was due in most cases more to the mixed background vegetation than to the effects of individual chemicals.

Experiment 901d: The effect of Garlon to control *Pueraria* ingress to weeded circles, Bebere

Cover crops under oil palms are vines which may over-grow and pin down the fronds of young palms, reducing their photosynthetic area and making inspection difficult. Cover crop routinely is pulled from young palms by hand every 4 to 6 weeks which is a time consuming and expensive operation. The aim of this trial was to investigate one possibility of chemical control of cover around the weeded circles as an alternative.

Design: 5 randomised blocks of 21 treatments each. Plots were of 4 palm circles.

Treatments:

Chemical
Garlon 480 (active ingredient: triclopyr) at 0.25, 0.5 and 1.0 l/ha

Additives
0 Chemical only
1 Ethokem 2%
2 Ethokem C12 2%
3 Sulphate of Ammonia (S of A) 5%
4 Mixture B 2%
5 Mixture B 2% + S of A 5%
6 Ethokem C12 2% + S of A 5%

Site: Bebere, Nahavio site in 2 year old replanted palms. The site contained windrowed, dead palms over which *Pueraria* dominated. Circles around the young palms were clean but there were no inspection paths in the areas.

Methods: All treatments were applied using a Micron Herbi through a blue nozzle giving an application volume of 12-13 l/ha, at a walking speed of 1m/s. The chemicals were applied by one sprayer walking around the trees so that a 1.2m ring was sprayed outside the weeded circle. Percentage kill of *Pueraria* was assessed 20, 40, 60 and 90 D.A.T. Each assessment was scored on a 1-10 basis were 1= no kill, 10= 100% kill, and a note was made of species present in each plot.

Spraying took place on the 9th July, (Replicates 1, 2, 3) and 16 July, (Replicates 5 and 6). Both mornings were hot and dry with no rain for at least 4 hours after spraying.

Results: Ammonium sulphate and Ethokem C12 flocculated in conjunction with Garlon, so that these mixtures were abandoned.

20 D.A.T. it was apparent that ground vegetation was by no means uniform. In some plots *Cyrtococum, Centothecea* and wild taro were more abundant than *Pueraria* and difficult to kill. It was decided to reject assessments from plots which contained less than 70% *Pueraria*. Many plots were, therefore, excluded from the statistical analysis because the amount of *Pueraria* present was atypical. An unbalanced analysis of variance using adjusted mean scores was therefore computed. The results are given in Table 82. There was a negative linear effect of increasing rates of application on kill of *Pueraria* which became increasingly evident up to 60 D.A.T., that is, the least concentrated dose was the most effective at preventing regrowth in the long term. The latter did not extend beyond 60 D.A.T.. This would seem an illogical result unless it is reasoned that a low rate is more insidious in its effect on the cover crop, in which case it is concluded that low rates are to be preferred. However, the practical difficulties of spraying in this situation render economic control unlikely. No effect of additives was detected.

Table 82: Experiment 901d, Adjusted mean scores for herbicidal kill for three rates of Garlon, Bebere

RATE	DAT				
	20	40	60	90	Mean
0.25	8.12	6.25	3.71	1.58	4.91
0.50	7.52	5.58	3.47	1.40	4.49
1.00	7.00	5.00	2.66	1.47	4.03
F (linear)	3.88	8.00	14.41	0.24	11.03
1.5 d.f.	ns	P=<.01	P=<.001	ns	P=<.01
Residual m.s.	2.83	1.70	0.72	0.32	0.62

Experiment 901e: Pre-emergence herbicide and fertilizer nursery trial, Kapiura

Design: Weed control was assessed in the main plots of 6 replicates of completely randomised blocks. Each plot comprised 64 (approx. 31.5m²) polybag seedlings. In 3 replicates the plots were split equally into 8 sub plots in which a set of fertilizer treatments was randomised.

