ANNUAL REPORT

OF

THE PAPUA NEW GUINEA
OIL PALM RESEARCH ASSOCIATION

1985

FIFTH ANNUAL REPORT

of the

PAPUA NEW GUINEA OIL PALM RESEARCH ASSOCIATION

1985

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MANAGEMENT BOARD

CHAIRMAN	R.A. Gillbanks.
NEW BRITAIN PALM OIL DEVELOPMENT LTD.	R.A. Gillbanks.
DEPARTMENT OF PRIMARY INDUSTRY	R. Doery. (alternate to Secretary, DPI)
HARGY OIL PALMS PTY. LTD.	N. van der Laan.
HIGATURU OIL PALMS PTY. LTD.	F.E. McGuire.
DIRECTOR OF RESEARCH	T. Menendez.

In attendance

MANAGING AGENTS REPRESENTATIVE AND SECRETARY	J.F.W. Benn.

SCIENTIFIC ADVISORY BOARD

as at 18th October, 1985

R.A. GILLBANKS (Chairman)	Chairman, PNGOPRA.
R. DOERY	Department of Primary Industry.
G. WATSON	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

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

EXECUTIVE STAFF

DIRECTOR OF RESEARCH	T. Menendez, B.Sc., DPB., M.I. Biol.
AGRONOMIST	Ir. F.C.T. Guiking. (until May)
	Ir. M. Vugts-Hovers. (from February)
SOILS AGRONOMIST (Higaturu)	R.L. Atherton, B.Sc. (from July)
ASSISTANT AGRONOMIST	P. Navus, B.Ag. Sc. (Higaturu to August Dami afterwards)
RESEARCH ASSISTANT	P. Sereva, B.Ag. Sc.
ENTOMOLOGIST[1]	R.N.B. Prior, M.Sc.
PATHOLOGIST[2]	P. Jollands, Ph.D. (until December)

NON-EXECUTIVE STAFF

PRIVATE SECRETARY	C. Pa'Agau
SENIOR TECHNICAL ASSISTANT	S. Embupa
TECHNICAL ASSISTANT	D. Tomare (Higaturu)
SUPERVISORS	M. Furigi (Deceased May)
	B. Rimandai (from August)
	D. Yapasi (Higaturu, from April)
JUNIOR SUPERVISOR	K. Kula (Aug. to Oct.)
SENIOR FIELD ASSISTANT	J. Nagi (Hargy)
RECORDS CLERK	C. Golu
SENIOR RESEARCH RECORDER	B. Lukara
RESEARCH RECORDER	P. Sio (Bebere)
RECORDERS	J. Dapo
	S. Makai
	W. Kanama (Higaturu)
	G. Betari (Higaturu)
	G. Bonga (Higaturu)
	M. Yaura (Higaturu)
	P. Lus
	A. Poka (from March)
(Clerical)	B. Bubu
	I. Duna (Higaturu)
	P. Tarau (until August)
DRIVERS/HANDYMEN	K. Duke
	E. Luscombe (Higaturu, from October)

1. on attachment from Department of Primary Industry
2. on part-time services from Cocoa Industry Company Ltd.

CHAIRMAN'S STATEMENT

The year 1985 was one of expansion for the palm oil industry in Papua New Guinea, not only did the three existing nucleus estate and smallholder companies continue their planned expansion but two new projects commenced planting, at Kapiura in West New Britain and at Milne Bay, and a third was indicated as likely to proceed at Numundo near Kimbe. As the industry expands and moves into new areas and new phases (such as replanting) so does the need for research to keep the industry abreast of technical development.

During the year, the price of palm oil products continued to decline significantly, the challenge of lower prices gives emphasis to the need to find the most cost efficient production modes to ensure that the competative edge, which the industry now has, is preserved into the future. The industry has been funding its own research with entomological staffing assistance from the National Government. It is understood that long-awaited provision for direct research assistance has now been included in the National Budget and it is hoped that this, combined with the continuation of the research levy on fruit production (currently K0.80 per tonne) will allow expansion of the research effort into new areas of need.

Areas needing greater inputs include nutrition in West New Britain and elsewhere and fruitset, especially in the Popondetta region. An extensive series of fertilizer and organic waste trials is in place or planned, whilst further study of Elaeidobius kamerunicus continues and a possible backup pollinator for dryer areas, Mystrops costaricensis pacificus is being studied with a view to possible introduction. Trials and demonstration plots are established in smallholder palms, but there remains a need for further investigation of farming systems among the oil palm growers with a view to improving their production and overall economic status.

I am most grateful to the Director of Research and his staff for their efforts during the year and also to the Managing Agents for their backup services. I note, with regret, the departure of Dr. Phillipa Jollands whose services were shared with the Cocoa Industry Company and whose leaving has effectively brought our pathological studies to an end for the time being. I also note the departure of Theo Guiking, our well-liked agronomist and his family from Dami. Our best wishes go with them. We welcome Marita Vugts-Hovers as agronomist at Dami and Richard Atherton as agronomist at the Popondetta substation.

Finally, having chaired the Association since its formative days, the time has come to say goodbye, or perhaps au revoir. PNGOPRA has led the way in industry-based research in P.N.G. It will undoubtedly go on to achieve an international reputation, I wish you all success. I would like to take this opportunity to express my thanks to the chief executives and principals of all three founder companies, NBPOD Ltd., Hargy Oil Palms Pty. Ltd. and Higaturu Oil Palms Pty. Ltd. for their enthusiastic co-operation and support over the years, without which the Association would have been stillborn.

Em tasol. Bai yu stap gut.

R.A. Gillbanks M.B.E.

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

MANAGEMENT BOARD AND SCIENTIFIC ADVISORY BOARD

The Management Board met twice, at Lae on 7-8th March and at Higaturu Oil Palms Pty. Ltd. on 18th October. The Fourth Annual General Meeting of the Association was held in Lae on 8th March. At this meeting Mr. R.A. Gillbanks was once again elected as Chairman and Messrs. Harrisons and Crosfield (PNG) Ltd were re-appointed as Managing Agents for the coming year. Mr. N. Hanson, Milne Bay Estates Pty. Ltd. was welcomed as newcomer but otherwise membership of the Board did not change from the previous year.

As usual the Scientific Advisory Board held one meeting, on this occasion at Higaturu Oil Palms Pty. Ltd. on 18th October which was preceded the day before by a trip to trials in the field on the estate and adjacent oil palm blocks of the Popondetta Agricultural Training Institute. There were some changes to the membership of this Board, Dr. G.A. Watson representing Higaturu Oil Palms Pty. Ltd. and Mr. N. van der Laan, Hargy Oil Palms Pty. Ltd. in place of Mr. J. Piggott and Dr. Guha respectively. Amongst those attending this meeting were also personnel from the member companies and Mr. E.A. Rosenquist of Harrisons Fleming Advisory Services Ltd. without whom there would have been a regrettable void and lapse of continuity. Unfortunately, much in the way of individual technical discussion before the meeting was impracticable but the Soils Agronomist in Oro Province was able to spend useful time with Dr. Watson before members flew in from most points of the compass. It was planned to meet in Dami in West New Britain Province in 1986.

FINANCE

Income from the levy from growers of 80 toea per ton 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 minimised 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

The Association experienced changing fortunes with its staff after a relatively stable four years. Mr. Guiking resigned in May to assume an interesting appointment at the University of Wageningen in Holland. It was a pity to lose him just when his experience was begining to fructify but we wish him a happy and successful continuation of his career in Holland. At the start of his career, Mr. R.L. Atherton was appointed in June. A graduate of the Soils Department of the University of Reading he had experience overseas in East Africa in connection with a Commonwealth Development Corporation project. He was placed in charge of PNGOPRA's expanding work in Oro Province. Mr. Navus was then able to return from Higaturu to Dami where his work has been directed to smallholder related problems. An additional agronomist was appointed in May when Mrs. M. Vugts-Hovers took over nutritional trials in West New Britain. Dr. Jollands whose work with the Cocoa Industry Company had been shared with PNGOPRA resigned her post and in December went back to the United Kingdom with her husband and young family. Losing her professional expertise will reduce the pathological research that can be undertaken. It is fortunate in this respect that no major disease problems have developed in Papua New Guinea. Our best wishes go to her and her husband in their new venture also. Mr. P. Sereva's appointment was confirmed as Research Assistant in October.

Amongst the non-executive staff the sevices of Morris Furigi, Supervisor at Dami, were lost as a result of a tragic and fatal road accident in May. It was some time before a successor could be found. Balib Rimandai joined PNGOPRA from the Department of Primary Industry. He had been working for seven years as a Rural Development Technician on smallholder subdivisions of the West Nakanai oil palm scheme. A supervisor, D. Yapasi was appointed at Oro Province to increase the staff there and assist the newly appointed agronomist. A driver, E. Luscombe was also appointed. P. Taru, records clerk, resigned but was not replaced. A new recorder, A. Poka, trained at the Ponini Agricultural Centre in West New Britain was appointed at Dami. K. Kula was appointed as junior supervisor at Dami but left after 2 months and was not replaced.

Mid-year salary increments were awarded as appropriate to all staff. Non-executive staff also received a revision of wages in March to meet increases in the cost of living.

For the first time an overseas student was accommodated so that short-term research outside the professional sphere of existing staff could be completed. This would also provide practical study and experience for the student. Mr. Waringa from the University of Wageningen spent 6 months at Dami working on soil moisture retention and crop evapotranspiration. A successful conclusion to this exercise in 1985 has encouraged similar arrangements to be pursued next year.

The distribution and establishment of staff during 1985 and recommendations for 1986 were as follows.

Post	Base	Filled as at 31/12/84	Filled as at 31/12/85	Recommended 1986
Director of Research	Dami	1	1	1
Agronomists	Dami	1	1	1
	Higaturu	0	1	1
Assistant Agronomists	Dami	1	1	2
Research Assistants	Dami	1	1	1
Pathologist	Kerevat	1	0	0
Entomologist	Dami	1	1	1
	Totals	6	6	7
Private Secretary	Dami	1	1	1
Clerks	Dami	1	1	1
Recorders (clerical)	Dami	2	1	1
	Higaturu	1	1	1
Driver/handyman	Dami	1	1	1
	Higaturu	0	1	1
Supervisors	Dami	1	1	1
	Higaturu	0	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	0	1	1
	Higaturu	0	0	1
Recorders	Dami	5	6	6
	Higaturu	4	4	4
	Totals	19	22	23

TOURS AND VISITS

For most staff it was a quiet, rather insular year. Whilst on leave the Director of Research conducted interviews in London for the post of agronomist, visited C.J. Breure at Renkum and Dr. Van Heel at the Rijks Herbarium at Leiden in Holland to discuss and co-ordinate mutual research. The Senior Entomologist combined furlough with an interesting tour of occidental and oriental oil palm developments in Colombia and Ecuador to appraise entomophilous pollination and fruit set of local oil palm.

In Papua New Guinea, executive staff visited between the stations where the Association was at work. Agronomists from Dami visited Hargy Oil Palms on three occasions, Higaturu Oil Palms once, and, from Higaturu, Milne Bay Estates once. The Senior Entomologist went to Oro Province four times, spending a fortnight there on one occasion and he also visited oil palm blocks at Kavieng and New Hanover and the Entomological Division of the Department of Primary Industry's Headquarters at Konedobu. The Soils Agronomist also visited the Land Resources Divisions and Soils Laboratory of the Department of Primary Industry in Port Moresby and, before assuming duty at Higaturu, spent his first three weeks at Dami which the Pathologist visited from Kerevat on two occasions. The peregrinations of the Director of Research involved visits to Oro Province, Milne Bay Estates, Port Moresby (once each), Lae (four times). The Agronomist and Entomologist in addition to the foregoing also visited Higaturu Oil Palms together when the Scientific Advisory Board held its meeting there.

PUBLICATIONS AND REPORTS.

An invited paper entitled "The Agricultural Use of Oil Palm Factory Waste Products in Papua New Guinea" was presented by the Director of Research at a Seminar on Management and Utilization of Wastes in Papua New Guinea sponsored by UNESCO and held at the University of Technology, Lae in September.

The PNGOPRA Advisory Leaflet No. 1 "Fertilizer Use in Replanted Oil Palm in West New Britain" based upon assets from Experiment 106 was published in September.

The Fourth Annual Report was prepared for publication and circulated but publication was delayed at the printers until June the following year. Alternative, more convenient, if less professionally finished printing is being tried this year. Four quarterly, technical progress reports were circulated to members and their technical advisors. Ten confidential, monthly reports were sent to the Managing Agents.

Occasional technical reports and reports on visits to Popondetta, Bialla and Dami (from Kerevat) were circulated appropriately. Regular entomological reports were copied to the Chief Entomologist of the Department of Primary Industry and their other senior entomologists.

A report submitted towards completion of the degree of Ingenieur was circulated and submitted to the University of Wageningen by N. Waringa. It was entitled "Soil Moisture and Climate in the West New Britain Area".

LIBRARY

This was maintained and administered by NBPOD at Dami, with some support and subscriptions from PNGOPRA.

VISITORS

The following visitors were recorded at the Directorate of Research (with apologies to those who escaped the recording system):

C. Blank, University of Florida, Gainsville, U.S.A.; P.A.C. Ooi, Commonwealth Institute of Biological Control, CPB Project, Batu Tiga, Malaysia; J.D. Menneer, Harrisons and Crosfield (PNG) Ltd, Lae; B. Vari, Department of Primary Industry, Konedobu; T. Kepui, Department of Primary Industry, Konedobu; W. Gore, Department of Primary Industry, Bialla; A.J. Barnes, Department of Primary Industry, Kimbe; C.C. Goldethorpe, Harrisons Fleming Advisory Services Ltd., London, U.K.; P. Newell, Price Waterhouse, Lae; A. Brownlie, I.C.I., Lae; P. Gunton, Harrisons and Crosfield PLC, London, U.K.; R.L. Namaliu, Minister for Primary Industry, P.N.G.; Brown Bai, Secretary, Department of Primary Industry, Konedobu; A. Nuli, Provincial Minister for Primary Industry, Kimbe; B. Kuamia, Ministry of Primary Industry, Konedobu; J.R. Leach, Harrisons Fleming Advisory Services Ltd., London, U.K.; P.B. Brown, Hassau and Associates, Canberra, Australia; G. Mosusu, Department of Primary Industry, Konedobu; R. Arnison, Hassau and Associates, Canberra, Australia; T.S. Tali, Agricultural Bank, Kimbe; A. Ngo, Agricultural Bank, Port Moresby; C.D. Jeffes, Koban Plantation, NBPOD, Banz; A.M. Gurnah, Department of Agriculture, University of Technology, Lae; G. Burton, Analytical Services Ltd., Cambridge, New Zealand; R. Orr, Analytical Services Ltd., Cambridge, New Zealand; Hew Choy Kean, Planter (M) Sdn, Bhd, Petaling Jaya, Malaysia; J. McGregor, PNG Analytical Laboratories, Lae; R.L. Atherton, Papua New Guinea Oil Palm Research Association, Popondetta; A. Kabaara, Coffee Research Institute, Aiyura; P. Harding, Coffee Research Institute, Aiyura; Aman Ng, Wingon Centre, Hong Kong; M.B. Wilson, Harcros Trading (PNG) Ltd., Kimbe; A. Hartley, Woller Bay; D. Willis, Waterford West, Queensland, Australia; D. Kivung, University of Technology, Lae; Kuldeep Singh, BA, Fiji Islands; Kaveing a Fa'anunu, Forestry Department, Fiji Islands; G. Vatasan, University of Technology, Lae; H. McKeag, Harrisons and Crosfield PLC, London, U.K.; R. James, Farmset, Rabaul; M. Benjamin, Walindi Plantation, West New Britain Province; G. Nau, Wards Aircargo, Port Moresby; Y. Salley, Harrisons and Crosfield (PNG) Ltd, Lae; M. Aruma, Bubia Agricultural Research Centre, Lae; C.J. Breure, Harrisons Fleming Advisory Services Ltd., London, U.K.; E.A. Rosenquist, Harrisons Fleming Advisory Services Ltd., London, U.K.; D. Friend, Pamol Plantations, Sdn. Bhd., Sandakan, Sabah; T. Breckner, Asian Development Bank, Manila, Philippines; K. Kulawarathrasan, Asian Development Bank, Manila, Philippines.

PHYSICAL DEVELOPMENT

Buildings

Revamping the rented offices at Dami commenced in December to plans prepared by the Director of Research. To do this the buildings had to be vacated the month previously and a disrupted period of boxing and coxing ensued for the next three months while work proceeded. Space was found temporarily for OPRA staff in NBPOD Chief Agronomist's office (while he was on leave) and in a small but cosy building previously used by them as a laboratory.

Reorganisation of other buildings at Dami enabled a much more convenient set of storerooms to be allocated to PNGOPRA.

When Mr. Navus returned to Dami he took over the quarters previously allocated to Mr. Guiking. Mr. Atherton moved into one half of a duplex on Higaturu Oil Palms.

The allocation of rented buildings is shown below.

	31/12/84	31/12/85
N.B.P.O.D.		
Offices and laboratory (rooms)	7	7
Entomological building	1	1
Storerooms	2	4
'M' houses	1	1
'A' houses	2	2
'AR' houses	1	1
'IB' houses	2	3
Junior Grade quarters (1 at Bebere)	7	7
Double labour quarter	0	1
Girls' quarters	1	0
Single man's quarters	0	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 House	1	0
Executive Duplex	0	1
Supervisors quarters	0	2
Bossboi quarters	1	1
IM quarters	1	1
Labour quarters	1	2

Vehicles

One of the fleet was changed, the worn out two-wheel drive utility in Oro Province being replaced with a four wheel drive model. All were kept in good running condition throughout. The body work of the Hi-Ace Commuter was nearing the end of its useful life and it was appropriate that it would be replaced early in 1986. A short wheel base truck with a canopy and side bench seats was budgetted for this. The work vehicles are listed below:

Vehicle	Reg. No	Customary user	Date Purchased	Km Run to 31/12/85
Hilux 2 WD single cab utility	ADT 834	Asst. Agron. (Higaturu)	May1982	83,831
Hi-Ace Commuter	AEA 691	Driver/ handyman	March 1983	96,747
Hilux 4 WD twin-cab utility	AEJ 558	Director of Research	Nov. 1983	33,708
Hilux 2 WD single-cab utility	AEJ 601	Entomologist	Dec. 1983	50,890
Hilux 4 WD single-cab utility	AEJ 621	Agronomist	Jan. 1984	46,548
Hilux 4 WD single-cab utility	AEQ 283	Agronomist (Higaturu)	March 1985	33,114

Conditional allowances were paid to executive staff to run private vehicles and two cars and one motorcycle were involved at the year's end. Allowances were also paid to non-executive staff to operate motorcycles for their work which had been bought on tied loans from PNGOPRA. Repayment was complete on one of these and continuing on three at the end of the year.

Equipment

All existing laboratory and office equipment functioned satisfactorily throughout the year. A second Hewlett Packard 41CX with card reader, statistics and mathematics packs was purchased.

A computer was delivered in mid year but was returned as unservicable after a frustrating introduction to its shortcomings. The object is to computerise storage, processing and statistical analysis of all experimental data instead of the current manual operations and use of calculators or the 41CX's and also to computerise the payroll and accounting. Until a person other than busy executive staff is available to set up and initiate the necessary systems, acquiring another and better computer will be postponed. Provision was made in the estimates to do this in 1986.

Additional air conditioners were ordered for the new office layout.

Services

A VHF line, giving a potential, full chorus of three incoming lines was installed by NBPOD at Dami. The land lines were connected through a PBX to a number of extensions of which four were allocated to PNGOPRA. NBPOD operated the switchboard. For the time being charges for calls were halved with NBPOD until a more precise monitoring system can be introduced. At Higaturu a telephone extension to the PNGOPRA office was needed but unavailable. Two new generators of greater capacity than the old were brought into use at Dami by NBPOD at the end of the year. Piped water continued to be poorly supplied but major work to install a new system was underway at Dami.

At Higaturu similar services were satisfactory throughout the year.

Company's Medical Services were available as usual. The Director of Research's wife required treatment in England (this coincided with furlough) and later in Australia all of which was well provided. Staff requiring treatment at local hospitals or clinics were transported as necessary.

The road to Bialla was breached by an earthquake and consequent washouts caused by rock slides and diversions to watercourses hindered access. The way was opened, more or less, to a four wheel drive vehicle later in the year, depending on the weather.

Communications between the Director of Research and Managing Agents were generally good but not with the substations because of poor telephonic, postal and aerial connections to Popondetta in particular. Telex machines at Higaturu, Lae, Mosa, Kimbe and Hargy were increasingly used and facsimile copiers installed at Higaturu, Lae and Mosa were especially useful to PNGOPRA and are likely to be used more in the future. PNGOPRA's volume of messages was not considered sufficient to justify its own telex or facsimile equipment however.