Treatments:

	Active ingredient (trade name)	Rate	Method of application
1	Oxyfluorofen (Goal)	1 l/ha	CDA
2.		2 l/ha	CDA
3.		2 l/ha	Knapsack
4.	Diuron	1 l/ha	CDA
5.		2 l/ha	CDA
6.		2 l/ha	Knapsack
7.	Ametriyn+Simazine (Gesatop Z)	1 l/ha	CDA
8.		2 l/ha	CDA
9.		2 l/ha	Knapsack
10.	Hand weeding		

Micron Herbis (yellow nozzles) were used for the C.D.A. treatments and Cooper Pegler C.P.3's for the knapsack application with VLV200 jets. 3 plots were not sprayed and were be used as a control in the measurement of phytotoxicity.

Site: Kapiura nursery. Seedlings in polybags planted in July 1986 approximately 0.77m apart. The site was hand weeded immediately prior to application.

Methods: The chemicals were applied on 15th October in the morning. Irrigation was not restarted until the following morning. Herbicides were to be resprayed when necessary.

Phytotoxicity would be assessed 84 D.A.T. and at the conclusion of the experiment from measurements of leaf production, petiole cross section and bole diameter taken from 24 seedlings in the three replicates assigned for fertilizer treatments.

This experiment was only in its preliminary stages at the end of 1986. Results of herbicidal effects up to 78 D.A.T. showed Gesatop to have been useless. Diuron and Goal had a similar effect and held back regrowth of weeds up to the end of the year. Goal was slightly better than Diuron. Goal controlled grasses best. Diuron was relatively weak against grasses and Gesatop particularly weak against *Euphorbiacious* weeds.

Experiment 901f: Use of weedwipers in kunai, Dami & Balabolo

Wick wipers are a relatively new but simple and robust tool for the application of herbicides. The hand-held versions are nylon wicks which soak up the herbicides by capillary action from a reservoir which doubles as a handle. They are designed to apply concentrated formulations of glyphosate based herbicides directly onto a target with minimum risk of operator contact. They leave a thin film of chemical on the leaves. This trial investigated the viability of one particular wick wiper with respect to one local weed problem.

Design: 4 replicates of completely randomised blocks. Plots were approximately 10m x 1-2m.

Treatments:

Applicator	Dosage (Round-up)	Additive	Rate of Additive
Herbi	2 l/ha	Sulphate of Ammonia	2%
Herbi	1 l/ha	Sulphate of Ammonia	2%
Wick wiper	1 + 2	Ethokem T25	1%
Wick wiper	1 + 3	Ethokem T25	1%
Wick wiper	1 + 3.5	Ethokem T25	1%
Wick wiper	1 + 4	Ethokem T25	1%
Wick wiper	1 + 3	Sulphate of Ammonia	2%

For weed wiper, dosage rates are described above as dilution rates; one part Round-up + *X* parts water. The wick wiper used was the 'Hortichem' (formerly Hectaspan) weed wiper Mini (double head).

Site: Replicates 1 to 3 were sited under cocoa at Dami, replicate 4 under coconuts on a plot in Balabolo village.

Methods: Treatments were assessed every 3 weeks. Kill was scored on a 1-10 basis (1 =no kill, 10 = 100% kill) and note taken of chlorosis. Scores were used only to assess an acceptable level of control. Comparisons between treatments were first made between those that achieved control and those that failed and then between features of ease of application, durability and safety, so that an overall assessment of treatments might be made.

Replicates 1 to 3 were treated on 3rd of September in the afternoon. Conditions were damp and cloudy but no heavy rain was recorded for at least 8 hours after application. Rep 4 was treated 9 days later on a hot, sunny, dry morning.

Results: 20 D.A.T. it was apparent that with the Herbi the chemical had not penetrated the canopy of kunai and that only the tips of the leaves were scorched. The kill from the weed wiper applications increased with strength of chemical, as expected. At this stage it was not possible to discriminate difference in kill between the 2 highest concentrations or within the scores for the other 3 concentrations. The results 84 D.A.T. are given in Table 83.

Table 83: Experiment 901f, Herbicidal effect of Round-up on *Imperator cylindrica*

TREATMENT	DAT 21	42	63	84	Mean
Herbi 2L/ha+SOA	1.5	2.5	4.0	4.5	13.5c
1L/ha+SOA	1.8	1.8	2.5	1.5	7.5d
					10.5b
Weedwiper 1:2+Ethokem T25	6.0	6.5	6.8	5.5	24.3a
1:3+Ethokem T25	4.8	6.0	5.3	4.0	20.0ab
1:3.5+Ethokem T25	4.5	5.0	5.5	4.8	18.5bc
1:4+Ethokem T25	4.0	4.5	4.8	5.2	19.8ab
					20.6a
Weedwiper 1:3+ SOA	2.5	3.5	3.8	2.0	11.8cd

Generally the Herbi gave poorer results than the weedwiper, but was better with a flow rate of 2L than 1L. It is not a suitable tool in tall kunai. The weedwiper gave best results with higher concentrations of Round-up (1:2 and 1:3). When S.O.A. was used as an additive Round-up gave especially poor results. This could have been because of the antagonistic effect of the fertilizer grade of this chemical as suggested earlier in this report. There was no treatment without Ethokem so whether or not this had any effect of its own could not be measured.

Observations about using this weedwiper are given below.

1. Weed wiping with the small, Hectaspan 'double' wiper was arduous and time consuming especially in this case where the weed was thick and tall.

2. The chemical on the weeds that have been wiped cannot be seen. The temptation, therefore, is to over wipe 'just to make sure'.

3. In use, the filling cap at the end of the handle of the wiper has to be open to prevent a vacuum forming in the tube. This is a potential hazard when the apparatus is not being used since the wiper should be stored head up. If weeds are tall the machine may be upside down at times and chemical run out onto the operator and non-target herbage.

4. Measurement of volume of liquid used for each small plot was impossible because small amounts were applied and measurements would be affected by factors such as drips and drying out of the wick. By recording volumes used to apply chemical over a half hour period an approximate volume (and therefore cost) applied in each treatment could be calculated.

5. The particular advantage of wick wipers is in spot weeding, especially where useful herbage surrounds a clump of weeds. Because the active ingredient is applied in such concentrated doses onto the target wipers may be especially useful in areas of high rainfall. It is a safer way of handling herbicides than by hand-wiping.

Experiment 901g: *Calapogonium caeruleum* control, Kumbango

This was a test of three herbicides and four additives to determine which combination warranted follow up trials to establish the optimum dilution for controlling *Calapogonium caeruleum*. On NBPOD plantations, Kumbango in particular, this leguminous cover crop had been considered a nuisance and trials on its control requested.

Design: 3 replicates of completely randomised blocks. Plots were 10m x 1.2m and selected for virtually uniform, exclusive cover by the target species.

Treatments:

	Herbicide		Additive
1.	Round-up @ 3 l/ha	1.	None
2.	2,4-D amine 2 l/ha	2.	Ethokem T25 @ 5%
3.	Round-up W 1 l/ha + 2,4-D @ 2L/ha	3.	S.O.A. (fertilizer
		4.	Mixture B @ 5%
5 & 6	Klinopine 3 l/ha (no additive)		

All factorial combinations of the first 3 herbicides and four additive treatments and two treatments with Klinopine were sprayed. Klinopine consists of a commercial mixture of 112g/l ametryn + 155g/l 2,4-D + 333g/l MSMA.

Percentage kill was measured 22, 34, 63, and 77 D.A.T. Results are given in Table 84. At the high rates kill was almost total and there were no significant differences for total score 77 D.A.T.. Initially 2,4-D was significantly slower to show its effect, as might be expected. With such a high level of kill there was little chance of assessing the effect of additives. Because 2,4-D worked well, is in general use and is relatively cheap it was decided to proceed to dilution trials with this herbicide (see Expt. 901i).