PART II. RESEARCH

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 have been applied twice yearly at rates increasing with age, according to the following schedule:

months from planting	kg fertilizer/palm										
	N			P		K			Mg		
	0	1	2	0	1	0	1	2	0	1	2
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 (exept for the last two applications as 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 K and Mg. Seedlings planted were either 16 or 24 months of age.

An atypically long drought immediately after planting checked growth and the application of nitrogen at 3 months was deliberately postponed by 3 months. The last fertilizer application was given in June.

Recording: Petiole cross section was measured every three months on frond 17. Yield recording commenced in December 1984.

Results: Petiole cross section measurements of the 1 and 2 year old seedlings showed varying trends between 1983 and 1985, as can be seen in Table 1.

Table 1: Experiment 106, Petiole cross section (cm^2) of 1 and 2 year old seedlings

AGE OF	1983			1984				1985			
PLANTED SEEDLING	May	Aug	Nov	Feb	May	Aug	Nov	Feb	May	Aug	Nov
1 YEAR	3.7	5.1	6.4	9.7	11.4	11.2	12.7	13.1	14.2	17.1	18.1
2 YEARS	3.5	4.4	5.7	8.4	9.7	10.8	12.4	12.9	13.5	15.0	16.0
DIFFERENCE	0.2**	0.7**	0.7**	1.3**	1.7**	0.4*	0.3	0.2	0.7**	2.1**	2.1**

significant at * 5%, ** 1%

Table 3: Experiment 106, Yield per hectare, December 1984 -December 1985

TREATMENT	AGE AT PLANTING						AVERAGE		
	1 year			2 years					
	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	3428	14.0	4.1	2679	14.2	5.3	3054 a	14.1	4.7 a
N1	3490	14.2	4.1	2870	14.5	5.1	3180 b(*)	14.3	4.6 b**
N2	3518	14.4	4.1	2959	14.3	4.8	3238 b	14.4	4.5 b
P0	3496	14.3	4.1	2787	14.1	5.1	3142	14.2	4.6
P1	3461	14.1	4.1	2884	14.5	5.1	3173	14.3	4.6
K/Mg0	3397	13.7	4.0	2839	13.7	4.8	3118	13.7 a	4.4 a
K/Mg1	3508	14.3	4.1	2842	14.5	5.1	3174	14.4 b*	4.6 b**
K/Mg2	3531	14.6	4.1	2826	14.8	5.2	3179	14.7 b	4.7 b
Average	3479 a	14.2	4.1 a	2836 b**	14.3	5.1 b**	3157	14.3	4.6

means with different letters differ
significantly at (*) 10%, * 5%, ** 1%

Table 4: Experiment 106, Effect of nitrogen and age of seedling on yield per hectare during 1985

		AGE AT PLANTING					
		1 year			2 years		
		No. of bunches	yield t/ha	s.b.w. kg	No. of bunches	yield t/ha	s.b.w. kg
Dec. 84-March 85	N0	734	2.8 a	3.8	241	1.1 a	4.5
	N1	951	3.5 b	3.7	378	1.7 b	4.4
	N2	1018	3.9 b	3.9	461	2.0 b	4.4
April-June	N0	1750	6.8 a	3.9	915	4.8 a	5.2
	N1	2017	7.7 b	3.8	1233	5.8 b	4.7
	N2	2104	8.3 c	3.9	1454	6.7 c	4.6
July-Sept.	N0	2717	10.6 a	3.9	1854	9.3 a	5.0
	N1	2894	11.3 b	3.9	2202	10.2 b	4.6
	N2	2962	11.8 b	4.0	2391	11.1 b	4.6
Oct.-Dec.	N0	3428	14.0	4.1	2679	14.2	5.3
	N1	3490	14.2	4.1	2870	14.5	5.1
	N2	3518	14.4	4.1	2959	14.3	4.8

means with the same letter do not differ significantly

By the beginning of 1985 the difference in vegetative growth favouring the younger seedlings was diminishing. From May onwards however it again diverged. The older seedlings were not as precocious and if the onset of production had the effect of retarding growth this would have occurred later in the older seedlings and have caused the variation in trends observed. Continued recording of yield and petiole cross section may show how these factors interact.

Effects of fertilizers on petiole cross section are shown in Table 2. Responses to nitrogen and potassium/magnesium found in 1984 appeared again in November 1985. Additional nitrogen had a statistically highly significant positive effect but there was no significant difference between level 1 and 2. A similar but only just statistically significant difference was found for K/Mg at both level 1 and 2. In 1984 the higher level only had effect.

Table 2: Experiment 106, Effect of fertilizers on petiole cross section, November 1985

TREATMENT	WxT cm^2	TREATMENT	WxT cm^2
N0	16.4a	K/Mg0	16.6 a
N1	17.2 b**	K/Mg1	17.3 b*
N2	17.6 b	K/Mg2	17.3 b

significant at * 5%, ** 1%

Production for 1985 is given in Tables 3 and 4. There was no significant response to nitrogen and to the age of seedling for most of the year in each case due to an increased number of bunches. In the last quarter however these effects disappeared because the increase in number of bunches was cancelled by a fall in single bunch weight. At the end of the year for the first time a response was found to potassium and magnesium which had been applied together in this trial. A similar response is now reported for Experiment 107 (q.v.).

The drought at the time of planting and the subsequent slow establishment of the cover crop have created a set of circumstances that can be extrapolated to other stress conditions, for example where maintenance is sub-standard and palms compete with weeds during their establishment. The early yield response to nitrogen of ± 1 ton FFB after 6 months would, if maintained, provide extra income when cashflow is low, shortly after the replant. Advisory leaflet No. 1 "Fertilizer use in Replanted Palms in West New Britain" was prepared on the basis of the results to mid 1985 as an interim recommendation for additional nitrogenous fertilizing. This may, however, be modified as more data is evaluated.

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: 3^2x2^3 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.

Treatments: Exept 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 (treatment "establishment N"). The other treatments commenced in February 1985. Half the

Table 5: Experiment 107, Yield per hectare for March - December 1985 (10 months)

TREATMENTS	No. of bunches	Wt. of bunches t	s.b.w. kg
N0	2369	9.9	4.1
N1	2421	10.2	4.2
N2	2373	10.0	4.2
P0	2369	10.0	4.2
P1	2342	9.8	4.2
P2	2452	10.2	4.2
K0	2336 a	9.7 a	4.2
K1	2439 b(*)	10.3 b *	4.2
Mg0	2347	9.6 a	4.1 a
Mg1	2429	10.3 b**	4.3 b**
- est. N	2386	9.9	4.2
+ est. N	2389	10.1	4.2
average	2388	10.0	4.2

significant at (*) 10%, * 5%, ** 1%

Table 6: Experiment 107, Yield per hectare of HBN and MSR progenies, March - December 1985

PROGENY HBN	No. of bunches	Wt. of bunches t	s.b.w. kg
1	2528	8.8	3.5
2	2349	9.5	4.0
3	2698	10.9	4.0
4	2391	9.5	4.0
5	2089	9.0	4.3
Mean	2411	9.5	3.9
MSR			
6	2468	10.5	4.3
7	2010	8.3	4.1
8	2151	7.2	3.4
9	2162	10.1	4.7
10	2561	12.7	5.0
11	2389	9.3	3.9
12	2948	11.4	3.9
13	2171	10.7	4.9
14	2376	11.2	4.7
15	2348	10.0	4.3
16	2513	10.5	4.2
Mean	2373	10.2	4.3

amounts are being applied twice yearly as follows:

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

Recording: Petiole cross section was measured every three months on frond 17. Yield recording started in March, 1985.

Results: Although a significant difference was found on petiole cross section, apparently associated with magnesium, this could not have been due to treatment, rather it was a reflection of chance pre-treatment differences.

Production during the first 10 months is given in Table 5. So far the palms of Expt. 107, unlike Expt. 106, have not shown a response to nitrogen (neither the establishment nitrogen, nor the nitrogen applied since February 1985). Expt. 107 however was established under much better weather conditions. The yield data on the other hand did show a statistically significant effect with potassium and magnesium. In so far as potassium was associated with an increased number of bunches it is unlikely this was a true effect because potassium fertilizer was first applied in February. In the case of magnesium, the yield increase was due to increased single bunch weight which might be due to the treatment.

In Tables 6 and 7 yield and petiole cross section data of HBN and MSR progenies are given.

Table 7: Experiment 107, Petiole cross section of HBN and MSR progenies (cm^2) Dec'84 - Sept'85

HBN	Dec.	March	June	Sept.
1	12.1	12.3	13.3	14.0
2	12.3	13.0	14.1	15.3
3	11.9	12.1	13.2	14.2
4	11.2	11.6	12.2	13.0
5	12.5	13.9	15.3	15.1
Mean	12.0	12.6	13.6	14.3
MSR				
6	13.5	14.8	16.5	17.1
7	11.3	12.4	13.7	15.0
8	11.8	12.4	13.7	14.2
9	12.0	12.5	13.5	14.1
10	11.9	12.9	14.4	14.9
11	11.7	12.5	14.6	15.1
12	9.9	10.8	11.5	12.1
13	12.5	13.7	15.4	15.1
14	12.9	13.7	16.5	16.4
15	11.4	12.0	13.8	14.2
16	12.0	12.7	13.8	14.2
Mean	11.9	12.8	14.3	14.8

Table 8: Experiment 108, Pre-treatment leaf nutrient level, July, 1985

	FIELD F		FIELD E	
PLOTS	1 - 16	17 - 32	33 - 48	49 - 64
nitrogen	2.2	2.0	2.2	2.1
phosphorous	0.14	0.14	0.14	0.14
potassium	0.96	1.06	1.04	0.95
magnesium	0.26	0.29	0.27	0.31
chloride	0.34	0.32	0.47	0.36
iron	64	63	73	59
manganese	64	64	63	64
zinc	23	23	27	24
copper	6	6	6	6
boron	15	17	16	18

Table 9: Experiment 108, Petiole cross section, July 1985

	plots	cm^2	s	cv	mean
Field F	1 - 16	41.7	1.85	4.44	39.6
	17 - 32	37.5	1.67	4.45	
Field E	33 - 48	43.2	3.12	7.22	41.4
	49 - 64	39.5	1.58	4.00	

Table 10: Experiment 108, Yield per hectare, August - December

AMMONIUMCHLORIDE kg/palm.year	No. of bunches	Wt. of bunches t	s.b.w. kg	Yield relative to level 0 %
0.0	272	5.0	18.4	100
0.9	310	5.5	17.7	109
1.8	311	5.6	18.0	112
2.7	281	4.9	17.6	99
3.6	302	5.5	18.2	110
4.5	348	6.2	17.8	123
5.4	321	5.9	18.5	118
6.3	322	5.8	18.0	116
DI-AMMONIUM PHOSPHATE kg/palm. year	**No. of bunches**	**Wt. of bunches t**	**s.b.w. kg**	**Yield relative to level 0 %**
0.0	345	6.0	17.5	100
1.2	361	6.3	17.4	104
2.4	373	7.2	19.2	119
3.6	331	5.7	17.3	95
4.8	389	6.9	17.7	114
6.0	418	7.0	16.7	116
7.2	378	6.4	17.0	107
8.4	388	6.5	16.8	108

Average t/ha per field:

F 1-16 : 6.1
F 17-32 : 5.9

E 33-48 : 5.0
E 49-64 : 7.1

EXPERIMENT 108, Systematic nitrogen fertilizer trial, Kumbango

This new experiment was initiated in 1985 in an area of Kumbango plantation which has shown a decreasing layer of topsoil over the last few years and yields had been falling. The site was planted in 1972 (seeds ex-Malaysia) 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. In order to counteract chance fertility gradients in the soils a set of levels (0-7) of each source is adjacent to a second set but with the direction of increase of dose in one set being opposite to the other. This arrangement was used in one block mulched with 30 ton/ha empty bunches in March '85 and repeated in an unmulched block. There is a total of 64 plots, each plot consisting of the two rows on either side of each harvesting path (twin-row) and on average comprised 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 are 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)

Recording: Leaf samples and petiole cross section measurements were taken in July. Yield recording started in August, when a system of counting and weighing total production from each twin-row rather than individual palms was adopted.

Results: Pre-treatment leaf nutrient levels are presented in Table 8. Levels for nitrogen, phosphorus and potassium were below the critical level, magnesium levels good and chloride moderate to good. Petiole cross section measurements revealed considerable variation between the blocks (Table 9). The data in Table 10 shows that production was indeed very low; annual yield is expected to be only about 15 ton/ha. It is premature to attempt to analyse trends thus far.

EXPERIMENT 109a, Mill waste useage experiment on young palms, Bebere

Planted in 1978 at 135 palms/ha; 1080 palms in total, 480 palms 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 mill effluent (POME) and munched bunches at the following rates.

		time of application
1.	nil	-
2.	nil	-
3.	raw effluent 500 l/palm	Oct/Nov '84 & Sept/Nov '85
4.	raw effluent 1000 l/palm	Oct/Nov '84 & Sept/Nov '85
5.	munched bunches + raw effluent 100t/ha	pending
6.	munched bunches 100t/ha	May - July '85

Table 11: Experiment 109a, Vegetative measurements in selected plots

	frond production 1/85 -1/86	leaf area m^2	leaf dry weight kg	WxT cm^2
nil plots	26.2	8.0	3.3	30.2
1000 l effluent plots	27.1	8.3	3.2	28.1

Table 12: Experiment 109a, Petiole cross section, May

TREATMENT PER PALM	May cm^2	difference compared to November '84
nil	28.6	2.7
nil	30.0	2.4
500 l	29.8	2.0
1000 l	28.1	2.9
munch bunch + POME*	29.2	2.3
munch bunch + POME*	29.1	2.5

* not yet applied at time of measurement

Table 13: Experiment 109a, Leaf nutrient levels in nil and high rate plots

	Nov '84		April '85		July '85		Sept '85		Nov '85	
	nil	1000 l	nil	1000 l	nil	1000 l	nil	1000 l	nil	1000 l
%										
nitrogen	2.6	2.6	2.6	2.6	2.5	2.5	2.5	2.5	2.7	2.5*
phosphorous	0.16	0.15	0.16	0.15	0.16	0.16	0.16	0.16	0.16	0.16
potassium	1.12	1.05	1.07	1.01	1.09	1.00	1.06	0.97**	1.07	1.03
calcium	0.93	0.96	0.97	0.93	0.92	0.98	0.93	0.97	0.91	0.89
magnesium	0.16	0.17	0.20	0.19	0.16	0.18	0.16	0.17	0.15	0.18(*)
chloride	0.10	0.14	0.15	0.16	0.11	0.18	0.12	0.17*	0.11	0.19*
ppm										
iron	56	58	63	59	62	59	63	62	52	54
manganese	40	42	35	33	38	43	34	40(*)	36	41
zinc	20	21	21	19	24	23	23	23	23	21
copper	5	5	5	5	6	6	6	6	5	5
boron	14	16	12	12	15	16	15	17	13	12

significant at (*) 10%, * 5%, ** 1%

Table 14: Experiment 109a, pH levels in selected plots, August 1985

	TREATMENT	
	500 l	1000 l effluent/palm
control	6.6	6.8
treated	6.4	6.5

Munched bunches are the result of passing empty bunches from the conveyor at the factory through a Mono-muncher which macerates them to an amorphous, fibrous mass. Treatment 5 was changed for practical reasons from 500 l raw effluent per palm + 100t munched bunches per ha mentioned in the Annual Report for 1984 to 100 ton per ha of a mixture made up of 22 ton raw effluent + 70 ton munched bunches. Effluent is applied annually and the other treatments once.

Recording: The following vegetative measurements were made: frond production, leaf area and petiole cross section. Leaf samples were taken in selected plots every 3 months and over the whole experiment in July.

The acidity of the effluent and its effect on the soil was measured by taking soil samples at a depth of 5 - 15cm from 4 sites affected by effluent and 4 adjacent sites not affected by effluent in each treated plot. In all plots pH then was determined in the laboratory using a pH meter. Differences were tested by a paired "t" test.

Yield recording commenced in March '84 before treatments started and was continued in 1985.

A start was made to assess the ground flora in selected plots over all 5 replicates scoring cover crops, grasses and broad leaved weeds and ferns as numerous, occasional or rare and which pre-dominated.

Results: Data in Table 11 show that frond production in the high rate plots is slightly greater than in the nil plots. The low figure for petiole cross section is caused by variation between palms, not to treatments. Table 12 shows relative growth of the petiole cross section since November 1984: it was highest for the 1000 l plots. The May measurements did not show a significant effect due to treatments.

Trends in leaf nutrient levels (Table 13) suggest a slight decrease in potassium and an increase in magnesium, chloride and manganese due to treatment 4 (1000 l raw effluent per palm). Soils can be expected to become more acid where sludge is applied, which would cause an increase in manganese. The soil samples taken gave pH values of 6.4 and 6.5 where effluent was applied at 500 and 1000 l, respectively, as compared to 6.6 and 6.8 for untreated soil (Table 14). These differences were significant however. Yield data (Table 15) showed that the high rate plots produced 2.2 ton more per hectare than the untreated plots. This difference however was not significant due to considerable variation in the yield of the nil plots.

Table 15: Experiment 109a, Yield per hectare, 1985

TREATMENT	No. of bunches	Wt. of bunches t	s.b.w. kg
nil	1618	26.6	16.7
500 l raw effluent/palm	1602	27.1	16.9
1000 l raw effluent	1691	28.8	17.0
100/ton MB/ha	1627	26.2	16.1

EXPERIMENT 109b, Bebere mill waste trial on old palms

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

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

Table 16: Experiment 109b, Petiole cross section pre-treatment, August

TREATMENT	cm^2
1.	40.0
2.	41.9
3.	38.8
4.	40.9
5.	43.8
6.	40.0
average	40.9

Table 17: Experiment 109b, Pre-treatment leaf nutrient levels, August 1985

NUTRIENT	TREATMENT						MEAN
	1.	2.	3.	4.	5.	6.	
%							
nitrogen	2.1	2.1	2.1	2.1	2.1	2.2	2.1
phosphorus	0.14	0.14	0.14	0.14	0.14	0.15	0.14
potassium	0.85	0.80	0.79	0.85	0.83	0.85	0.83
calcium	0.86	0.90	0.98	0.86	0.89	0.88	0.90
magnesium	0.24	0.24	0.24	0.23	0.23	0.24	0.24
chloride	0.46	0.40	0.43	0.44	0.47	0.47	0.45
ppm							
iron	46	47	56	48	47	55	50
manganese	61	62	63	59	62	58	61
zinc	23	23	28	23	23	24	24
copper	6	6	6	6	6	7	6
boron	14	11	10	12	11	15	12

Table 18: Experiment 109b, Yield per hectare, May - December

TREATMENT	No. of bunches	Wt. of bunches	s.b.w.
		t	kg
nil	589	12.3	21.0
500 l effluent	551	11.6	21.1
1000 l effluent	515	10.6	20.6
50 t EB	591	12.1	20.5
50 t MB	617	13.2	21.5

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:

		applied
1.	nil	-
2.	nil	-
3.	500 l raw effluent/palm	June-Sept '85
4.	1000 l raw effluent/palm	June-Sept '85
5.	50 t empty bunches/ha	Sept-Oct '85
6.	50 t munched bunches/ha	Oct-Nov '85

Recording: Petiole cross section measurements and leaf samples were taken in August. Yield recording per twin-row started in May.

Results: Petiole cross section data are presented in Table 16. Pre-treatment leaf nutrient levels (Table 17) show low values for nitrogen, phosphorus and potassium, which indicate deficiencies in the soil. Levels for magnesium and chloride are good. Yield data (Table 18) can show no trend as yet. Annual yields are estimated to be only 17 to 18 tons/ha at this site as against 27 tons/ha in Experiment 109a.

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 Experiment 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.

Treatments:

			kg/palm. year	
		level	source of nitrogen	additional ammonium nitrate
1.	Ammonium chloride	0	0	0.80
2.		1	0.25	0.60
3.		2	0.50	0.40
4.	Ammonium sulphate	0	0	0.80
5.		1	0.63	0.40
6.		2	1.25	0
7.	Di-ammonium phosphate	0	0	0.80
8.		1	0.70	0.40
9.		2	1.40	0
10.	nil			
11.	nil			
12.	nil			

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

The same levels all 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

Table 19: Experiment 110, Petiole cross section, as influenced by previous fertilizer applications, 1985

TREATMENT	April	cm^2 July	October
N0	4.8	7.1	8.9
N1	4.9	7.2	9.0
N2	5.0	7.3	9.2
P0	4.9	7.2	9.0
P1	4.8	7.2	9.0
K/Mg0	4.9	7.2	9.1
K/Mg1	4.9	7.3	9.0
K/Mg2	4.8	7.1	9.0
unmulched	4.7	7.0	8.8
mulched	5.0	7.3	9.3
mean	4.9	7.2	9.0

Table 20: Experiment 110, Petiole cross section (cm^2)

	Level 0		Level		Level 2	
JULY 1985	no mulch	mulch	no mulch	mulch	no mulch	mulch
ammonium chloride	-	-	6.7	7.2	6.9	7.4
ammonium sulphate	-	-	7.2	7.1	7.2	7.0
ammonium phosphate	-	-	6.9	7.0	6.9	7.3
ammonium nitrate	7.0	7.5	-	-	-	-
nil	7.2	7.4	-	-	-	-
OCTOBER 1985						
ammonium chloride	-	-	8.9	9.0	8.8	9.6
ammonium sulphate	-	-	9.1	9.1	8.5	9.1
ammonium phosphate	-	-	8.7	9.6	9.2	9.5
ammonium nitrate	8.6	9.2	-	-	-	-
nil	8.7	9.4	-	-	-	-
Relative increase since July						
ammonium chloride	-	-	2.2	1.7	2.0	2.2
ammonium sulphate	-	-	1.9	2.0	1.3	2.1
ammonium phosphate	-	-	1.8	2.6	2.3	2.2
ammonium nitrate	1.6	1.7	-	-	-	-
nil	1.5	2.0	-	-	-	-

treatments 13 - 24 were mulched with about 100 kg empty bunches/palm in April/May 1984. Application of fertilizer started in June 1985 and will be continued at half yearly intervals. The aboves rates will be doubled in 1986.

Under the abandoned design (see Annual Report for 1984, page 18) some fertilizers (namely sulphate of ammonia, triple super phosphate, bunch ash and magnesium) were given, of which any residual effects on leaf nutrient levels and petiole cross section were examined.

Recording: Petiole cross section data, as influenced by fertilizer applications under the old design are presented in Table 19. Mulched palms which received nitrogen in 1984 showed more vigorous vegetative growth as indicated by the greater petiole cross section. Since treatment effects were separated from the effect of the mulch by blocking, the mulching effect will not interfere with future results and the residual nitrogen effect will be minimised but the unwished for variation it may cause will have to be taken into account. October's measurements of petiole cross section are also expressed as a relative growth since July, 1985 in Table 20.

Precocity data (Table 21) show that both mulching and nitrogen enhanced flowering, mulching more so than nitrogen.

Table 21: Experiment 110, Precocity
(% of palms per plot with female inflorescences)

TREATMENT	August	October
N0	46	84
N1	52	92
N2	52	90
Unmulched	41	87
mulched	58	90

Average leaf nutrient levels (Table 22) were satisfactory. Mulch is the only treatment which seems to have had a positive effect on the leaf nutrient levels of nitrogen (2.6 versus 2.5) and chloride (0.53 versus 0.42).

EXPERIMENT 111, Malilimi fertilizer experiment on young palms

The suitability of the soil at Malilimi for oil palm was questioned and three pilot blocks were planted in September 1983 at 135 palms per hectare to see if they could establish succesfully. The opportunity was taken to superimpose a simple experiment to detect the differences expected from analysis of the soil.

Design: Four replicates of completely randomised blocks, each of two pilot blocks containing 6 plots. Two plots of the third pilot block, originally meant for root studies, were included at a later date.

Treatments: The objective of this experiment is to test if soil fertility and compacted layers 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

Fertilizers were given in April and October.

Table 22: Experiment 110, Pre-treatment leaf nutrient levels (average of 72 plots), June

NUTRIENT	%	s	lowest	-	highest
nitrogen	2.5	0.11	2.3	-	2.8
phosphorus	0.16	0.01	0.14	-	0.18
potassium	1.21	0.06	1.08	-	1.34
sulphur	0.16	0.01	0.14	-	0.19
calcium	1.30	0.08	1.11	-	1.49
magnesium	0.24	0.02	0.19	-	0.28
sodium	0.01	0.00	0.01	-	0.04
chloride	0.48	0.08	0.30	-	0.70
	ppm				
iron	67	7.0	52	-	89
manganese	56	9.0	38	-	85
zinc	18	2.9	13	-	33
copper	7	0.5	6	-	8
boron	14	2.8	10	-	29

Table 23: Experiment 111, Yield per hectare, November and December 1985 and petiole cross section measurements

	TREATMENT	No. of bunches	Wt. of bunches	s.b.w.	July	Oct.
			t	kg		cm^2
Block 1	nil	283	1.0	3.5	8.8	10.7
	P	401	1.5	3.7	8.4	10.5
	NP	414	1.4	3.5	9.1	11.2
Block 2	nil	114	0.3	3.0	7.2	9.8
	P	59	0.1	2.5	6.1	8.2
	NP	55	0.2	3.2	6.8	9.0
Block 3	nil	228	0.7	3.2	-	-

Recording: Petiole cross section was measured in July and October. Yield recording started in November.

A number of soil pits have been described and some soilwater retention curves (pF) determined, (see Investigation 704).

Results: At this stage it would be premature to give comments on the effects of the fertilizer applications. Measurements taken are shown in Table 23.

The soil in block 3 is thought to have the worst physical properties but shows a precocity similar to block 1.

The lower yield figures in block 2 are positively correlated with petiole cross section values.

EXPERIMENT 201, Hargy fertilizer trial

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	3
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

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,P,Mg), July (bunch ash) and October (N,P,Mg).

It was decided to apply boron in December because the management of Hargy Oil Palms was concerned about the many boron deficiency type of symptom seen in the plantations. Boron was applied as split plot treatment in which palm 1-8 of each plot received 50g of borax mixed with 300g talcum powder for easier distribution. The mixture was applied to the soil.

Recording: Petiole cross section was measured in June. Yield recording has been continuous since 1983. Bi-monthly leaf sampling in selected plots was started in July (see Investigation 708). Boron deficiency symptoms were scored in December, as light, moderate or severe.

Results: Average petiole cross section in June was 38.1 cm^2. There were no significant differences due to treatments.

Yields (Table 24) averaged 24 ton/ha, which were still fairly good (compare annual yield for 1983: 24.3 ton/ha, 1984: 26.7 ton/ha). Application of 0.8kg TSP/palm year gave a very highly significant yield response of 1.6 ton/ha, confirming the response obtained previously. The yield response due to Mg just failed to be statistically significant.

Table 24: Experiment 201, Yield per hectare, 1985 and to date

	1985			Since June '82
	No. of bunches	Wt. of bunches t	s.b.w. kg	Wt. of bunches t
N0	1072	23.9	22.4	92.4
N1	1070	24.1	22.6	91.1
N2	1084	24.0	22.2	93.1
P0	1022 a	22.7 a	22.3	88.3
P1	1094 b*	24.3 b**	22.3	93.1
P2	1110 b*	25.0 b**	22.6	95.3
K0	1085	23.8	22.0	91.5
K1	1077	24.5	22.7	92.8
K3	1064	23.7	22.4	92.4
Mg0	1038 a	23.5	22.7	91.3
Mg1	1080 b(*)	23.9	22.3	91.9
Mg2	1108 b(*)	24.6	22.2	93.5
mean	1075	24.0	22.4	92.2

significant at (*) 10%, * 5%, ** 1%

Table 25: Experiment 201, Percentage of palms with boron deficiency symptoms

	Light Symptoms	Moderate	Severe
Block 1	10.4	5.9	3.6
Block 2	9.6	8.7	3.5
Block 3	7.8	7.3	8.3
Average	9.3	7.3	5.1

Table 26: Experiment 202, Petiole cross section, July

TREATMENT	cm^2
nil	37.7
50 ton EB	38.0
100 ton EB	37.4
100 ton EB + SOA	38.9
25 ton EB	36.9

An estimate of the percentage of palms with boron deficiency symptoms is given in Table 25.

Leaf nutrient levels are given in Table 26 (Investigation 708).These indicated that most nutrients (including boron) were available in sufficient quantities, apart from magnesium (±0.13%, low) and chloride (0.20%, moderately low). Despite the significant effect of TSP on yield, leaf levels of P were not increased, neither were the levels in the untreated plots below what is considered the critical level (0.15%).

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 ton empty bunches/ha	Aug-Dec.'84
4.	100 ton empty bunches/ha	Aug-Dec.'84
5.	100 ton empty bunches/ha + SOA (1kg/palm)	Aug.'84- Jan.'85
6.	25 ton empty bunches/ha	Jan-Feb.'85

Treatments are applied only once.

Recording: Petiole cross section was measured in July. Yield recording started in March 1984. Leaf analyses were done in August 1985.

Results: No significant differences due to treatment could be found between the petiole cross sections, (Table 26). It can be expected to take longer before significant effects on yield will show. Average annual yield for 1985 (including last 3 months of pre—treatment period) was 20.4 ton/ha which is about 4 ton less than experiment 201, situated next to Experiment 202 and planted in the same year. Yield data is given in Table 27.

Table 27: Experiment 202, Pre-treatment and post-treatment production per hectare

	March '84 - March '85			April '85 - Dec '85		
TREATMENT	No. of bunches	Wt. of bunches t	s.b.w. kg	No. of bunches	Wt. of bunches t	s.b.w. kg
nil	1126	24.5	21.8	827	17.7	21.4
50 ton EB	1054	24.9	23.8	693	16.5	23.9
100 ton EB	967	23.8	24.6	769	17.8	23.2
100 to EB + SOA	1085	24.7	22.8	703	16.2	23.0
25 ton EB	997	24.3	24.6	714	16.3	22.9

Table 28 shows that treatments have increased chloride levels in the leaves (significant at 5%). Potassium also showed an upward trend, whereas calcium levels seemed to be falling.

Table 28: Experiment 202, Leaf nutrient levels, August 1985

NUTRIENT	TREATMENT							Sept.'84
	1	2	3	4	5	6	average	average 1984
%								
nitrogen	2.4	2.4	2.4	2.5	2.4	2.4	2.4	2.4
phosphorus	0.16	0.16	0.17	0.17	0.17	0.16	0.17	0.15
potassium	1.02	1.09	1.12	1.10	1.15	1.12	1.10	1.10
sulphur	0.19	0.18	0.19	0.19	0.19	0.18	0.19	0.17
calcium	1.05	1.04	1.00	1.00	0.98	0.99	1.01	0.95
magnesium	0.16	0.15	0.17	0.15	0.16	0.15	0.16	0.13
chloride	0.23a	0.23a	0.27ab	0.30b	0.31b	0.24a	0.26	0.20
ppm								
iron	59	69	60	60	58	61	61	57
manganese	71	68	70	69	72	70	70	64
zinc	24	25	28	24	27	34	27	24
copper	7	8	8	8	8	8	8	7
boron	24	22	25	23	23	21	23	22

Table 29: Experiment 305, Yield per hectare, 1983 and to date

TREATMENT	YIELD Wt. of bunches t	No. of bunches	s.b.w. kg	CUMULATIVE YIELD Oct'81 - Dec'85 t
N0	32.6 a	2179 a	15.0	128.6 a
N1	36.3 b**	2396 b**	15.2	134.8 b**
N2	36.1 b	2381 b	15.2	135.3 b
P0	35.1	2366 b	14.8	132.1
P1	35.0	2270 a(*)	15.5	133.9
K0	33.6 a	2336	14.4	128.6 a
K1	35.4 b**	2288	15.5	134.6 b**
K2	36.0 b	2332	15.4	135.5 b
Mg0	34.8	2299	15.1	132.4
Mg1	35.3	2338	15.1	133.5

Data with different letters differ significantly at (*) 10%, * 5%, ** 1%

ORO PROVINCE

(R.L.A.)

EXPERIMENT 305, Factorial fertilizer experiment, Arehe

Initiated in 1981 on a 1978 planting occupying an area of 'A' type soil. The latter is yellowish brown clay loam with a dark brown humic surface horizon. Drainage is moderate.

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

Treatments: There have been no changes to the 1984 treatment levels. Fertilizers were applied in March and September and were as follows for the year:

		kg/palm.yr	
LEVEL	0	1	2
ammonium sulphate	0	2.0	4.0
triple super phosphate	0	2.0	-
potassium chloride	0	2.0	4.0
magnesium sulphate	0	1.0	-

Results: Yield data for 1985 and to date are presented in Table 29. Statistical analysis showed highly significant yield responses to nitrogen (low rate) and potassium (low rate) with regard to weight of bunches per hectare. The number of bunches produced was highly significantly increased by the low rate of nitrogen but there was no effect of potassium. This confirms the previous year's trends. The depression of bunch number by phosphate is consistent with previous data.

N x P, P x K and P x Mg interactions also gave significant yield responses (kg/ha) at the 1%, 5% and 10% levels respectively and P x K and N x P significantly more bunches.

Petiole cross sections were measured for selected plots in February and for the whole experiment in August. Results from the latter are given in Table 30.

Table 30: Experiment 305, Petiole cross section measurement, August 1985

TREATMENT	WxT (cm^2)		"xT (cm^2)
N0	30.9 a	K0	29.9 a
N1	31.9 b**	K1	32.2 b**
N2	32.4 b	K2	33.0 c
P0	31.7	Mg0	31.5
P1	31.8	Mg1	32.0

Data with different letters differ significantly at ** 1%

Both N at the low rate and K at the high rate gave highly statistically significant growth effects as did the N x K and P x K interactions. This conforms to the yield responses observed.

Petiole cross section and leaf area measurements from 1984 to the present give an indication of the effect of fertilizer on growth (Tables 31 and 32).

Table 31: Experiment 305, Petiole cross section measurements, November 1984 to August 1985

	WxT cm^2			
FERTILIZER RATE	November '84	March '85	August '85	% increase
Low (nil)	26.8	25.6	28.7	7.1 %
High	29.3	29.8	35.0	19.5 %

Table 32: Experiment 305, Leaf area measurements, February 1984 and August 1985

	LEAF AREA cm^2		
FERTILIZER RATE	February '84	August '85	% increase
Low (nil)	445.5	500.5	12.4 %
High	471.1	556.2	18.1 %

The high rate of fertilization gave consistently better vegetative growth than the control.

Height measurements were taken in April 1985, but only the P x K interaction was significant.

Leaf samples were taken monthly in selected plots. The results show that levels of N were still on the decline from their pre-treatment levels. Levels were slightly higher in the 'High' fertilizer plots (2.7% N) as compared to the control (2.5% N), but all were above critical. Leaf levels of K were on the whole slightly below the assumed critical level, especially in the 'High' fertilizer plots (0.90%) in comparison to the control (1.00%). This is an antagonistic effect caused by the calcium in the soil combining with the chloride in the potassium fertilizer, and being taken up preferentially by the palms. The fact of a yield response remains however.

EXPERIMENT 306, Factorial fertilizer experiment, Ambogo

Initiated in 1982 on a 1980 planting occupying an area of 'K' type soil, regarded as poor for oil palm growth. The latter is a young greyish yellow coarse sand with moderate to excessive drainage, hampered by seasonally high water-tables.

Design: A 3^4 (NPKMg) factorial, replicated once with 3 blocks of 27 plots; 36 palms per plot of which the central 16 are recorded.

Treatments: There have been no changes to the 1984 treatment levels. Fertilizers were applied in April and October, with the exception of kieserite which was unavailable. The treatments are as follows:

	kg/palm.yr		
LEVEL	0	1	2
ammonium sulphate	0	1.5	3.0
triple super phosphate	0	0.5	1.0
potassium chloride	0	2.5	5.0
magnesium sulphate	0	0.75	1.5

Results: Yield data for 1985 and to date are presented in Table 33. Statistical analysis showed that the low rate of potassium fertilizer gave a highly significant yield response with regard to kg/ha. The high rate of K fertilizer appeared to have a slight depressive effect on kg/ha and bunches /ha as compared to the low rate. The trend of response to nitrogen was similar to Experiment 305 but the differences were not statistically significant.

The low rate of magnesium fertilizer gave significantly increased bunch numbers per hectare as compared to the nil and high rates.

Table 33: Experiment 306, Yield per hectare, 1985 and to date

TREATMENT	YIELD			CULMULATIVE YIELD
	Wt. of bunches	No. of bunches	s.b.w.	May'83 -Dec'85
	t		kg	t
N0	34.4	3172	10.8	66.3
N1	35.3	3209	11.0	68.3
N2	34.3	3183	10.8	70.4
P0	34.2	3245	10.5	68.4
P1	35.0	3177	11.0	68.5
P2	34.8	3142	11.1	67.9
K0	33.3 a	3215	10.4	64.6 a
K1	35.9 b**	3246	11.1	71.3 b**
K2	34.8 b	3103	11.2	69.1 b
Mg0	34.2	3120 a	11.0	67.3
Mg1	34.8	3290 b(*)	10.6	70.2
Mg2	35.0	3154 a	11.1	67.4

Data with different letters differ significantly
at (*) 10%, ** 1%

A highly significant response was found with the P x K interaction for bunches/ha.

Petiole cross section data for selected plots was collected in March, and for the whole experiment in August. The data is presented in Table 34.

Table 34: Experiment 306, Petiole cross section measurements, August 1985

TREATMENT	W x T cm^2	TREATMENT	W x T cm^2
N0	26.9	K0	26.1 a
N1	27.3	K1	27.8 b**
N2	27.8	K2	28.0 b
P0	27.1	Mg0	27.0
P1	27.6	Mg1	28.0
P2	27.2	Mg2	27.0

Data with different letters differ significantly
at ** 1%

A highly significant vegetative growth response was found for the low rate of K fertilizer, this tieing up well with the yield data.

Comparative W x T and leaf area data for the selected plots are presented in Tables 35 and 36. These require some explanation. Whilst the control plots appear to be growing faster over time, the high fertilizer plots have appreciably larger petiole cross section and leaf area figures. The high rate of nitrogen fertilizer alone gives equally good vegetative growth as the more complete treatments (2220) and (2122).

Leaf samples were taken monthly in the selected plots (see Investigation 708). The results show that levels of N have remained stable throughout the trial since pre-treatment and are above critical. Unlike Experiment 305, leaf K levels appear to be above the assumed critical level throughout. Levels are the lowest in the highly fertilized plots, as in Expt. 305 (Ca/K antagonism).

Table 35: Experiment 306, WxT measurements, August 1984 to August 1985

TREATMENT	WxT cm^2			% increase
N P K Mg	August '84	March '85	August '85	
0 0 0 0	18.9	20.5	24.9	31.7%
0 0 0 1	18.3	21.0	25.3	38.3%
2 0 0 0	22.5	24.1	28.3	25.8%
2 2 2 0	22.0	24.2	27.8	26.4%
2 1 2 2	22.1	24.0	27.2	23.1%

Table 36: Experiment 306, Leaf area measurements, April 1984 and August 1985

TREATMENT	LEAF AREA cm^2		% increase
N P K Mg	April '84	August '85	
0 0 0 0	386.8	436.6	12.9%
0 0 0 1	343.4	453.7	32.1%
2 0 0 0	422.9	496.7	17.5%
2 2 2 0	408.8	494.8	21.0%
2 1 2 2	410.8	486.7	18.5%

EXPERIMENT 307, Smallholders 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

Design: Seven replicates originally, now reduced to six, of completely randomised blocks; replicates confounded with sites and variation in planting date.

Treatments: First applied in October/November 1984. Re-applied in May and November 1985.

	kg/palm. year ammonium sulphate	triple super phosphate
1.	0	0
2.	2	0
3.	2	0.5

Results: As yet no statistically significant yield response has emerged. However the N fertilizer has had a statistically significant effect on leaf N levels.

EXPERIMENT 308, Arehe mill effluent trial

Initiated in 1984 on a 1978 planting to the south of and near the effluent pond. It is sited on a brown-yellow volcanic sandsoil with a black humic topsoil with good internal drainage.

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

Treatments:

	kg effluent/palm
1.	nil
2.	625
3.	1,250

Progress: Pre-treatment recording of yield commenced in April 1984. Application of effluent treatments were not possible until 1986.

A simple trial was set up in this area in November, 1985 to investigate the possibilities of inoculating the leguminous cover crop, *Calapogonium caeruleum*, with cultured cowpea *Rhizobium*. Plants already growing and seeds were inoculated and the latter planted with untreated adjacent controls. The treatments were all duplicated using as individual plots the area around 8 oil palms. When the cover reaches maturity the success of the inoculation will be assessed.

EXPERIMENT 309, Bunch refuse manurial trial, Ambogo

Initiated in late 1984/early 1985 on a 1980 planting.

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

Treatment: Empty bunch application was completed in early 1985 and is next scheduled for October 1986.