Table 84: Experiment 901g, Effects of herbicides on *Calapogonium caeruleum*, Kumbango

TREATMENT	Mean score D.A.T.					
	22	34	49	63	77	Mean
Herbicide						
2,4-D amine 2L/ha	9.9	9.4	9.2	8.0	6.4	8.6
Roundup 1L/ha+2,4-D 2L/ha	10.0	9.5	9.3	7.9	6.3	8.6
Klinopine 3L/ha	10.0	9.4	9.0	7.4	5.8	8.0
Roundup 3L/ha	9.9	9.1	8.6	6.8	5.3	8.3
Additive						
Nil	9.9	9.3	9.1	7.9	6.2	8.5
Ethokem T25 5%	9.9	9.3	9.1	7.4	6.2	8.4
Sulphate of ammonia 5%	9.9	9.3	9.2	7.7	6.3	8.5
Mixture B 5%	10.0	9.4	8.9	7.3	5.4	8.2

Experiment 901h: Control of *Merremia* spp, Kapiura

Two species, *Merremia peltata* and *Merremia pacifica* were of concern at Kapiura plantation. Instead of being suppressed by sown leguminous cover crop these aggressive weeds had sprouted profusely from cleared jungle and become dominant. A test of herbicides similar to that carried out on *Calapogium caeruleum* was therefore proposed.

The first trial, using similar treatments to Expt. 901g, was sprayed in November but destroyed accidentally by plantation workers a few days later. In view of the results of Expt. 901g and the good control of these jungle weeds obtained by the plantation with 2, 4-D, it was proposed to test only dilutions of 2,4-D on the creepers at juvenile and mature stages of growth during 1987.

Experiment 901i: *Calapogium caeruleum* 2,4-D dilution trial, Kumbango

Design: 6 replicates of randomised blocks. Plots were 10m x 1.2m strips.

Treatments: The following treatments were applied on 2nd December to uniform plots of almost pure *Calapogonium caeruleum* in oil palm. The few other weeds present were *Pueraria, Paspalum* and ferns.

	Herbicide	Rate
1.	2,4-D	1.75 l/ha
2.	"	1.5 l/ha
3.	"	1.25 l/ha
4.	"	1.0 l/ha
5.	"	0.75 l/ha
6.	"	0.5 l/ha
7.	"	1.5 l/h + SOA 5% (fertilizer grade)
8.	"	1 l/ha + SOA 5%
9.	"	0.5 l/ha + SOA

APPENDIX I

METEOROLOGICAL DATA

The Data presented below was made available by courtesy of NBPOD, Hargy Oil Palms Pty. Ltd., Higaturu Oil Palms Pty. Ltd., and Milne Bay Estates Pty. Ltd. Nationally accredited meteorological stations are sited near PNGOPRA's offices at Dami and Higaturu. PNGOPRA personnel continued recording at Higaturu during the year; the other stations were recorded by staff of the plantation companies.

Table 85: Rainfall (mm) all sites 1986

Plantation	Jan	Feb	March	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
W.N.B.P.													
Dami	596	566	229	629	285	140	43	25	175	176	155	197	3216
Bebere	768	394	231	488	294	160	106	50	207	118	198	372	3386
Kumbango	569	446	186	532	277	115	88	68	196	112	224	470	3282
Togulo	540	472	234	571	242	227	78	70	296	128	195	458	3512
Navarai	872	418	372	836	158	175	40	92	98	157	195	175	3590
Navo	485	422	-	598	217	233	226	121	292	815	977	669	-
Hargy	527	698	350	1266	620	239	323	243	60	108	474	1083	5991
ORO PROVINCE													
Arehe	203	315	148	435	134	225	64	180	44	123	306	184	2361
Ambogo	184	227	200	273	119	190	37	165	30	141	312	162	2040
Isavene	172	274	219	485	102	230	93	196	69	110	310	25	2496
MILNE BAY PROVINCE													
Hagita	211	202	313	269	103	180	106	89	56	85	87	184	1885