Treatment	Wt. of empty bunches per ha		
1 and 2	nil		
3	50 t		
4	100 t		
5	100 t	+	1 kg SOA per palm

Results: Yield data for 1985 are given in Table 37. There was a significant positive effect on the weight of bunches per hectare by way of immediate response largely due to increased s.b.w., which is a trend observed in Experiment 202 also. These preliminary results reflect the considerable variability after this trial. This will smooth out with time. The effects of treatments on bunch numbers will also become apparent at a later stage.

Table 37: Experiment 309, Yield per hectare, 1985

TREATMENT	Wt. of bunches t	No. of bunches	s.b.w. kg
nil	27.0 a	3521	7.7
50 t	31.3 b*	3709	8.4
100 t	30.0 b	3915	7.7
100 t + SOA	31.9 b	3691	8.6

Data with different letters are significantly different at * 5%

The treated plots gave on average 4.1 t/ha more yield than the control plots.

Leaf samples were taken in October. The results show that leaf levels of N are high throughout the trial (well above 2.5%). Levels of potassium per treatment are given in Table 38.

Table 38: Experiment 309, Leaf levels of K, October 1985

TREATMENT	Leaf K %
nil	0.91 a
50 t	1.03 b**
100 t	1.06 b
100 t + SOA	1.08 b

Data with different letters differ significantly at ** 1%

This shows a highly significant result. All the treated plots possess leaf K levels above the assumed critical level of 1.00% K. All the control plots are below this level. The decomposing action of the SOA on the empty bunches appears to be enhancing K uptake by the palms.

PHYSIOLOGY

(T.M.)

This section is a convenient setting for research of physiological rather than cultural nature. The following investigations are now in progress.

102 Dami density trial
702 Effects of competition
703 Study of female inflorescence characteristics in relation to pollination and fruitset
705 Arehe clone and density trial
706 Continuous flowering censuses
707 Continuous vegetative growth study
708 Continuous variation of leaf nutrient levels.

EXPERIMENT 102, Density and fertilizer trial at 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 would have been 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: It had been decided that production should continue to be recorded in this classic experiment until its demise. Information from the experiment has been and continues to be incorporated in publications on the physiology, agronomy and breeding of oil palm in Papua New Guinea. Extensively reported previously, this year's summary is restricted to up-dating trends in production already observed.

In Table 39 current and cumulative yield are given together with their calculated optimum planting densities.

Table 39: Experiment 102, Production 1985 and cumulative

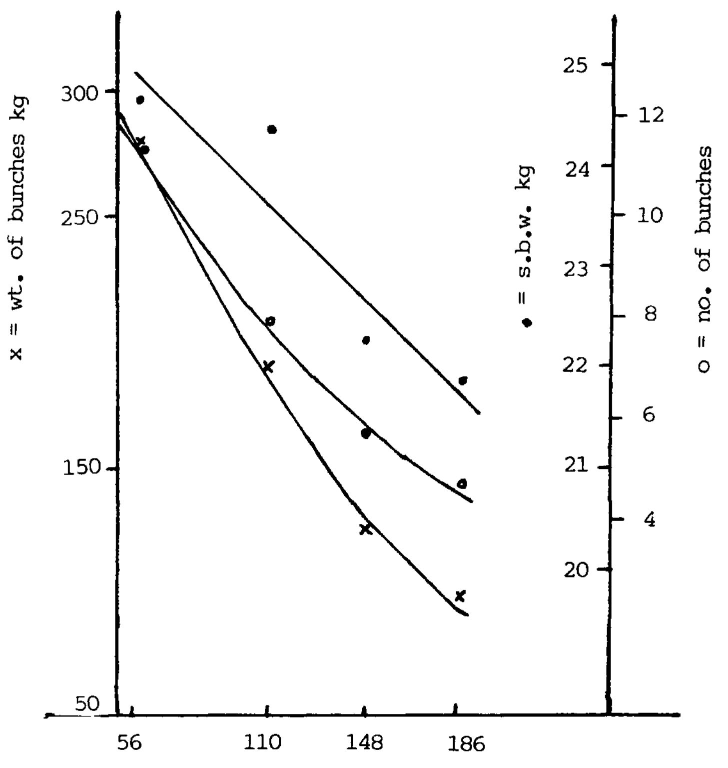
TREATMENT	PER PALM			PER HECTARE		1973-1985
	No. of bunches	Wt. of bunches	s.b.w.	No. of bunches	Wt. of bunches	Wt. of bunches/ha
palms/ha		kg	kg		t	t
56	11.3 a	277 a	24.6 a	631	15.5	181
110	7.8 b	188 b	24.3 a	856	20.7	288
148	5.6 bc	124 bc	22.2 b	833	18.4	278
186	4.5 c	97 c	21.8 b	832	18.1	252

Optimum density for current yield 123 palms/ha[1]
139 palms/ha[2]
Optimum density for cumulative yield 131 palms/ha[1]

Previous Fertilizer regime	No. of bunches/palm	Wt. of bunches/palm kg	s.b.w. kg
0	6.4	147	22.7
50	7.1	161	22.7
100	6.5	152	23.2
150	6.8	165	24.4

means with different letters differ significantly
1 based on 110 - 186 palms/ha
2 " " 56 - 186 palms/ha

Figure 1: Experiment 102, Relationship between density and components of yield, 1985



Response to density remained strongly and negatively correlated throughout the range of planting densities for the number and weight of bunches produced per palm. In this respect, single bunch weight deviated from linearity quite strongly during the last two years because of the difference between 148 and 186 palm/ha being relatively less than between the other spacings. The effect of density on the components of the yield from individual palms is shown in Fig. 1 in which the best fitting logical curves are drawn (parabolic for weight and bunch number, linear for s.b.w.). Translated into yield per hectare for the current year (1985) and throughout the productive life of these palms optimum densities for current and cumulative yield are calculated to be 123 and 131 palms/ha respectively. This represents very little change for current yield during the last three years and a static situation for cumulative yield since January, 1982. All of this accords with the findings published in the annual report for 1984.

Residual effects of fertilizer that had increased single bunch weight but reduced bunch number with no resulting effect on yield were not demonstrable in 1985's data.

EXPERIMENTS 104 and 105, Thinning trials at 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. Its objective was to evaluate the result of thinning palms from the density at which they had been planted and which experience had shown was too high for the kind of lush growth peculiar to the environment of Papua New Guinea.

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

Treatments:

		Palms per hectare	
		Expt 104	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: A final summary of production and changes in leaf nutrients was given in the Annual Report for 1984. It was concluded that whilst thinning caused no overall loss in cumulative yield (both trials had recovered after 36 months) thinning by a seventh, as practiced on the plantation, appeared to have little value. Yield after thinning by a third was accumulating more rapidly than after thinning by a seventh or no thinning at all, but these differences were not statistically different when yield recording was suspended at the end of 1984. Higher levels of magnesium were found in the shadier, unthinned palms but other leaf nutrients were not affected by the treatments.

During 1985 the experiment was concluded after completing measurement of trunk girth so the production of vegetative dry matter could be calculated. This was done in two ways. Recorded frond production was available from July 1980 to June 1984 in both experiments and VDM was calculated for this period. In order to cover a greater period likely to have an effect, VDM was also calculated from March 1978 to June 1980 in Experiment 104 and July 1984 to January 1985 in Experiment 105 using additional values for frond production obtained from the regression of frond production on time. The results are shown in Table 40. VDM production was greatest after thinning by 1/3 to give a hexagonal arrangement (each remaining palm adjacent to one vacancy). This was significant in Experiment 105, with its 4 replicates, but did not achieve significance in Experiment 104 although the trend was the same. Bunch index (the ratio between bunch dry matter and total dry matter production calculated from BI =kg FFBx0.5275 ÷ VDM + FFBx0.5275) was estimated from this data with the results given in Table 40. Thinning by 1/3 is seen not only to have increased vegetative growth but bunch dry matter even more so, resulting in a substantially greater (30% and better) improvement in bunch index. Thinning by 1/7 in Experiment 105 also gave significantly better bunch index. These quite large differences in bunch index were highly significant and this parameter was particularly responsive to the treatments in this experiment.

Table 40: Experiments 104 and 105, Vegetative dry matter production and bunch indices

THINNING	VDM		BI	
Expt.104	7/81 -7/84 kg	3/78 - 2/85 kg	7/81 - 12/84 %	3/78 - 12/84 %
nil	325	841	40.2 a*	32.0 a**
1/3 hex	346	870	52.0 b	45.0 b
1/3 row	322	832	54.1 b	44.5 b
Expt.105		7/81 - 1/85		
nil	-	372 a*	-	32.8 a*
1/3 hex	-	404 b	-	43.2 c
1/7	-	381 b	-	35.5 b

significant at * 5%, ** 1%

INVESTIGATION 702, Effects of competition

Treatments: Four high density plots (186 palm/ha) of Experiment 102, were thinned to leave 10 palms in each arranged so as to minimise interpalm competition. Four similar plots were not thinned and ten palms in each allocated as recorded palms. As the subplots of Experiment 102 had received four different levels of fertilizer these were equally allocated to the thinned and unthinned palms of Investigation 702 to remove differences due to fertilizer. A total of 160 palms was studied in this experiment, 80 thinned and 80 unthinned. Thus two populations of palms were created, one in which stress due to competition between palms continued to be high and another which was released from this stress.

The ordinal number of each leaf was recorded throughout the duration of the experiment. The youngest fully open frond at the start was designated leaf +1. The leaves present in the crown at the time of thinning were given a positive number in the sequence of their emergence. Leaves emerging after thinning were given a negative number in the sequence they emerged.

In 1981 growing points of the thinned palms were sampled and also forty eight palms were dissected in 1983 to establish the ordinal leaf number in which characteristic stages of inflorescence development occured, namely the initiation of the first spikelet and the start of the differentiation of the spikelet.

Recording: Bunches identified by the ordinal number of their subtending leaf were weighed and analysed for their components, namely stalk, the number of spikelets, number of flowers per spikelet, percentage fruit set, percentage fertile fruit to bunch, single fruit weight, weight of empty spikelets, weight of the 'frame'. These records were taken for three years. In addition bunches were analysed for all four spacings of Experiment 102 (56, 110, 148, and 186 palms/ha) in 1984, to examine the effects of density on bunch components.

Dissected material was examined by light microscope and scanning electron microscope at Wageningen and at Leiden in Holland.

The results of this study are presented as seperate topics.

Effect of interpalm competition on yield sub-components: This study was reported on page 38 of the Annual Report for 1984. The raw data has since been sent to the University of Wageningen for more detailed analysis at their computer centre. The results are being combined with other data from NBPOD to compile a paper on this topic.

Inflorescence development in relation to yield sub-components: Data to the end of 1984 was discussed in the report for that year. In order to clarify results regarding the onset of changes in sex ratio flowering studies were continued until the end of 1985. This raw data was also sent to the computer centre for more detailed analysis than could be done at Dami. As these complex results are still being collated for presentation in a paper they are repeated in outline only here. Previous annual reports have already given much interim discussion of their details.

The developmental scale of stages in inflorescence development was reported last year. To this can be added leaf + 17 (range 14-20, s.d. 1.3) for the stage of anthesis. The material studied with the scanning electron microscope showed considerable differences in leaf number for these stages and indeed Corley in Malaysia found much lower leaf numbers to be associated, although the number of leaves between stages was similar. It is very likely these differences are seasonal as the opening of spear leaves is known to vary with moisture stress. Furthermore, palms dissected later at Dami that were growing in atypical surroundings (a gravelled drive) or a palm with substandard growth used for demonstration purposes showed very much higher ordinal leaf numbers at different flowering stages, for example anthesis at leaf on +25 in at least three cases.

Fruiting activity, which is a measure of yield based on 10 successive leaves (that is, yield from 1-5 months after any one time), causes stress in the form of a high demand for assimilates. As one of the effects of thinning was to increase fruiting activity this itself increased stress from the start of the experiment until reaching a peak with the bunches swelling in the axils of leaves -10 to -12. Fruiting activity therefore had a negative effect on thinning because differences in it caused by abortion, in particular, and later sex ratio perturbed the results strongly and have made the results that much more difficult (but interesting) to interpret. However, by focusing more sharply on fruiting activity it has been possible to explain what at first seemed conflicting or irregular results.

Another effect of thinning that made comparison between the two experimental populations difficult as time went by was the more rapid production of leaves from the thinned palms.

The growth rate of inflorescences and confirmation of abortion occuring as they expand rapidly by leaf +7 (which agrees with previous workers) was described in the

Annual Report for 1983. Female inflorescences were found to be significantly longer than male inflorescences in the axils of leaves 7+ and older.

Differences in abortion rate were also found to be statistically different for leaves younger than +7. The unthinned palms had very highly significantly more abortion. The sex ratio of the population did not differ correspondingly except for markedly higher sex ratio in the thinned populations after leaves +5, +6 and +7 and the differences in abortion continued very much longer than that. Our conclusion is held up that abortion is not always preferential of either male or female inflorescences but that the actual number of aborted of either sex may also depend on the sex ratio before abortion.

Because of the perturbing effects mentioned above in connection with fruiting activity especially, the tentative conclusion is that in the material studied sex was determined at leaf -7, which was 3 leaves before spikelets were initiated. This is eleven leaves later than Corley concluded from his results and suggests that conditions affecting sex determination may have an effect on the crop harvested 18 rather than 24 months later. As will be seen below, sexual differences could not be defined visually until leaf -2.

All the results of bunch analysis have been analysed in greater detail at the Wageningen computer centre and data for each corresponding ordinal leaf number has been compared between the thinned and the unthinned populations. The results of thinning were several. Single bunch weight increased highly significantly for leaf +11 whereas in older leaves upto +17 (anthesis when the experiment started) it increased moderately. The initial effect was a highly significant increase in the single fruit weight at leaf +17 and a significant increase in the weight of the frame at leaf +15. This suggests that fruit of inflorescences already pollinated at the start of the experiment were not affected. The clear difference in bunch weight disappeared around leaves +7 to +1 but this can be explained by the greater fruiting activity affecting these leaves when the bunch components of their subtended inflorescences were determined.

A consistent increase in the number of spikelets per bunch appeared at leaf 0. If this was real, it implies that the meristematic capability for producing spikelets can continue to the stage when the spear leaf opens. Although consistent over 6 leaves this effect disappeared at leaf -9 but resurfaced at leaf -14. This dip could be explained by the observation that the leaves subtending these inflorescences were passing through the stage of opening during a peak in fruiting activity.

At leaf -8 the number of flowers per spikelet was increased and it is at this stage that this component was clearly determined.

The effect on fruit set and fruit to bunch, which are of course related, was in contrast to the foregoing as it favoured the unthinned palms, commencing with those inflorescences at anthesis when the experiment started. Later, both positive and negative fluctuation in fruit set occurred that can be related to weather conditions at the time of anthesis. From this it is suggested that these differences were linked with the habits of the pollinating weevil which appears more efficient under cooler, more shady conditions, that is high density plantings or overcast skies.

A discussion of these results will be presented next year for publication as a paper and in PNGOPRA Annual Report for 1986.

The early development of inflorescences and flowers of the oil palm as seen through the scanning electron microscope: The work carried out with Dr. Van Heel will be published in 1986. He will be senior author in view of his increasing interest and participation in the project. A summary is given here.

The development of inflorescences and flowers prior to anthesis was illustrated by scanning electron images. The time of origin relative to the development of the foliage leaves of the acropetalous succession of flowering rachillae was determined as well as the time of morphological sex definition. The logical stage when sex is determined was inferred to be not before the first appearance of the first spikelet primordia which, in contrast, develop in a basipetal sequence. As the primary axis continues to elongate after spikelets begin to be initiated the latter further develop in an acropetal sequence also (c.f. the definition of spikelets per bunch described in the previous section). This change in morphogenetic direction is also reflected in the sequence of anthesing spikelets. Female flower groups develop acropetally as triaxial cincinni, the male units as reduced ones. A cincinnus is a monochasial system and in this case consists of the development of two successive axes each producing a bracteole and a male flower and one producing a bracteole and a terminal female flower. Each successive axis develops in the axil of the previous bracteole and successive bracteoles and flowers originate opposite each other. All these parts are compressed and end up as a tri-floral group buried in a pit formed by its subtending bracts and the main axis. In female inflorescences the development of male flowers is usually arrested. In male inflorescences only the first male flower and its bracteole are produced.

Morphological definition of the sex of an inflorescence is only possible when the first bracts are initiated on spikelet primordia, and it is supposed that the morphogenetic impulse causing sex differences acts before this, but it is unlikely that this will be before the appearance of the axillary meristem that gives rise to the spikelets (c.f. the definition of sex in the previous section).

INVESTIGATION 703, Study of female inflorescence characteristics in relation to pollination and fruit set

The object here was to observe flowering and fruit set in two populations of palms, one of which was typified by poor and the other good fruit set, in order to recognise characteristics that may be responsible for this difference.

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. The characteristics of these palms are given in Table 41.

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 at the bottom, middle and top of the inflorescence, presence of abnormal 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.

INVESTIGATION 704, Soil moisture relations project (N.A.W.)

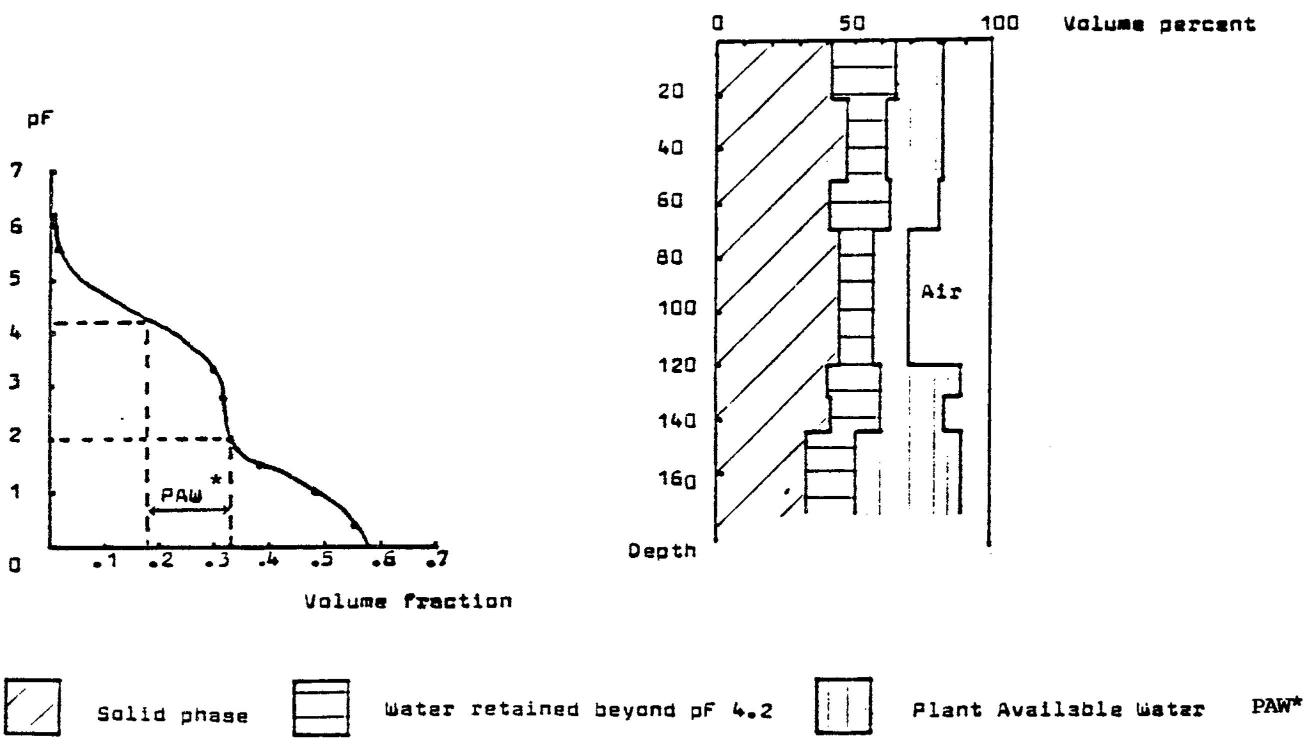
The main purpose of the investigation was to establish pF curves for different soils from West New Britain and Oro Provinces, calculate their water storage capacity and develop a model for calculating water balance during the year. The distribution of oil palm roots in the soils sampled would also be observed.

Soil structure: Soil pits were examined at 14 locations listed below and their physical characteristics described.

Table 41: Experiment 703, Percentage fruit-set of selected palms

REP	PROGENY	PALM	FRUIT-SET %		
			OPRS Record		Current
			11/81 - 7/85	cv%	12/85
I	652	04	81.9	8	
II	644	04	82.2	4	
III	635	04	80.2	10	
IV	636	07	85.0	7	
	639	09	80.9	3	57.4
	653	05	82.3	3	
V	639	07	80.2	9	
	653	12	80.1	7	72.5
VI	633	01	81.4	5	76.5
I	638	02	30.2	23	30.4
		11	32.1	49	
	644	05	48.2	4	68.1
		07	34.8	41	
II	638	01	24.8	73	32.9
		06	34,6	18	
IV	638	04	39.6	10	60.4
		10	35.4	39	72.5
	650	10	49.1	7	66.4

Figure 2: Investigation 704, A pF-curve and a graph showing the available water in the different soillayers in the soil profile at Dami



W.N.B.P.

1. Dami, Expt.102, replicate II, plot 1
2. Dami, Expt.102 replicate IV, plot 3
3. Kumbango, field F8, Expt.108, plot 3
4. Kumbango, field E7
5. Malilimi, Expt.111, physical analysis of soil from 4 previously dug pits

ORO PROVINCE

6. Arehe estate, Expt.308, between plots 7 & 8
7. Ambogo estate, Expt.306, between plots 8 & 9
8. Girua block 010184, Expt.307, between plots 8 & 9
9. New Warisota block 500619, soil pit, Expt.307, between plots 13 & 14
10. Sakita block 410021, Expt.307, between plots 20 & 21
11. Soputa block 251013, Expt.307, between blocks 5 & 6
12. Plot 9,10,11 Embi grass area destined to become a smallholders' development
13. Plot 4,7,9 of oil palm trial plot E of main road

Lengthy and detailed descriptions are given in the main report of this project and are not repeated here. Some soils in smallholders' blocks in Oro Province showed profiles considered certainly not ideal for oil palm. For example, at Girua shallow sticky clay, compacted layers causing poor drainage and infiltration resulted in dense, superficial root development. Attention was drawn to waterlogging in places where people or animals passed or rested frequently in a soil with otherwise good characteristics at Sakita. In parts of the Embi grass area the poor water holding capacity and the capillary rise of the coarse and other sandy layers at one site will be likely to cause water deficits and poor retention of applied fertilizer. Elsewhere in the Embi area and on Ambogo (Experiment 306) the presence of compacted clays leads to good waterholding characteristics but poor aeration and high water-tables restricting root development.In these Embi areas drainage is generally necessary.

Figure 2 gives an example of a pF curve and water availability in a soil profile at Dami. In the particular young volcanic (pumice) soils in W.N.B.P. the low bulk densities and good soil structure generally allowed good penetration and excellent soil water availability.

The rooting depth and plant available water (between pF 2 and pF 4.2) of that particular soil are given in Table 42. Plant available water is used as soon as the amount of rainfall does not meet the amount of water required for evapotranspiration.

Table 42: Investigation 704, Rooting depths and available water at 13 sites in West New Britain and Oro Provinces

LOCATION	ROOTING DEPTHS cm	PLANT AVAILABLE WATER mm
Dami (West New Britain)	120	175
Kumbango	100	290
Arehe (Popondetta)	130	364
Ambogo	95	152
Girua	80	140
New Warisota	135	390
Sokita	145	348
Soputa	120	125
New smallholder development area (DPI Popondetta)		
Embi grass plot 910	135	189
Embi grass plots 917-918	75	225
Embi grass trial plot	115	178

Table 43: Investigation 704, Comparison of the estimates of annual evapotranspiration (mm) by the different methods for calculating water deficits

	IRHO	THORNTHWAITE	PENMAN
1978	1440	1698	1730
1979	1470	1713	1771
1980	1470	1696	1741
1981	1440	1710	1731
1982	1560	1701	1804
1983	1440	1719	1578
1984	1440	1701	1732

Table 44: Investigation 704, Yearly water deficits (mm) from January 1978 - July 1985, Dami

YEAR	IRHO	THORNTHWAITE	PENMAN
1978	0	26	0
1979	0	63	99
1980	0	49	10
1981	0	6	0
1982	347	428	582
1983	0	4	0
1984	0	3	0
1985 (½)	0	0	0

Table 45: Calculation of monthly deficits (mm) on Dami in 1982

	IRHO	THORNTHWAITE	PENMAN	RAINFALL
January	0	0	0	758
February	0	0	0	665
March	0	0	0	378
April	0	0	0	356
May	0	0	0	139
June	0	20	0	57
July	0	52	37	51
August	52	58	119	60
September	86	66	121	64
October	89	111	146	31
November	120	121	159	30
December	0	0	0	364
Total	347	428	582	2953

Evapotranspiration: The level of potential evapotranspiration is related to the evaporative demand of the air, which can be derived from meteorological data by means of the Penman equation. A computer programme was written and is available on disc at Dami. Meteorological inputs needed are monthly means of temperature, dewpoint, wind-run and hours of bright sunshine.

In order to estimate the empirical relationship between solar radiation and hours of bright sunshine, sunshine was measured using a Stokes-Campbell recorder. Data from such a unit could be compared with records obtained simultaneously at Dami with a Kipp solarimeter over a 21 month period from January 1980 to September 1981. On the basis of this short period for comparison it was concluded that the most reliable relationship ($r^2 = 0.67$, $r^2 = 0.70$) was the one based on the comparison of daily records rather than grouped observations. The relationship used in Penman's calculation of evapotranspiration was;

$$Rs = (0.27 + 0.54\ n/N)\ Ra$$

where
- n = actual sunshine hours
- N = mean daily duration of maximum possible sunny hours
- Rs = solar radiation (solarimeter)
- Ra = extraterrestrial radiation

(N and Ra are obtained from FAO publication 24 on crop water requirements 1977).

Plant available water or soil water reserve: In determining the effect of rainfall on production it was convenient to look for periods of water deficit. This is determined by rainfall, soil moisture retention and availability and evapotranspiration of the crop. Surre (1968) in West Africa (IRHO) developed a quick formula for calculating water balance that has come to be used generally. This calculation assumes a water reserve of 200mm over a 2 metres deep rooting zone. More precise but complex methods employ formulae of Penman (which offer the best result) and Thornthwaite & Mather (1957) which takes other climatic factors into consideration. The latter indicates periods of drought very well but underestimates evapotranspiration in the dry season. Nearly every year deficits occur with this method because it includes the effect that moisture becomes less easily available as depletion of the soil water reserve increases. None of these methods takes into account that water stress occurs in oil palm well before the soil reserve has been depleted, and pF 4.2 is reached. To calculate water balances by these three methods requires the following information.

IRHO: Rainfall per month and rainy days.

Thornthwaite & Mather: Mean monthly values (from daily records) of maximum and minimum temperature, and precipitation with information on the water holding capacity of the soil in question.

Penman based: Radiation energy, wind and humidity to estimate evapotranspiration; this can also be obtained from daily evaporation from a class A pan multiplied by a pan coefficient to take into account the environmental conditions. A crop coefficient is also used to relate reference crop evapotranspiration to crop evapotranspiration which requires additional information on dewpoint and hours of bright sunshine. Soil water reserve is also required.

All three methods were used to calculate water balances at Dami over a 7½ year period from January 1978 to July 1985. The annual summaries for estimates of evapotranspiration are shown in Table 43. Yearly water deficits at Dami are given in Table 44 and monthly data for the dry year 1982 are given (Table 45). A detailed breakdown is given in the appendices of the main report.

The IRHO method tended to underestimate water balance because its estimate of water balance was too high and it underrated evapotranspiration. If the accurate measure of evapotranspiration embodied in the Penman equation is modified by data on soil water reserves it can be adapted to local conditions and this is believed to be the best available method to use. Both methods, however, ignore the fact that water is less easily available as the soil water reserve is depleted. This phenomenon is included in Thornthwaite's calculation but his estimate of evapotranspiration is too low in the dry season because of the strong winds, making allowance only for latitude and mean air temperature.

The actual water reserve at Dami was 175mm. At other sites sampled it ranged from 125mm at one site at Saputa to 390mm at New Warisota. It was concluded that the IRHO method of calculating water balance is not developed for the conditions found in P.N.G. where oil palm is cultivated. Generally it underestimates deficits.

The modified Penman method of estimating water deficits using real values of soil water reserve and the best estimate of evapotranspiration is recommended. It is accurately and quickly calculated with a computer, once soil water reserve is known, wherever adequate meteorological data are available. Refer to the full report for examples of the computations required.

Water deficits are quite rare at Dami. If this data for the relatively dry year of 1982 are examined, a reasonable estimate of moisture deficit according to the modified Penman equation is obtained by the relationship $D_{penman} = .7647\ D_{irho} + 69$ ($r^2 = 0.96$).

Where the IRHO method shows a surplus this is calculated as a negative deficit. Knowing the pF-curves (of each separate layer) it is possible to investigate the soil moisture content at which the oil palm actually closes its stomata. This can be done by installing tensiometers in the main water providing layers in the soil profile and measuring stomatal aperture at the same time. It is very important to know this critical soil moisture level because beyond this point assimilation reduces (and thus yield) also because the uptake of nutrients will slow down. When this critical soil moisture content occurs at considerably lower pF- values than 4.2 it is obvious that the plant available water of the profiles is less than the present values. This inevitably means that water deficits will occur sooner. Another growth indicator which could be used is leaf temperature measured by thermocouples. Canopy temperature rises when only part of the available energy is used to evaporate water and the remainder becomes available as heat. The influence of water deficits on the yield can also be measured now. Correlations can be determined between water deficits and sex differentiation and yield. This information can provide important insight in how water deficits really affect the yield under the P.N.G. climatological conditions.

INVESTIGATION 705, Clone and density trial, Arehe

Planted December 1985; 735 palms (total), 324 (recorded), area 4.2 hectares on the site of the old Arehe nursery.

Design: Split-plots with 3 replicates of 3 main plots of 4 sub-plots, 9 palms per sub-plot unguarded, 36 recorded palms per main plot, guarded on all four sides with double guardrows.

Treatments:

	palm/ha	spacing m
Main plots	115	10
	143	9
	180	8

	clone
Sub plots	UF 6
	UF 12
	UF 15
	UF 18

Routine plantation practice will be followed for maintenance and manuring.

Recording:

Monthly	First frond marking
Three monthly	Petiole cross section (1st 2 years)
Six monthly	Frond Production
Annually	Leaf area frond 1
	Petiole cross section (yr 3 onwards)
Continuously	Production (yr 3 onwards)
Occasionally	Precocity $2\frac{1}{2}$ years from planting
	Height increment
	Growth and flowering abnormalities
Duration	Indefinite

This experiment was set out and planted in December.

INVESTIGATION 706, Continuous flowering census

The objective is to keep records of flowering at one site on each major oil palm development to 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:

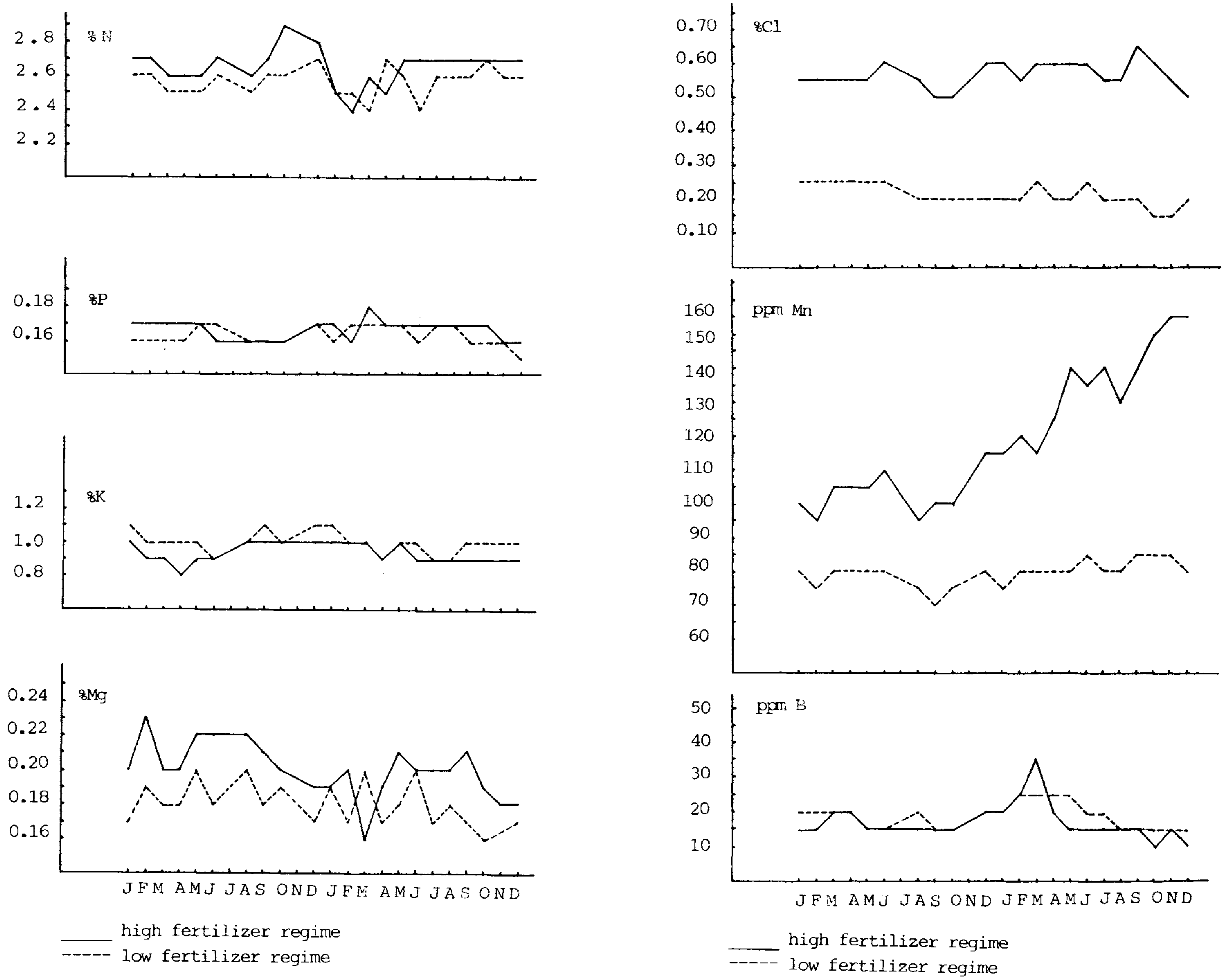
	Site	Planted	Period
W.N.B.P.	Expt. 102, Dami	1970	1978-1985
	Dami, Buluma	1978	Jan, '85 continuing
	Expt. 201	1973	Starting 1986
Oro Province	Expt. 305, Arehe	1978	Continuing

The plan is to continue recording continuously at Buluma, Experiments 201 and 305 and, in due course in 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.

INVESTIGATION 707, Continuous vegetative growth study

Since 1980 it has been the policy to measure growth continuously in the different

Figure 3: Investigation 708, Monthly nutrient levels in leaf 17, Jan. '84 - Dec. '85, (Experiment 305), O.P.



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

INVESTIGATION 708, Continuous variation of leaf nutrient levels

From April 1982 to April 1984 monthly and seasonal fluctuations in leaf nutrient levels were studied in Experiment 101. These results were published in the Annual Report for 1984. The field trial in its entirety had been concluded in 1982, but selected plots continued to be recorded and monitored until the end of 1984. Because the area would be due for replanting in the near future, the study was moved to field trials on younger palms. Similar observations are carried out at the sites in West New Britain and Oro Province where Investigation 707 is currently engaged.

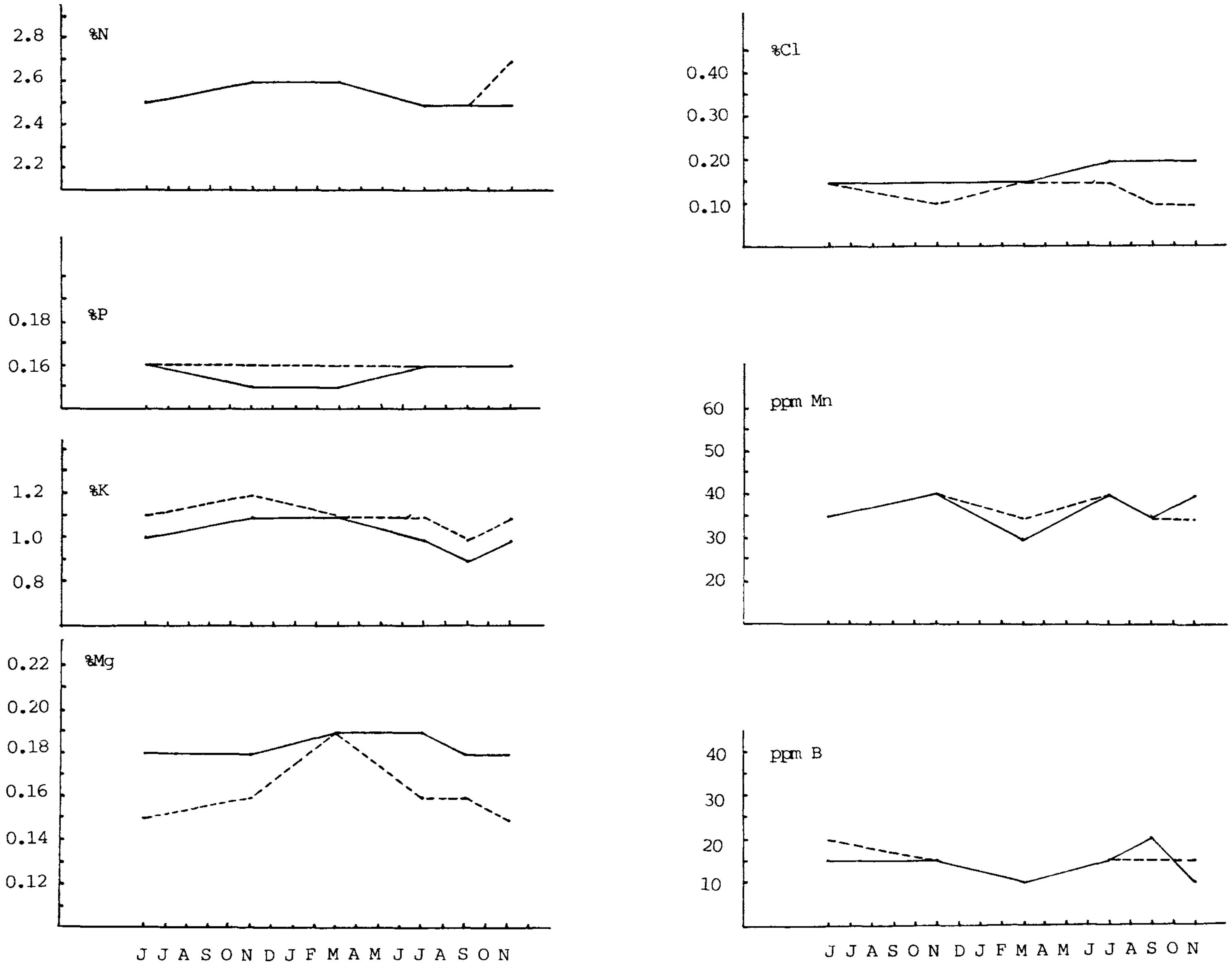
The objective is to analyse the dynamics of leaf nutrient contents, so as to assist in the interpretation of estate leaf sampling results.

Time of sampling is particularly important in countries where the dry season is marked, but less so in regions where the annual water deficit is small. Experiment 101b (concluded last year) showed how levels of nitrogen and magnesium can fall in a spell of dry weather (June-November 1982) because of reduced absorption of water and nutrients. Low leaf nutrient levels can also be caused by dilution by dry matter production (related to "effective sunshine hours"), by leaching from the leaves by rain (potassium), or vary with the age of the palms. No general rule can be given. K levels have a tendency to decrease fairly systematically with age, N levels can show a marked fall with age as is happening now with the older palms at Bebere and Kumbango Plantations (see Table 46).

Leaf nutrient levels are being studied in the various oil palm growing regions. This is being done by taking monthly or bi-monthly leaf samples in selected plots, which are under both high and low fertilizer regimes, see Tables 47-50 and Figures 3-5.

Seasonal trends will not be discernable until several more years' data has been accumulated. The figures to date suggest no outstanding trend. The only element showing some fluctuation is magnesium in Experiment 306 where levels drop around November/December. Other interesting trends are: Nitrogen levels are consistantly higher in the fertilized plots. Levels vary haphazardly between 2.9 and 2.4; Phosphorus levels are very consistent with not much difference between fertilized and unfertilized plots; Potassium levels are in all cases lower in the fertilized plots; Magnesium levels are higher in the fertilized plots in Experiments 305 and 109a, but lower in Experiment 306; The influence of chlorinated fertilizers is obvious. Also the raw effluent has had a positive influence on chloride levels. Manganese levels have risen sharply over time, especially in the fertilized plots of Experiment 305 and 306. Manganese levels in the plots under low fertilizer regime do not show this marked increase over time and levels remain at a moderate level in Experiments 305 and 201, and a low level in Experiments 306 and 109a. Levels of boron show one marked peak in both Experiments 305 and 306 around January/February and thenceforward a downgoing trend to low levels.