Table 87: Meteorological data, Higaturu, 1985

	Rainfall mm			Sunshine hrs			Rainy days		
	1985	1986	1981-86	1985	1986	1981-86	1985	1986	1981-86
January	196	203	222	152	101	158	21	17	16
February	223	315	280	89	145	125	21	20	13
March	272	148	326	145	171	162	23	10	19
April	178	435	248	189	174	171	15	22	19
May	232	134	197	154	222	167	21	11	15
June	192	225	184	120	134	139	16	19	16
July	65	64	71	177	184	157	11	10	10
August	141	180	130	194	187	174	14	13	14
September	203	44	126	180	196	178	20	6	13
October	365	123	236	230	180	177	13	19	17
November	366	306	262	139	168	181	25	18	16
December	371	184	312	171	191	157	16	18	18
Total	2803	2361	2598	1938	2055	1948	216	183	195

Table 86: Rainfall (mm), Hargy 1985

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
1985	550	610	1460	345	1620	383	467	368	248	218	1199	1620	9088
1986	527	698	350	1266	620	239	323	243	60	108	474	1083	5991
Mean 1981-86	523	603	737	484	475	253	362	277	219	239	406	862	5461

Table 87: Meteorological Data, Dami, 1986

	Rainfall mm			Sunshine hrs			Temperature °C		Rainy days	Sunshine hrs
			Mean			Mean	max	min		
	1985	1986	1970-86	1985	1986	1970-86	1986	1986	1986	1986
January	530	596	644	113	94	117	28.7	22.0	29	94
February	409	566	642	154	104	119	31.3	21.8	25	104
March	889	229	537	89	166	117	33.1	21.6	18	166
April	139	629	364	173	136	152	32.3	21.6	27	136
May	267	285	238	151	152	167	33.2	20.4	21	152
June	246	140	162	166	131	163	33.4	21.6	18	131
July	205	43	181	144	115	156	32.8	21.5	14	115
August	126	25	150	151	196	176	33.8	21.0	8	196
September	247	175	178	179	128	184	33.8	19.2	15	128
October	181	176	164	164	200	181	34.7	20.2	9	200
November	454	155	254	126	162	174	34.3	22.0	19	162
December	386	197	363	126	153	130	35.0	19.4	19	153
Total	4079	3218	3877	1735	1737	1839	-	-	222	1737

APPENDIX II

THE ASSOCIATION'S ACCOUNTS FOR 1986

Auditor's Report to the Members of the Papua New Guinea Oil Palm Research Association Inc.

In our opinion the attached balance sheet, income and expenditure account and the accompanying notes thereon as set out are drawn up so as to give a true and fair view of the state of the affairs of the Association as at 31st December 1986 and of its income and expenditure for the period ended on that date.

Price Waterhouse
Chartered Accountants
Lae, 27th March, 1987

Balance sheet as at 31st December, 1986

	KINA
Accumulated funds	179,533
Represented by:	
FIXED ASSETS	45,884
CURRENT ASSETS:	
Cash at bank and on hand	149,330
Debtors	78,652
	227,982
CURRENT LIABILITIES:	
Trade Creditors	39,007
Other Creditors and Accruals	55,326
	94,333
Net Current Assets/Liabilities	133,649
	179,533

Statement of Income and Expenditure for the year ended 31st December 1986

INCOME:	KINA
FFB Levy	447,462
Profit on Disposal of Fixed Assets	2,700
Interest received	5,458
Government grant received	116,000
	571,620
EXPENDITURE:	
Agency, Audit, Legal and Professional fees	17,819
Bank charges	1,379
Depreciation	21,514
Direct experiment costs	99,601
Electricity, water and gas	19,951
Insurance	5,875
Laboratory	620
Medical	2,664
Motor Vehicles	20,271
Office expenses	11,579
Rentals and other accommodation costs	51,045
Repair and Maintenance - buildings	13,869
Salaries, wages and allowances	186,654
Staff recruitment	-
Staff training	3,082
Travel and entertainment	11,192
Loss on disposal of fixed assets	-
	467,115
SURPLUS FOR THE YEAR	104,505
ACCUMULATED FUNDS 1ST JANUARY	75,028
ACCUMULATED FUNDS 31ST DECEMBER	179,533