Figure 5: Investigation 708, Bimonthly nutrient levels in leaf 17, Experiment 109a, W.N.B.P.



_____ raw effluent 1000 l/palm
----- nil

Figure 4: Investigation 708, Monthly nutrient levels in leaf 17, April '84 - Dec. '85, Experiment 306, O.P.

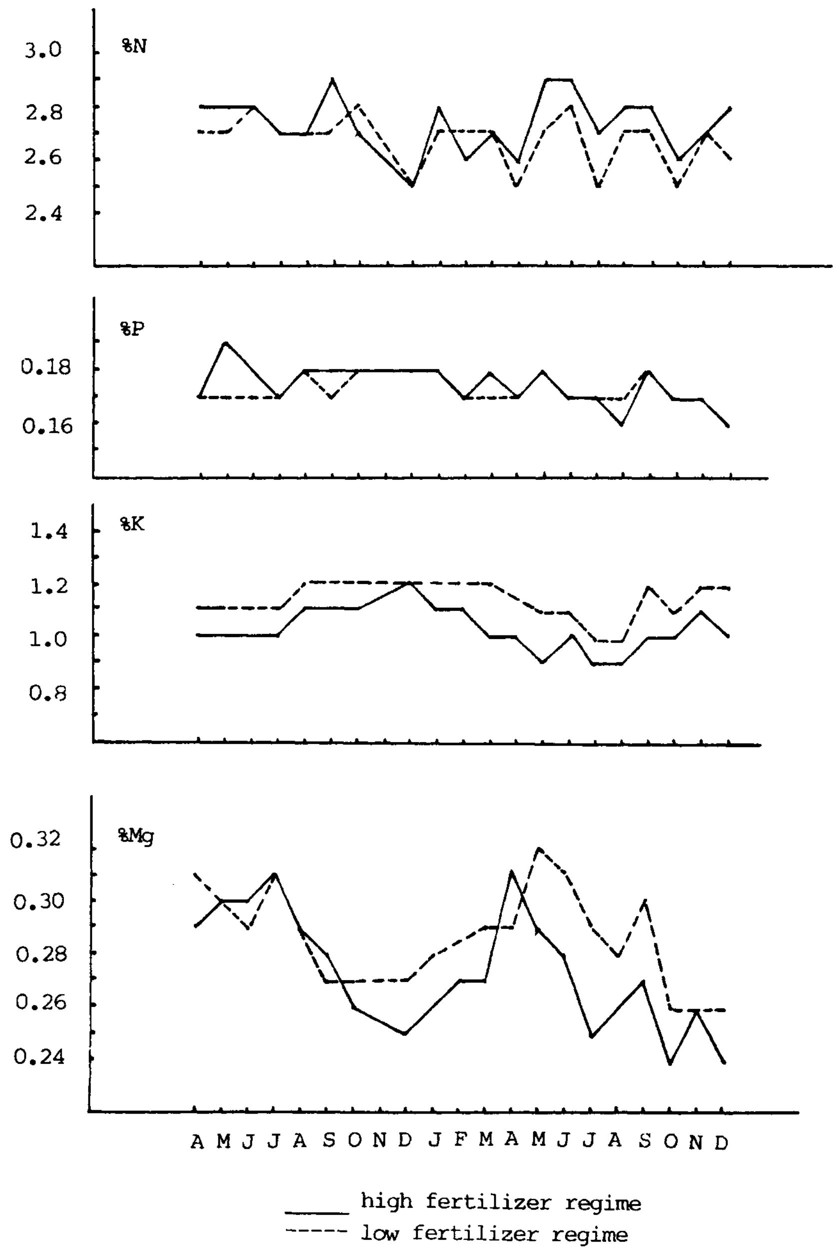


Table 46: Investigation 708, Effect of age on leaf nitrogen content

	PLANTED	LOCATION	SAMPLED	NITROGEN %
Expt. 101	1968	Sect. 16, Bebere	1975	2.5
		"	1982	2.4
		"	1985	2.3
Expt. 103	1972	E 7/8, Kumbango	1979	2.6
		" "	1983	2.3
		E 7/F8, "	1985	2.1
Expt. 104/105	1970	Sect. 12/13, Bebere	1984	2.0
Expt. 109b	1970	Sect. 10/11, Bebere	1985	2.1

Table 47: Investigation 708, Monthly leaf nutrient levels, Arehe, Experiment 305, O.P.,1985

		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
%													
N	0000	2.5	2.4	2.4	2.7	2.6	2.4	2.6	2.6	2.5	2.6	2.5	2.5
	2121	2.5	2.4	2.6	2.5	2.7	2.7	2.7	2.7	2.7	2.7	2.7	2.7
P	0000	0.16	0.17	0.17	0.17	0.17	0.16	0.17	0.17	0.16	0.16	0.16	0.15
	2121	0.17	0.16	0.18	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.16	0.16
K	0000	1.08	1.02	0.98	0.94	1.02	0.96	0.88	0.92	0.97	1.03	0.98	1.00
	2121	1.01	0.95	1.00	0.98	0.96	0.91	0.85	0.87	0.87	0.94	0.89	0.93
S	0000	0.17	0.19	0.19	0.19	0.18	0.19	0.18	0.18	0.18	0.18	0.18	0.17
	2121	0.19	0.18	0.21	0.19	0.18	0.19	0.19	0.18	0.19	0.19	0.19	0.18
Ca	0000	0.89	0.89	0.88	0.93	0.93	0.93	0.88	0.89	0.90	0.90	0.94	0.91
	2121	0.89	0.89	0.89	0.90	0.90	0.90	0.85	0.80	0.88	0.90	0.91	0.84
Mg	0000	0.19	0.17	0.20	0.17	0.18	0.20	0.17	0.18	0.17	0.16	0.18	0.17
	2121	0.19	0.20	0.16	0.19	0.21	0.20	0.20	0.20	0.21	0.19	0.18	0.18
Na	0000	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	2121	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cl	0000	0.20	0.20	0.24	0.20	0.20	0.19	0.26	0.19	0.24	0.17	0.16	0.20
	2121	0.59	0.53	0.61	0.58	0.59	0.60	0.57	0.55	0.63	0.62	0.53	0.52
ppm													
Fe	0000	88	74	70	68	57	61	57	64	58	65	60	50
	2121	101	90	64	65	61	62	63	62	62	82	66	54
Mn	0000	74	79	80	80	79	83	79	85	85	85	84	79
	2121	117	119	116	126	138	133	140	130	142	151	157	154
Zn	0000	18	20	20	19	19	23	19	20	23	23	23	18
	2121	18	19	18	17	17	19	20	19	23	23	19	19
Cu	0000	6	6	6	6	6	6	6	6	7	6	5	9
	2121	6	6	6	6	5	7	6	6	6	5	5	11
B	0000	20	27	27	24	23	18	21	17	15	15	16	14
	2121	20	23	35	20	16	15	16	13	15	12	13	11

Table 48: Investigation 708, Monthly leaf nutrient levels, Ambogo, Experiment 306, O.P.,1985

%		Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
N	low	2.6	2.8	2.7	2.5	2.8	2.8	2.5	2.7	2.8	2.5	2.7	2.7
	high	2.8	2.6	2.7	2.6	2,9	2.9	2.7	2.8	2.8	2.6	2.7	2.8
	N only	2.9	2.4	2.7	2.6	2.7	2.7	2.6	2.7	2.7	2.5	2.8	2.6
P	low	0.18	0.18	0.18	0.17	0.18	0.17	0.18	0.17	0.19	0.17	0.18	0.16
	high	0.18	0.17	0.18	0.17	0.18	0.17	0.17	0.16	0.18	0.17	0.17	0.16
	N only	0.18	0.17	0.17	0.17	0.18	0.17	0.16	0.17	0.18	0.16	0.16	0.16
K	low	1.17	1.19	1.11	1.02	1.02	1.10	0.99	1.03	1.20	1.14	1.21	1.10
	high	1.09	1.08	0.98	0.99	0.92	1.03	0.93	0.87	1.01	1.03	1.05	1.03
	N only	1.23	1.26	1.14	1.09	1.11	1.14	0.99	1.02	1.26	1.16	1.17	1.27
S	low	0.19	0.19	0.19	0.18	0.17	0.18	0.18	0.19	0.20	0.18	0.19	0.18
	high	0.20	0.19	0.19	0.17	0.18	0.18	0.19	0.18	0.19	0.18	0.19	0.19
	N only	0.19	0.19	0.19	0.18	0.17	0.18	0.17	0.19	0.19	0.17	0.19	0.17
Ca	low	0.86	0.81	0.81	0.84	0.84	0.82	0.75	0.71	0.78	0.73	0.73	0.71
	high	0.89	0.88	0.89	0.86	0.88	0.85	0.78	0.78	0.84	0.80	0.83	0.83
	N only	0.89	0.88	0.89	0.82	0.89	0.87	0.78	0.77	0.83	0.76	0.79	0.76
Mg	low	0.29	0.28	0.30	0.30	0.34	0.33	0.31	0.29	0.32	0.27	0.27	0.27
	high	0.26	0.27	0.27	0.31	0.29	0.28	0.25	0.26	0.27	0.24	0.26	0.24
	N only	0.25	0.25	0.26	0.26	0.28	0.27	0.26	0.25	0.26	0.24	0.25	0.23
Na	all plots	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Cl	nil	0.16	0.12	0.11	0.09	0.10	0.12	0.11	0.11	0.09	0.08	0.07	0.09
	high	0.52	0.58	0.56	0.53	0.48	0.55	0.50	0.48	0.56	0.52	0.58	0.49
	N only	0.11	0.13	0.14	0.14	0.14	0.25	0.12	0.17	0.18	0.09	0.08	0.12
	Mg only	0.18	0.22	0.20	0.15	0.20	0.20	0.23	0.26	0.24	0.18	0.24	0.22
ppm													
Fe	low	86	77	81	77	62	83	70	67	78	78	98	66
	high	80	77	67	65	58	80	80	79	66	83	105	81
	N only	89	84	82	68	64	73	90	85	87	57	85	74
Mn	low	37	31	30	30	29	32	36	39	49	50	51	45
	high	55	55	59	62	76	71	75	79	91	100	104	96
	N only	35	36	37	41	42	43	48	51	52	56	61	60
Zn	low	18	17	19	18	19	18	20	21	20	22	22	17
	high	17	15	17	19	18	16	17	16	18	17	21	17
	N only	17	15	14	17	17	15	15	17	14	15	22	15
Cu	low	8	7	8	7	7	6	7	7	8	6	6	12
	high	7	7	7	7	7	6	6	6	8	6	5	11
	N only	6	6	6	5	5	5	4	4	5	3	5	10
B	low	42	33	32	16	16	20	16	11	10	12	13	10
	high	37	32	26	18	13	16	14	12	8	11	11	10
	N only	36	31	22	20	15	18	13	12	8	11	13	11

Table 49: Investigation 708, Bi-monthly leaf nutrient levels, Bebere, Experiment 109a, W.N.B.P., 1985

%	POME	July	Sept.	Nov.
N	nil	2.5	2.5	2.7
	1000 l	2.5	2.5	2.5
P	nil	0.16	0.16	0.16
	1000 l	0.16	0.16	0.16
K	nil	1.05	1.04	1.07
	1000 l	0.99	0.94	1.03
S	nil	0.17	0.18	0.16
	1000 l	0.17	0.18	0.16
Ca	nil	1.00	0.97	0.91
	1000 l	0.97	0.98	0.89
Mg	nil	0.16	0.16	0.15
	1000 l	0.19	0.18	0.18
Cl	nil	0.13	0.12	0.11
	1000 l	0.18	0.19	0.19
ppm				
Fe	nil	65	62	52
	1000 l	59	64	54
Mn	nil	39	34	36
	1000 l	39	37	41
Zn	nil	25	23	23
	1000 l	23	24	21
Cu	nil	6	5	5
	1000 l	6	5	5
B	nil	15	16	13
	1000 l	17	18	12

Table 50: Investigation 708, Bi-monthly leaf nutrient levels, Experiment 201, W.N.B.P., 1985

		July	Sept.	Nov.			July	Sept.	Nov.
N	nil	2.4	2.4	2.6	Cl	nil	0.29	0.24	0.21
	P only	-	2.4	2.7		P only	-	0.16	0.21
	NP only	2.5	2.4	2.5		NP only	0.22	0.21	0.22
	NPKMg	2.7	2.4	2.6		NPKMg	0.27	0.26	0.18
P	nil	0.15	0.16	0.15	Fe	nil	50	54	57
	P only	-	0.16	0.16		P only	-	58	61
	NP only	0.16	0.16	0.15		NP only	53	61	53
	NPKMg	0.16	0.16	0.16		NPKMg	53	57	55
K	nil	1.07	1.02	0.98	Mn	nil	80	71	72
	P only	-	1.00	1.03		P only	-	65	61
	NP only	1.03	0.92	0.99		NP only	61	60	56
	NPKMg	1.04	0.99	1.04		NPKMg	68	61	61
S	nil	0.16	0.18	0.17	Zn	nil	25	25	24
	P only	-	0.16	0.17		P only	-	27	23
	NP only	0.16	0.18	0.16		NP only	21	22	24
	NPKMg	0.16	0.18	0.17		NPKMg	21	24	25
Ca	nil	0.96	0.97	1.01	Cu	nil	7	7	6
	P only	-	1.04	1.01		P only	-	7	6
	NP only	0.92	0.93	0.88		NP only	6	7	6
	NPKMg	0.97	0.99	0.95		NPKMg	6	7	6
Mg	nil	0.12	0.15	0.12	B	nil	29	16	19
	P only	-	0.15	0.12		P only	-	17	17
	NP only	0.15	0.17	0.16		NP only	15	19	15
	NPKMg	0.11	0.13	0.12		NPKMg	17	20	17

Table 51: Investigation 603, Fruitset 1985

SITE	PLANTED	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Mean	
Arehe 1	4/77	60.1	65.7	61.5	58.9	53.9	63.1	61.2	54.5	55.0	52.8	60.4	63.8	59.2	ab
Arehe 11	8/77	50.2	55.6	55.6	67.0	55.1	61.4	64.4	54.1	54.4	65.0	63.4	43.2	56.7	b
Arehe 7	4/77	57.0	67.6	60.9	66.0	62.5	59.2	62.1	59.7	59.5	69.4	60.2	63.3	62.3	a
Arehe M21-25	11/79	52.3	45.2	38.0	54.7	45.6	41.5	48.9	37.4	44.4	38.6	48.2	40.3	44.6	cd
Isavene M6-10	2/78	45.7	51.5	70.8	66.8	53.4	54.9	60.4	55.3	58.2	55.2	58.9	51.1	57.8	ab
Isavene M16-20	2/79	50.7	47.1	44.6	40.9	46.3	51.2	48.0	57.2	49.3	54.1	42.0	46.2	48.1	c
Ambogo M26-30	12/79	36.9	33.3	45.0	41.9	36.9	50.1	51.5	46.0	38.5	39.3	41.2	46.8	42.3	de
Ambogo 306	4/80	51.7	36.1	40.1	42.0	39.7	53.4	45.4	33.3	36.1	32.3	29.8	33.6	39.5	e
Means (HOPPL)		50.6	50.3	52.1	54.8	49.2	54.4	55.2	49.7	49.4	49.7	50.5	48.5	51.3	RS=0.95***[i]
Beuru	1980	41.1	47.5	39.1	46.7	41.0	53.0	44.1	40.9	47.3	43.1	39.7	49.9	44.5	
Tunana	1980	58.8	58.4	54.8	72.9	62.8	61.7	56.6	47.8	43.0	51.0	53.9	34.4	54.7	
Means (Oro)		50.0	53.0	47.0	59.8	42.3	57.4	50.4	44.4	45.2	47.1	46.8	42.2	49.6	
Buluma	1978	70.2	70.7	69.6	70.6	56.9	47.7	41.0	34.5	54.0	49.3	55.5	48.8	55.7	b
Hargy 1	1973	56.1	75.4	81.1	62.6	64.5	60.7	60.1	59.4	46.9	78.8	72.4	67.3	65.4	a
Hargy 2	1973	67.2	72.4	67.5	80.4	70.0	62.8	75.9	76.9	71.8	71.4	78.1	56.3	70.9	a
Means (WNB)		64.5	72.8	72.7	71.2	63.8	57.1	59.0	56.9	57.6	66.5	68.7	57.5	64.0	

i Between fruitset and age significant at 0.1%

Means with different letters differ significantly at 5%

ENTOMOLOGY

INSECT POLLINATION

(R.N.B.P./T.M.)

INVESTIGATION 603, *Elaeidobius kamerunicus*, field studies

Population census and fruitset: Rainfall over West New Britain oil palm area was average for most months of the year. In March 1460mm was recorded at Hargy (Bialla), which is the highest ever recorded. In Oro Province rainfall was also average for most of the year with the usual dry season pattern during April, May and June. Records again indicate a markedly wetter area towards the west of the development which appears to favour weevil development as recorded at Tunana for most months.

The causes of fluctuations in fruitset are difficult to ascertain precisely but during the wettest months in W.N.B. the very heavy rainfall in March probably had the effect of lowering weevil activity during continuous heavy rain. Emergence figures from field material collected then were the lowest on record which coincides with the lowest average fruitset of 51.5% recorded later in August. It is interesting to note that on Dami the number of male flowers per hectare for March was as high as 26 per hectare, however the very low weevil emergence figure (7 adults per spikelet) gave a pollination force of only 23,000, which is well below the estimated minimum of 100,000 weevils per hectare required to give fruit set of 40% and over. For the same period in Oro Province the weevil emergence figures were average to good, in the range 58-167 per spikelet, but in all cases the number of male flowers per hectare (range 9-13), drastically reduced the potential pollination force. The variability in any of the factors used to calculate the pollination force can be caused by overriding climatic effects quite beyond anyones' control. The results todate point more than ever to the need to investigate alternative pollinators to cope with these effects. Genetic planting material which will maintain a continuous supply of male inflorescences becomes more obviously necessary as these studies proceed.

In Oro Province, where the population dynamics of the weevil, flowering and fruitset was monitored at four sites, fruitset was also assessed from monthly samples, each of 20 bunches, taken from six other sites. These ten sites include a range of ages of palms from those planted in 1977 to 1980. Since May 1985 just three sites have been monitored in West New Britain because fruitset was generally considered satifactory, and the weevil and flowering were studied at only one plot on Dami near Buluma. Table 51 shows the fruitset obtained at all sites in 1985. In figure 6 the fruit sets at 2 sites in W.N.B.P. and at both 4 sites and 10 sites in Oro Province are shown graphically which contrasts with a similar presentation given on page 47 of the Annual Report for 1984.

In West New Britain fruitset at Hargy was good but at Buluma deteriorated sharply in May and continued at a level considered marginal for oil to bunch (see Annual Report for 1984, page 47). Average fruitset for the year was highly significantly poorer than at Hargy Oil Palms. In the Province as a whole fruitset was good and showed the mid year drop of about 10% which appears to be the established pattern.

Eight of the sites recorded in Oro Province were on plantations of Higaturu Oil Palms. Average fruitset for the year differed markedly and these differences were very highly significantly ranked positively with the age of the palm. Fruitset in palms seven years or more in the field was above 50% and can be considered satisfactory. There was no statistically significant difference from month to month overall. Age of palm was confounded with site and it can be argued that the correlation with age was false but it follows nicely the expected effect of lower sex ratio as the palms get older. Time will be the test of this as the younger sites continue to be monitored. The exception to this in Oro Province was the village oil palm plot at Tunana where fruitset continued to be good despite the youth of the planting. It is considered the higher rainfall contributed to this result.

Pollination in Oro Province: A study to try and elucidate the reasons for consistently poor fruitset was replicated at Arehe and Ambogo plantations where the worst fruitset has been recorded.

There were four treatments in each plantation with approximately 30 bunches per treatment. In the first treatment female flowers close to anthesis were exposed by removing adjacent fronds and bunches and the sheathes that were covering the flower. In the second treatment the female flowers were exposed in the same way as the first treatment but when the flowers came into anthesis they were given assisted pollination by hand. The third treatment was the control where no fronds or bunches were removed and no assisted pollination was given. The fourth treatment was also left in a natural situation with no frond or bunch removed but assisted pollination was given. It is important to note that in all four treatments insect pollination was constant, no attempt being made to exclude weevils from any of them. Sampling was carried out in two phases, the first was 3 month-old black bunches and the second series was on ripe bunches close to normal harvest condition. Half the bunches were analysed on each occasion. Each bunch was analysed completely (not by sub-sampling) and spikelets from the top, centre and base of the bunches were kept seperate. Percentage fruitset was determined in the usual way as fertile fruit as a percentage of total flowers.

The results indicated that the poor fruitset in this age of planting at Popondetta arose from a combination of pollen shortage which our other studies indicate was due to low numbers of male flowers and, to a less extent, compaction of the base of anthesing flowers due to overcrowding by developing black bunches. The biggest loss in fruitset occurred in the basal portion of the control inflorescences (only 25 percent fruitset). These gave the usual low average fruitset for the whole bunch in the control treatment of around 40 percent, but interestingly the top and centre parts of the bunch had much better percentage fruitset at fifty to sixty percent. Results are summarized in Table 52.

In bunches that had been exposed, basal fruit set was also numerically less than at both the centre and top regions, indicating that weevils were less attracted to the basal region. The reasons for this preference are not fully understood but as anthesis sometimes occurs at a different time at the base it is considered likely that the strength of the odour from the smaller number of basal flowers attracted fewer insects. As anthesis progresses quite rapidly over the rest of the bunch a greater proportion of flowers in simultaneous anthesis occurs in the middle and apical regions and could atract more insects.

Access to the basal part of the inflorescences would appear to be limiting when comparing the control data with those bunches given assisted pollination. The non-exposed bunches given assisted pollination boosted the basal fruitset over the control and one can conclude that pollen blown into the basal part of the inflorescence was effective in most cases. The use of a smaller pollinator than *Elaeidobius* may obtain better penetration in the basal region. The most obvious limiting factor still remains the source of pollen (i.e.) male flowers.

For future breeding the selection of material with long stalks to the bunches should be given more emphasis, as these may give easier access to pollinating insects as well as harvesters.

These experiments confirm that pollen shortage was the main problem in Popondetta at that time and the monitoring of fruitset on all ages of palms indicate that this imbalance of male to female flowers would correct itself after a few years. However this same phenomenon was observed in Columbia where a prolonged dry climate would appear to have a great influence on the sex ratio cycle and produced seasonal pollen shortage in palms 10-15 years old with resulting poor fruit set. In such circumstances irrigation of the plantation in advance of the dry season was considered to be a practical solution which assisted not only palm growth but prevented the dessication of the internal parts of the male flowers where *Elaeidobius* larvae feed. Another alternative would be to change the pollinator fauna for species accustomed to an extremely dry climate. In Popondetta, inspite of the generally poorer fruitset and related low oil extraction from poorly pollinated bunches, the palms appear to compensate by producing a larger number of bunches and total yield per hectare often exceeds 30 tonnes per annum. In West New Britain the high fruit set produces a greater stress on the palms with subsequent effects on yield.

Plantation yields: Production at Walindi plantation was again taken to exemplify trends in W.N.B.P. (Table 53). Both the annual yield, monthly yields and single bunch weights followed closely the pattern of the previous year. No fertilizer has been added to this plantation since the establishment phase in the early 1970's. The total yield has remained the same for three consecutive years.

Table 52: Fruitset studies Arehe and Ambogo estates, Popondetta, 1979/80 plantings

TREATMENT	Fruitset bunch regions top %	centre %	base %	Overall fruitset %	Percentage improvement of treatment over control
1 Exposed	76.7	67.7	46.1	61.6a	+ 40
2 Exposed + assisted pollination	72.6	73.8	70.3	71.9a	+ 64
3 Control	67.6	49.6	25.0	43.9b*	-
4 Assisted pollination	83.4	78.5	48.5	67.8a	+ 54
	65.4 a	60.1 a	45.4 b**	64.1	

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

Table 53: Production FFb/ha 168 hectares, Walindi Plantation, W.N.B.

MONTH	1984 t	s.b.w. kg	1985 t	s.b.w. kg
January	2.6	24.2	2.1	26.2
February	2.4	24.8	1.6	26.1
March	3.8	24.0	2.6	23.1
April	2.8	23.3	2.6	22.7
May	3.2	22.1	2.9	21.9
June	2.0	21.7	2.6	18.5
July	1.9	19.8	2.6	18.2
August	1.3	20.7	1.3	18.3
September	1.0	20.0	2.1	18.8
October	1.1	20.6	1.1	19.4
November	1.0	23.1	1.1	18.0
December	0.7	23.3	1.2	22.5
	23.8	Av. 22.3	23.8	Av. 21.1

Figure 6: Investigation 603, Average monthly fruit, W.N.B. and Oro Province, 1985

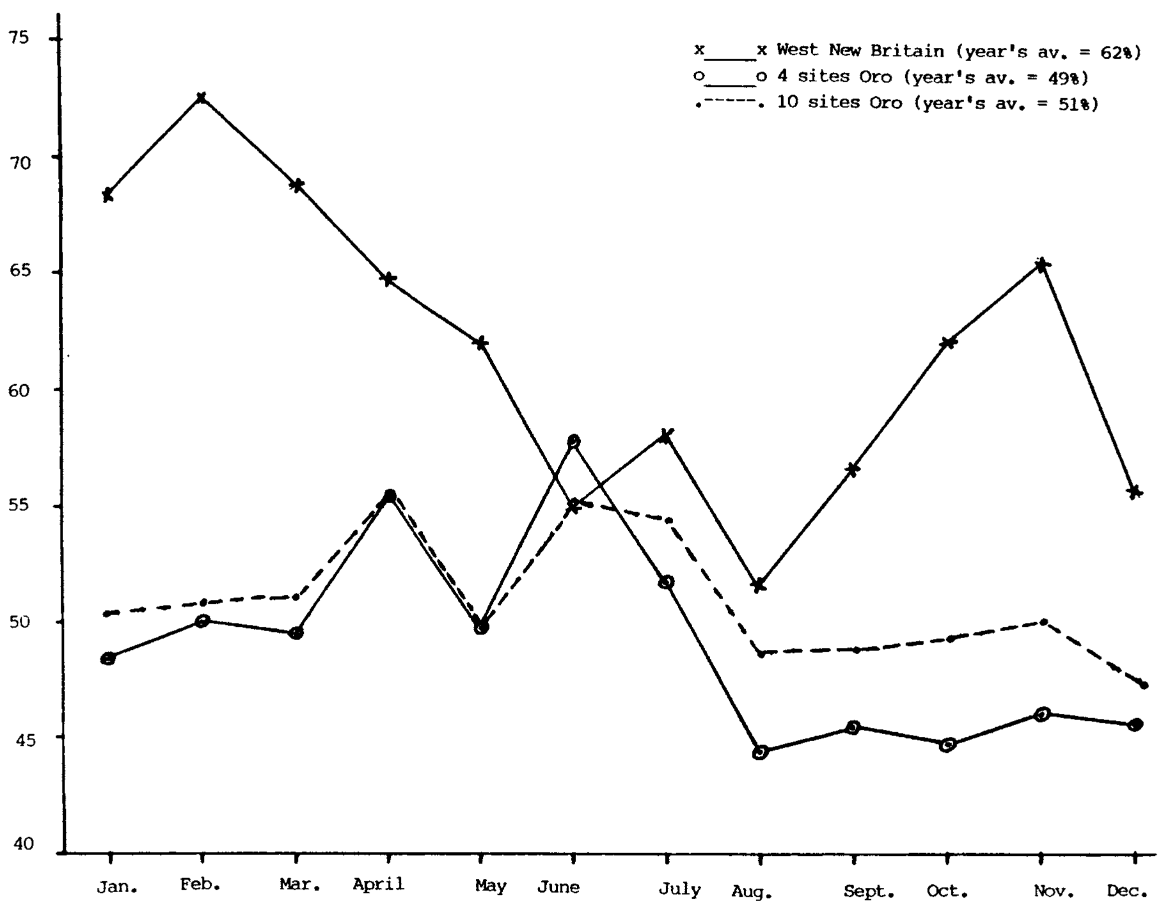
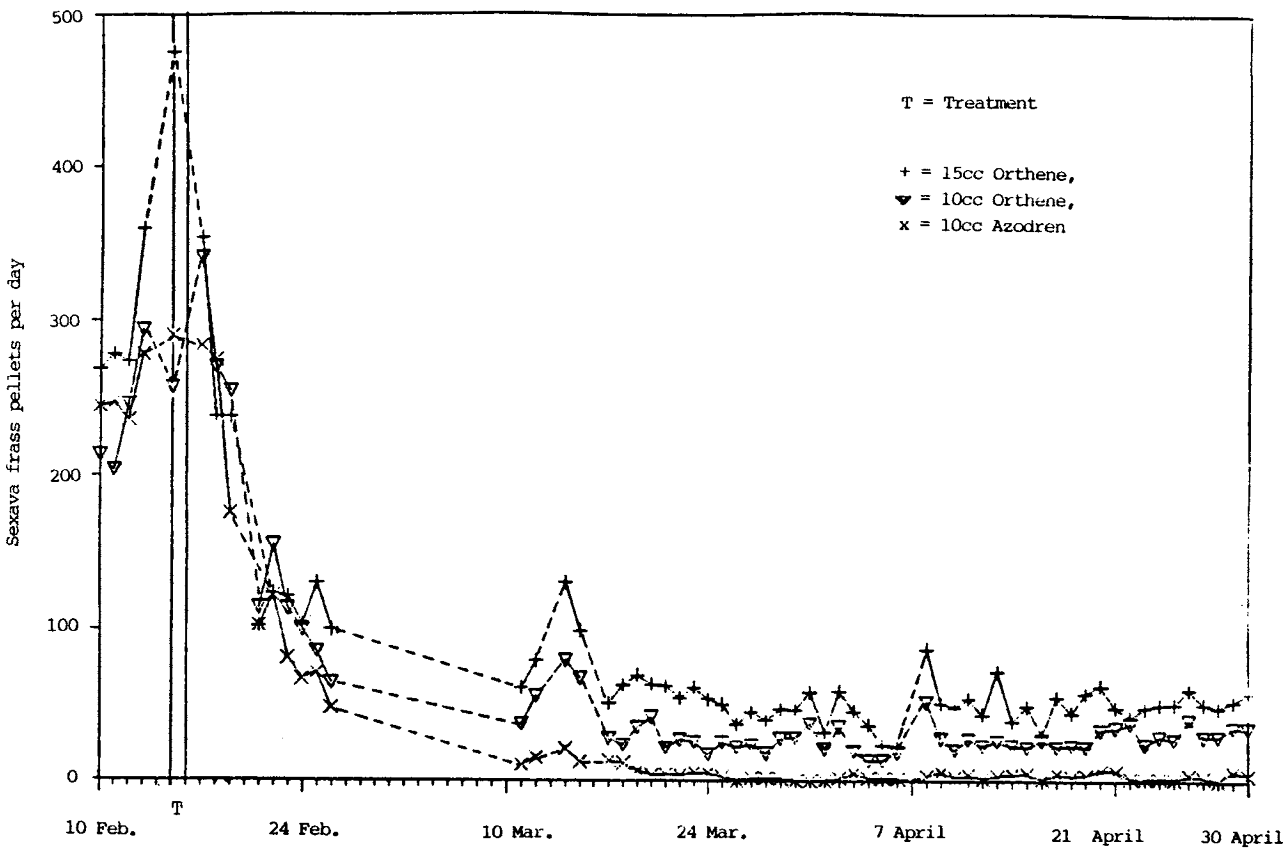


Figure 7: Investigation 601, Effect of systemic insecticides on populations of Sexava



"SEXAVA", SEGESTIDEA AND SEGESTES SPP.

(R.N.B.P.)

INVESTIGATION 601, Sexava chemical control

In West New Britain *Segestidea defoliaria* (Uvarov) remained at low incidence during the year with a slight increase in activity in the last quarter. A related insect, *Segestes decoratus* Redt., severely damaged coconut in the Talasea district of W.N.B. in February. Treatment was successfully carried out on 15,000 palms by injecting 15cc of liquid acephate (Orthene 20L) which gave a spectacular 'knockdown' kill a few days after treatment. As most of the coconuts were over 50 feet tall it was a conclusive demonstration of the effective translocation of the chemical by this method. At Hargy plantation, Bialla, W.N.B. no records of Sexava damage were reported. In Oro Province, where *Segestidea novaeguineae* (Brancsik) is the damaging Sexava, treatment at a low level continued throughout the year on scattered smallholdings.

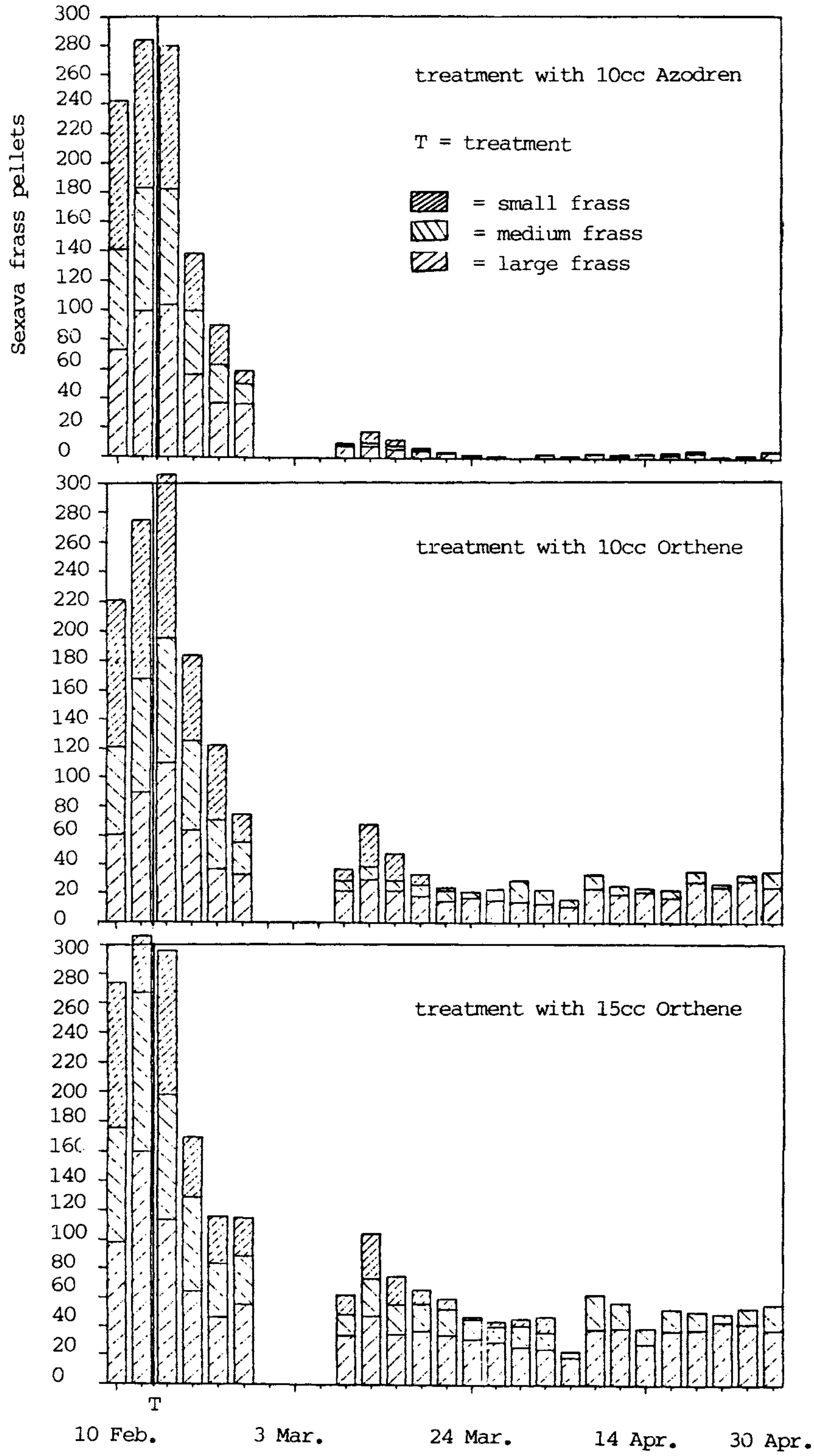
A trial comparing the relative effectiveness of liquid Orthene (acephate) and Azodrin (monocrotophos) was completed between February and April.

The results of the comparative trial using undiluted Orthene 20L at 10cc and 15cc and monocrotophos (Azodrin 40) at 10cc are presented in Figures 7 and 8. The chemicals were applied by trunk injection in one hole. Three blocks of approximately 400 palms were each divided into 3 and randomised for each treatment. 1 metre square sampling sheets were placed randomly, one each under four palms in each treatment block. These blocks were first selected for uniform activity of Sexava by studying pre-treatment frass counts. Damage levels were in the moderate category (above 30 percent defoliation) and pre-treatment counts were of necessity short to prevent more serious damage occurring. This trial was the third attempt to compare these three treatments. Usually the worst damage by Sexava occurs during the rainy season and this makes observations very difficult and in previous attempts they had to be abandoned due to continuous heavy rain at night. A method to assess the level of Sexava activity and the effects of the chemical by determining how many Sexava remained alive after the treatment was developed in 1980. This involved catching the insects' frass by placing trays or plastic sheets under the affected palms. Sexava frass is visible even from the smallest instar as cylindrical pellets ranging from 3mm in the first instar nymphs to 10mm in the adult and the proportions of different instars present can be judged by the proportions of the different frass sizes. The method has been tested several times and has proved very useful when requiring knowledge of the composition of the Sexava population, whether it is mainly adult, immature stages or a mixture of both.

In this experiment a one metre square tray or triangular plastic sheet was used to catch the frass under the palms sampled. Frass counts were taken before, during and after treatment and the frass sorted into large, medium and small categories. As the Sexava feeds at night, counts were done early in the morning, the trays or sheets emptied and replaced for the next morning's count. As sometimes happened, heavy rain during the night spoiled the counts and then the trays were simply cleaned and reset.

Results: The graph (Fig. 8) illustrates the combined (large, medium and small) daily frass counts for all three treatments. The data clearly demonstrate the rapid kill obtained within five days after treatment for all three treatments and the residual population after 30 days is not significantly different. However the monocrotophos (Azodrin) treatment left the smallest number of surviving insects. The recommendations of Orthene 20L manufacturers is 15cc for trunk injection in coconuts and this is why this concentration was used in the trial. Interestingly the 10cc level appeared to give

Figure 8: Investigation 601, Composition of Sexava population before and after treatment



a slightly better result and this concentration can be considered as satisfactory for oil palms 30-40ft tall. The histograms (Fig. 8) show more clearly how the treatment affected the various growth stages of Sexava and in all treatments the small nymphs were eliminated and only a few adult and larger nymphs remained unaffected. The residual affect of the chemicals in the palms could only be judged by the absence of young nymphs which would emerge from eggs laid before treatment began by finding dead or dying insects on the trays during frass counting. Previous trials indicated that monocrotophos (Azodrin) was still giving an effective kill 30 days after treatment and in this trial this was confirmed along with acephate (Orthene) also remaining effective against newly emerged Sexava.

Conclusion: Although this is the first trial to be completed satisfactorily, previous trials have indicated that acephate might be used as an alternative to monocrotophos but there were doubts as to its persistance. The present trial suggests that it is a suitable substitute for monocrotophos.

Until recently a liquid formulation of acephate was not available and wettable powders, although appearing to be similarly effective, were difficult and dangerous to handle in the humid tropics and often exhibited 'flaking' due to some reaction with local water supplies. Acephate is a much safer chemical to handle than monocrotophos insofar as toxicity to man is concerned and this is particularly important locally.

Acephate, as a safer alternative to monocrotophos should be the prefered chemical. However it is recommended that successive treatments in any one area should alternate acephate and monocrotophos to minimise resistance to these insecticides building up in Sexava.

INVESTIGATION 607, **Sexava bio-control**

***Stichotrema* internal parasite studies *(Stylopididae)*:** It had been suspected that some of the mortality in the laboratory infection of *Segestidea defoliaria* in the previous years' experiments may have been caused by too many triungulins invading the host. It can be presumed that in the natural state infection would be of a low order (1-3 triungulins per Sexava) as determined by dissection of many infected specimens. A new set of infections was started in the laboratory in February. Although only 2 out of 12 infected specimens survived for the parasite to mature and emerge, the longevity of the others indicated that the attempt to limit infection to one or two triungulins was successful compared with very rapid mortality where large numbers of triungulins were permitted to invade the Sexava host.

Results (Table 54) also indicate that the time required for the parasite to obtain maturity in this host *(S. defoliaria)* species is approximately 60 days. Attempts to infect Kurakum *(Oecophylla)* ants and other species in the laboratory for rearing of male *Stichotrema* failed completely, mainly because the ants proved difficult to contain and maintain in the laboratory.