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 on 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 10% per annum
Motor vehicles 33.33% per annum

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

FIXED ASSETS

	KINA
Household and office furniture at cost....................	44,550
Less accumulated depreciation.............................	15,455
	29,095
Motor vehicles at cost....................................	54,330
Less accumulated depreciation.............................	37,541
	16,789
Total written down values.................................	45,884

CAPITAL COMMITMENT

Capital expenditure authorised and contracted for totalled K8,900

MANAGEMENT BOARD'S STATEMENT

We, F.E. McGuire and J.R. Gilbert, being two members of the Management Board of the Papua New Guinea Oil Palm Research Association 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 as at 31st December, 1986 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.

SECRETARY'S STATEMENT

I, John F.W. Benn, Secretary of the Papua New Guinea Oil Palm Research Association do hereby state that the accompanying balance sheet and statement of income and expenditure are to the best of my knowledge, drawn up as to exhibit a true and fair view of the state of affairs of the Association as at 31st December, 1986 and of the results for the period ended on that date.

Lae,
March 1987

APPENDIX III

LIST OF INVESTIGATIONS

Number	Title	Initiated	Concluded
NUTRITION			
101	Bebere fertilizer trial	1968	1982
102	Dami density/fertilizer trial	1970	
103	Kumbango sources of potash trial	1976	1982
104	Bebere thinning trial	1978	1984
105	Bebere thinning trial	1979	1984
106	Bebere replanting establishment trial	1982	
107	Bebere replanting fertilizer trial	1982	
108	Kumbango mature palm nitrogen/anion systematic trial	1985	
109a	Bebere Div.II factory-waste manurial trial	1984	
109b	Bebere Div.I factory-waste manurial trial	1985	
110	Bebere nitrogen/anion trial on young replanted palms	1984/85	
111	Malalimi nitrogen and phosphate fertilizer trial	1985	
112	Buvussi nitrogen & phosphate fertilizer trial	1985	
113	Smallholders' nitrogen fertilizer and food cropping demonstrations on replanted palms W.N.B.P.	1985	
114	Togulo discoloured fronds investigation	1985	
201	Hargy fertilizer trial	1982	
202	Hargy refuse manurial trial	1984	
203	Navo effect of establishment phosphate	1986	
305	Arehe fertilizer factorial experiment	1981	
306	Ambogo fertilizer factorial experiment	1983	
307	Smallholders' fertilizer trial, Oro Province	1984	
308	Arehe mill effluent manurial trial	1985	
309	Ambogo bunch refuse manurial trial	1984	
310	Ambogo fertilizer frequency and anion trial	1986	
401	Kapiura fertilizer trial	1986/89	
501	Hagita establishment fertilizer trial	1986	
502	Hagita fertilizer trial	1986/89	
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	Study of female inflorescence characteristics in relation to pollination and fruitset	1985	

704	Soil moisture relations project	1985	1985
705	Arehe clone and density trial	1986	
706	Continuous flowering censuses	1981	
707	Continuous vegetative growth study	1980	
708	Continuous leaf nutrient study	1981	

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	First weed control project		
901a	Kumbango mixed grasses control	1986	1986
901b	Bebere mixed weeds control	1986	1986
901c	Ponini mixed weeds control	1986	1986
901d	Bebere, control of Pueraria ingress	1986	1986
901e	Kapiura, pre-emergence herbicide and fertilizer nursery trial	1986	
901f	Dami use of weedwipers in kunai	1986	
901g	Kumbango *Calapogonium caeruleum* control	1986	1986
901h	Kapiura *Ipomaea* spp. control	1986	
901i	Kumbango *Calapogonium caeruleum* 2,4-D dilution trial	1986	

APPENDIX IV

LITERATURE CITED

GENTY,P., GARZON, A., LUCCHINI,F., and DELVARE,D.,(1986). Polonizacion entomofila de la palma africana en America tropical. Oleagineux, 41, 3, 99-112.

VAN HEEL,W.A., BRUERE,C.J., MENENDEZ,T, (1987). The early development of inflorescences and flowers of the oil palm (Elaeis guineensis Jacq) seen through the scanning electron microscope. Blumea, 32, 67-78.

MENENDEZ,T. (1987). The results of oil palm thinning experiments in West New Britain. Proceedings of the 1987 International Oil palm Conference (in press).

PRIOR,R.N.B. (1987). Insect pests of oil palm in Papua New Guinea and their control. Proceedings of the 1987 International Oil Palm Conference (in press).

APPENDIX V

ADDRESSES

ATHERTON, R.L.,
P.N.G.O.P.R.A.,
c/o Higaturu Oil Palms Pty Ltd.,
P.O.Box 28,
Popondetta,
Oro Province,
Papua New Guinea.

BENN, J.F.W.,
Harrisons and Crosfield (PNG) Ltd.,
P.O.Box 586,
Lae,
Morobe Province,
Papua New Guinea.

BENTON, A.,
Higaturu Oil Palms Pty Ltd.,
P.O.Box 28,
Popondetta,
Oro Province,
Papua New Guinea.

CHRISTENSEN, J.,
Department of Primary Industry,
P.O.Box 417,
Konedobu,
National Capital District,
Papua New Guinea.

DOERY, R.,
Department of Primary Industry,
P.O.Box 417,
Konedobu,
National Capital District,
Papua New Guinea.

FLEMING, T.,
Harrisons Fleming Advisory Services Ltd.,
1-4 Great Tower Street,
London, EC3R 5AB,
United Kingdom.

GILBERT, J.R.,
Harrisons and Crosfield (PNG) Ltd.,
P.O.Box 586,
Lae,
Morobe Province,
Papua New Guinea.

GILLBANKS, R.A.,
New Guinea Plantations Ltd.,
P.O.Box 1131,
Rabaul,
East New Britain Province,
Papua New Guinea.

HANSON, N.,
Milne Bay Estates Pty Ltd.,
P.O.Box 36,
Alotau,
Milne Bay Province,
Papua New Guinea.

HARRIES, H.C.,
New Britain Palm Oil Development Ltd.,
Oil Palm Research Station,
P.O.Box 165,
Kimbe,
West New Britain Province,
Papua New Guinea.

McGUIRE, F.E.,
Higaturu Oil Palms Pty Ltd.,
P.O.Box 28,
Popondetta,
Oro Province,
Papua New Guinea.

MENENDEZ, T.,
Papua New Guinea OIl Palm Research Association,
P.O.Box 97,
Kimbe,
West New Britain Province,
Papua New Guinea.

PIGGOTT, J.,
1 St.Marks,
Brunswick Place,
Dawlish,
Devonshire,
United Kingdom.

PRIOR, R.N.B.,
Papua New Guinea Oil Palm Research Association,
P.O.Box 97,
Kimbe,
West New Britain Province,
Papua New Guinea.

ROSENQUIST, E.A.,
Oaktree House,
Hare Lane,
Little Kingshill,
Great Missenden,
Buckinghamshire, HP16 OEE,
United Kingdom.

SHEARER, M.,
Cranfield Institute of Technology,
Bedford,
Bedfordshire,MK43 OAL,
United Kingdom.

VAN der LAAN, N.,
Hargy Oil Palms Pty Ltd.,
P.O.Box 21,
Bialla,
West New Britain Province,
Papua New Guinea.

VUGHTS-HOVERS, M.,
Papua New Guinea Oil Palm Research Association,
P.O.Box 97,
Kimbe,
West New Britain Province,
Papua New Guinea.

VUGHTS,J.A.,
New Britain Palm Oil Development Ltd.,
P.O. Kimbe,
West New Britain,
Papua New Guinea.