During the year stylopised *S. decoratus* were received from D.P.I. Bubia, Morobe Province and some individuals were caged in the field whenever material was surplus to laboratory tests. This was done at Pangalu in young coconuts adjacent to the infested area and which remained untreated, in this case the species of Sexava was the same and therefore transfer of parasites should be easier. Of the hundreds of Sexava species examined both during the Pangalu outbreak on coconuts and from the treated oil palm blocks no evidence exists that *Stichotrema* is present in W.N.B. but efforts to achieve a successful introduction are continuing.

Hymenopterous parasites of Sexava eggs: A visit to New Hanover, New Ireland Province at the begining of September yielded a collection of several hundred Sexava eggs many of which proved to be parasitised. From this material two of the most important egg parasites, *Leefmansia bicolor* Waterst. and *Doirania Leefmansia* Waterst., were successfully hatched and mass rearing in the laboratory for field release into infested areas on West New Britain began in October. One batch of *L. bicolor* was taken to Oro Province and liberated in a Sexava infested block at Waru.

Tachinid fly parasite of adult and immature Sexava: Although the presence of a Tachinid parasite of Sexava has been previously recorded from Morobe and Madang Provinces, a Tachinid has now been recorded from *Segestidea novaeguineae* in Oro Province and identified by Dr. N.P. Wyatt (British Museum Natural History, London) as *Exorista notabilis* (Wlk.). Several Tachinid pupae were collected from Popondetta and sent to W.N.B. Unfortunately they emerged very irregularly and mating could not be achieved.

Two organisms, *Nosema locustae* (Protozoa) and *Paecilomyces reinformis* (Fungal pathogen), have not been pursued.

Table 54: Results of infection by triungulins from Segestes decoratus ex coconuts Bubia, Lae into Segestidea defoliaria ex laboratory reared on oil palm, 2nd February 1985

Adult Material	Days to death after infection	Comments
male	37	3 immature parasite larvae in body
male	41	1 immature parasite larva in body
female	41	5 immature parasite larvae in body
male	44	1 large immature parasite larva in body
female	48	ditto
female	51	ditto
male	58	Mature parasite inside body of host
female	58	ditto
female	58	ditto
male	59	Mature parasite emerged through body wall
female	59	ditto
female	?	Specimen missing

INVESTIGATION 606, Bagworms, *(Lepidoptera Psycidae)* control

In all areas the bagworm, *Mahasena corbetti* caused only slight to moderate damage throughout the year. In one small area on Kumbango Plantation treatment by trunk injection was necessary. In this case large numbers of small bagworms per frond were found and only 7 percent parasitised. In other areas, Sarakolok had moderate damage to two blocks and samples revealed a high natural mortality (71%) with a proportion (17%) parasitised by Tachinids. On Togulo, *M. corbetti* was widespread in June but sampling revealed a high natural mortality (80%) including 28% parasitism by Tachinid flies. No treatment was recommended and subsequent months showed a decline in damage which at no time reached economic levels thus confirming the appropriateness of the recommendation. Collection and identification of parasites continued as material was bred from regular field collections.

INVESTIGATION 605, Records and observations of other pests

Rat damage to male flowers and black bunches was reported as being severe on Arehe plantation, Higaturu, Oro Province at the begining of the year. Subsequently fluctuations in rat damage were noticed during the year in this and other areas on Higaturu. The damage by rats was not assessed in relation to reduction in the weevil population but previous studies in W.N.B. indicated that even in severe cases damage did not correlate with any reduction in fruitset. However the situation in Oro Province, where there is known to be a shortage of male flowers per hectare from time to time may lead to a measurable effect. The several species of rats known to occur on the Higaturu estates have not been identified.

Leaf damage by cockchafers, *Dermolepida* species and by the longicorn beetle *Mulciber linnaei* continue to contribute a little to defoliation by *Segestidea novaeguineae*. However no serious levels of damage have been caused solely by these two beetles.

A new insect pest of oil palm appeared in oil palm blocks on the Isaveni division, Popondetta, Oro Province in association with Sexava *(S. novaeguineae)*. This large insect, a species of *Phasmatodea*, (stick insects) has been sent for identification. It is quite different from another commonly occurring stick insect in the oil palm, *Euracanthus horridus*, which is only found in very small numbers. The new stick insect was in large numbers and could apparently chew a considerable amount of leaf as gauged from caged specimens and field damage. Treatment, if needed would be the same as for Sexava by trunk injection.

PATHOLOGY

(P.J.)

EXPERIMENTS 801 - 804, Incidence and control of Ganoderma disease

A series of experiments numbered 801 through 804 were initiated from 1982 onwards. Their details have been described in the Annual Reports for 1983 and 1984. The Pathologist prepared a report on this research up to the end of 1985 when she departed. This is given here.

Basal stem rot of oil palm - the situation in West New Britain

Introduction: This study first started in 1981 when it was reported by Dr. Turner that in a thinning trial carried out by NBPOD extensive development of numerous fungi was noted on the poisoned palms, and subsequent indentifications at Kew Royal Botanic Gardens showed these to include *Ganoderma* spp. which have been determined as pathogenic to oil palm in other parts of the world. It was necessary to find out whether there would be a potential disease problem using a replanting technique in which poisoned palms were left to rot in situ. Basal stem rot has resulted in losses of up to 60% only 20 years after field planting in parts of Sumatra and Malaysia. Experiments were initiated to investigate ways to avoid this disease hazard if it occurred.

Research using chemical and biological manipulation of oil palm stumps: Disease control was attempted by altering the stump environment, both biologically and chemically, and hence causing a more rapid decay of the stump so that it was no longer a favourable environment for *Ganoderma* spp. This involved two approaches, the first being to alter the stump enviroment chemically using ammonium sulphamate. This has been used in other tree crops and has been found to encourage the development of saprophytic fungi isolated from stump tissue which were antagonistic to *Ganoderma* spp. It was thought that these fungi might be able to compete successfully with the *Ganoderma* within the stump tissue and hence exclude the latter fungus from the stump.

A trial (Experiment 802) was set up to test the ability of ammonium sulphamate as a palm poison and as a degrader of stumps. The results can be summarised as follows:

1. Ammonium sulphamate does not work as a poison for oil palm: even after repeated applications the palms lost the lower fronds but the spear was still alive and the palms recovered.

2. Ammonium sulphamate does not alter the stump environment so that it is unfavourable for *Ganoderma* spp. Application of AMS to the cut stump surface did not alter the rate at which the stump decayed or the number of stumps with *Ganoderma* spp. compared with poisoned palms. It did accelerate decay compared with untreated and non-poisoned stumps.

Useful observations from the trial showed that *Ganoderma* spp. colonised from the frond bases inward towards the centre of the stump, but so did many other fungi which have the potential to be exploited as biological control agents.

Numerous saprophytic fungi and also *Ganoderma* spp. were isolated from the stumps which had been poisoned two and three years previously, and from stumps which had been felled without poisoning. The type of rot that these fungi caused was noted. It was hoped that these, or a selection from the collection, could be used to test their competitive saprophytic ability against *Ganoderma* spp. (Experiment 804). Unfortunately at that time, the pathologist became in sole charge of all cocoa pathology and this very time consuming work had to be abandoned. From preliminary investigations it became obvious that work in oil palm wood for some reason was not as easy as work in dicotyledonous wood: the fungi were more difficult to establish by artificial inoculation and growth was slow. In stumps the fungi have probably become established within the frond bases instead of the stump tissue. If the work is restarted it may be worth trying interactions in wood from the frond bases instead of the stump tissue. Use of coconut tissue as a preliminary screen may be easier to handle than oil palm.

Tests of pathogenicity of species of *Ganoderma* existing in West New Britain: The trials that are in progress (Experiment 803) are all aimed at testing whether or not there is a danger from pathogenic species in West New Britain in replanted palms. Pathogenic species do exist, for example a palm with basal stem rot has been recorded on Dami, but they may occur in such low numbers that they are not a disease hazard.

A field test using seedlings as indicators (Experiment 801): This experiment was set up in 1982 at Bebere plantation on poisoned and non-poisoned palms. Although oil palm plantings do not show symptoms of basal stem rot until they are 5 years old, on several occasions young palms have been killed within 1 - 2 years when planted close to large infected remnants of the previous oil palm stand. It was thought that by planting seedlings as bait close to test material, early infections could be recorded, also palms could be dug up at intervals (2 years or more) and split to look for first indications of the disease before any leaf symptoms developed. The trial has now been closely monitored for three years and seedlings have been removed from treatments in section 9 in 1984 and 1985 to look for infection but none has been found. Throughout the past 3 years the presence of *Ganoderma* sporophores on the stumps has been noted and all of the treatments had numerous sporophores at some time depending on the state of decay of the stumps. It is suggested that at least one seedling palm per stump should remain for another 2 years by which time 5 years of observations will be concluded. If there are no indications of disease by this time we can safely suppose the risk of *Ganoderma* infection in replanted palms will be low if not minimal.

Several methods were used to test pathogenicity by artificial inoculation of oil palm. These methods used were described in detail in the Annual Report for 1984 (Experiment 803). Results can be summarised as follows:

1. Using seedling palms in nursery bags, no infection was found. The roots of the seedlings had grown through the infected oil palm wood without any damage.

2. By direct inoculation into roots of standing palms there were no indications of infection from leaf symptoms, but the palms have not been investigated at the root level.

3. With direct inoculation into the stems of standing palms, one set of which has been cut down and excavated, there was no evidence of infection. The palms at Keravat have not been felled but there is no indication of infection.

4. The main test involved planting infected palm wood at the base of young field palms. So far there is no indication of infection. Two such sets have been planted at Dami beach.

   The last two methods are being repeated using an isolate of the fungus *Ganoderma miniatocinctum* which was isolated from a live infected palm at Dami. This will give an indication of how pathogenic the fungus is and whether the methods used in 3 and 4 are successful.

Pathogenicity of different *Ganoderma* species: In Steyaert's publication on *Ganoderma* species of palms he describes the following three species as probably pathogenic, *G.*

zonatum, *G. miniatocinctum* and *G. boninense*, and the following as probably saprophytic, *G. chalceum*, *G. tornatum* and *G. xylonoides*. The species collected in West New Britain and sent to the Royal Botanic Gardens, Kew for indentification were mainly *G. tornatum* but in addition, specimens of *G. boninense*, *G. miniatocinctum*, *G. pseudoferreum* (also reported as pathogenic), and *G. chalceum* were identified.

Pathogenic species therefore do exist in West New Britain and almost certainly in other oil palm growing areas of the country but in small numbers, the majority of the population being dominated by saprophytic species. What is unknown is how competitive the pathogenic species are compared with the saprophytic ones: that is, when colonising a poisoned palm, are the saprophytic or pathogenic species most successful. Indications suggest the saprophytic species are dominant. If this is the case there is little danger of pathogenic species infecting replanted palms.

Replanting of oil palms - suggestions from the evidence so far: So far, there seems to be little danger of a widespread attack of basal stem rot in replanted palms. To summarise:

a) none of the pathogenicity testing so far has resulted in any infection;

b) there has been no infection in any of the seedling palms planted close to decaying stumps;

c) the majority of *Ganoderma* spp. in West New Britain are not pathogenic.

However, the experiments reported have only been running for a relatively short time in terms of the time *Ganoderma* takes to establish within a living palm so caution should still be adopted. A few more years are needed until it can be said with more certainty that it is possible to poison the palms in situ and leave them standing.

It is suggested that until we have more results from pathogenicity testing and from oil palm seedlings in the field palms need not be bulldozed from the ground but can be poisoned in situ and felled some time within the first year as close to the ground as possible. This will avoid the expense and harmful effects of the current method but by felling the palm as close to the ground as possible will leave a very small food base for pathogenic *Ganoderma* species if they occur.

Suggestions for future work: Pathogenicity studies should continue as well as monitoring disease in the seedling palms. The two methods of pathogenicity testing most likely to give success are direct inoculation into live palms and planting a lump of *Ganoderma* infected tissue at the base of the field palms.

SERVICES

This is a new section to the report and summarises services other than research carried out for the industry. These normally fall into three categories, namely: nutritional (soil and leaf analysis), pests and other problems.

Nutrition

Soil surveys: Soil pits were examined and described in coffee and cocoa areas and in the Embi grassland areas of Oro Province where oil palm is planned. In West New Britain descriptions were given of the soils on Malilimi plantation. Soil water retention characteristics were analysed for soils from both Provinces and reported.

Leaf analysis: Reports were written on results of leaf nutrient analyses taken over Hargy Oil Palms in West New Britain and smallholder blocks in the Popondetta Oil Palm development. On Togulo plantation in West New Britain areas affected by leaf yellowing and sites where symptoms similar to boron deficiency were common were sampled and reported upon. An observational trial was laid down with potassium sulphate, muriate of potash and kieserite and petiole cross section measured in the areas with leaf yellowing and these will be monitored.

Pest control

Monthly surveys of defoliation caused by insects were carried out at Hargy Oil Palms in West New Britain and the smallholding development around Popondetta. Elsewhere they were done by either the Department of Primary Industry or nucleus plantation staff. In all cases reported outbreaks were assessed by PNGOPRA's entomological staff and recommendations given for treatment by trunk injection of systemic insecticide. This was necessary against Sexava in Pangalu, Buvussi, Kumbango, Kapore, Galai, Kavui in West New Britain, Higaturu Oil Palms and Popondetta blocks. Control of bagworms was necessary at Kumbango, Bebere (hand-picking in the nursery), otherwise natural biological control was sufficient. Recommendations were given to control the weevil *Rhabdoscelis* by sanitation (removing bunch remains from palm crowns) on Togulo plantation.

Pests of cocoa and coconuts at Mamba (Oro Province) and at the Lavengai Mission Station (New Ireland) were visited and reported upon.

The first field release of a hymenopterous egg parasite of Sexava was made at Kumbango and Buvussi.

Other

Demonstration of the Association's work were given to Smallholders in Oro Province and fertilizer use in replantings in West New Britain to DPI personnel and blockholders there. Sick cocoa at Ponini Agricultural Centre was examined by the Pathologist and underspread damage by *Pantorytes* beetles diagnosed. Comments were made about fly problems associated with mulching of empty bunches on a wide scale on Kumbango plantation.

APPENDIX I

METEOROLOGICAL DATA

The data presented below was made available by courtesy of NBPOD, Hargy Oil Palms Pty. Ltd., and Higaturu Oil Palms 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 55: Rainfall (mm), Hargy, 1985

	Jan.	Feb.	March	April	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Total
1985	550	610	1460	345	1620	383	467	368	248	218	1199	1620	9088
1984	215	229	687	164	169	240	443	143	375	567	190	1325	4747
Mean 1981-85	546	584	814	328	446	256	370	284	251	265	393	818	5355

Table 56: Meteorological data, Higaturu, 1985

	Rainfall mm			Sunshine hrs			Rainy days		
	1984	1985	1981-85	1984	1985	1981-85	1984	1985	1981-85
January	55	196	226	210	152	169	10	21	16
February	176	223	273	168	89	121	20	21	12
March	289	272	362	132	145	160	23	23	21
April	204	178	210	174	189	170	20	15	18
May	229	232	210	143	154	156	19	21	16
June	180	192	176	130	120	140	18	16	16
July	88	65	72	137	177	154	11	11	10
August	164	141	121	140	194	172	18	14	14
September	144	203	143	219	180	174	12	20	14
October	362	365	259	167	230	176	19	13	17
November	239	366	253	226	139	184	17	25	16
December	291	371	338	141	171	150	21	16	18
Total	2421	2803	2645	1987	1938	1926	208	216	197

Table 57: Meteorological data, Dami, 1984

	Rainfall mm			Sunshine hrs			Temperature °C		Rainy days	Sunshine hrs
			Mean			Mean	max	min		
	1984	1985	1970-85	1984	1985	1970-85	1985	1985	1985	1985
January	194	530	647	209	118	120	30.3	22.6	27	118
February	241	409	647	177	115	117	31.1	22.6	22	115
March	565	889	555	136	121	123	25.3	21.8	30	121
April	373	139	347	132	149	148	31.6	22.8	18	149
May	126	267	234	145	170	173	31.4	22.8	17	170
June	219	246	163	139	163	161	31.4	22.7	15	163
July	185	205	190	122	158	161	30.3	22.7	17	158
August	104	126	158	188	179	178	30.9	22.7	18	179
September	180	247	178	164	185	183	31.2	22.4	26	185
October	197	181	163	185	184	187	31.7	22.9	19	184
November	233	454	261	191	180	184	30.8	22.8	27	180
December	572	386	374	57	131	134	31.1	22.8	22	131
Total	3189	4079	3917	1845	1852	-	-	-	258	1852

APPENDIX II

THE ASSOCIATION'S ACCOUNTS FOR 1985

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 1985 and of its income and expenditure for the period ended on that date.

Price Waterhouse
Chartered Accountants
Lae, March 1986

Balance sheet as at 31st December, 1985

	KINA
Accumulated funds	75,028
Represented by:	
FIXED ASSETS	46,074
CURRENT ASSETS:	
Cash at bank and on hand	21,559
Debtors	91,842
	113,401
CURRENT LIABILITIES:	
Trade Creditors	47,194
Other Creditors and Accruals	37,253
	84,447
Net Current Assets/Liabilities	28,954
	75,028

Statement of Income and Expenditure for the year ended 31st December 1985

INCOME:	KINA
FFB Levy	434,864
Profit on Disposal of Fixed Assets	-
	434,864
EXPENDITURE:	
Agency, Audit, Legal and Professional fees	13,886
Bank charges	1,801
Depreciation	17,477
Direct experiment costs	46,417
Electricity, water and gas	15,685
Insurance	3,510
Laboratory	592
Medical	3,559
Motor Vehicles	16,909
Office expenses	7,662
Rentals and other accomodation costs	62,785
Repair and Maintenance - buildings	15,276
Salaries, wages and allowances	165,046
Staff recruitment	6,701
Staff training	-
Travel and entertainment	16,409
Loss on disposal of fixed assets	364
	394,079
SURPLUS FOR THE YEAR	40,785
ACCUMULATED FUNDS 1st JANUARY	34,243
ACCUMULATED FUNDS 31st DECEMBER	75,028

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	40,354
Less accumulated depreciation	11,193
	29,161
Motor vehicles at cost	44,137
Less accumulated depreciation	27,224
	16,913
Total written down values	46,074

MANAGEMENT BOARD'S STATEMENT

We, R.A. Gillbanks M.B.E. and N. van der Laan, 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, 1985 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, 1985 and of the results for the period ended on that date.

Lae,
March 1985

APPENDIX III

LIST OF INVESTIGATIONS

Number	Title	Initiated	Concluded
101	Bebere fertilizer trial	1968	1982
102	Dami density trial	1970	
103	Kumbango sources of potash trial	1976	1982
104	Bebere thinning trial	1978	1985
105	Bebere thinning trial	1979	1985
106	Bebere replanting establishment trial	1982	
107	Bebere replanting fertilizer trial	1982	
108	Kumbango mature palm nitrogen/anion fertilizer trial	1985	
109a	Bebere factory-waste manurial trial	1984	
109b	Bebere factory-waste manurial trial	1985	
110	Bebere nitrogen/anion trial on young replanted palms	1984/5*	
111	Malilimi nitrogen and phosphate fertilizer trial	1985	
112	Buvussi Nitrogen and phosphate fertilizer trial	1985	
113	Smallholders' nitrogen fertilizer trial on replanted palms with food crops, W.N.B.P.	1986	
201	Hargy fertilizer trial	1982	
202	Hargy refuse manurial trial	1984	
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	1984	
309	Ambogo bunch refuse manurial trial	1984	
601	Sexava: chemical control	1981	
602	Pollinators: introductions	1980	
603	Elaeidobius kamerunicus: field studies	1981	
604	Sexava: field studies	1981	
605	Other pests: general studies	1981	
606	Bagworms: general studies	1982	
607	Sexava: biological control	1983	
701	Flower fertility project	1979	1981
702	Effects of competition	1981	
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	1985	
706	Continuous flowering censuses	1981	
707	Continuous vegetative growth study	1980	
708	Continuous leaf nutrient level study	1980	
801	Incidence of Ganoderma disease	1982	
802	Treatment of oil palm stumps with AMS	1983	
803	Ganoderma spp. tests of pathogenicity	1983	

* modified 1985 from establishment trial

APPENDIX IV

LITERATURE CITED

1. Surre, C. (1968) Les besoins en eau du palmier a huile. Oleagineux, 23, (3), 165-167.

2. Thornthwaite, C.W. and Mather, J.R. (1957) Instructions and tables for computing potential evapotranspiration and the water balance. Centerton, New Jersey.

3. Steyaert, R.L. (1967) Les *Ganoderma* parmicoles. Bull. du Jardin Botanique de Belgique 37, (4), 465-392

4. van Heel, W.A., Breure, C.J. and Menendez, T. (1986) The early development of inflorescences and flowers of the oil palm (*Elaeis guineensis*, Jacq.) as seen through the scanning electron microscope. Blumea (in press).