ANNUAL REPORT

OF

THE PAPUA NEW GUINEA
OIL PALM RESEARCH ASSOCIATION

1984

FOURTH ANNUAL REPORT

of the

PAPUA NEW GUINEA OIL PALM RESEARCH ASSOCIATION

1984

MANAGEMENT BOARD

CHAIRMAN — R.A. Gillbanks, New Britain Palm Oil Development Ltd.

DEPARTMENT OF PRIMARY INDUSTRY	R. Doery (alternate to Secretary, D.P.I.)
HARGY OIL PALMS PTY. LTD.	N. van der Laan,
HIGATURU OIL PALMS PTY. LTD.	F. E. McGuire
DIRECTOR OF RESEARCH	T. Menendez,
MANAGING AGENTS REPRESENTATIVE AND SECRETARY	J.F.W. Benn.

SCIENTIFIC ADVISORY BOARD

as at 8th November, 1983

R.A. GILLBANKS (Chairman)	Chairman, PNGOPRA,
R. DOERY	Department of Primary Industry,
J. PIGGOTT	Higaturu Oil Palms Pty. Ltd.
GUHA	Hargy Oil Palms Pty. Ltd.
P.D. TURNER	New Britain Palm Oil Development Ltd.,
E.A. ROSENQUIST	Harrisons Fleming Advisory Services Ltd.
T. MENENDEZ	Director of Research,

In attendance

J.F.W. BENN	Secretary, PNGOPRA.
F.E. McGUIRE	Higaturu Oil Palms Pty. Ltd.
A. BENTON	Higaturu Oil Palms Pty. Ltd.
T.M. CRABB	New Britain Palm Oil Development Ltd.
H.C. HARRIES	New Britain Palm Oil Development Ltd.
R.N.B. PRIOR	Entomologist, PNGOPRA.
F.C.T. GUIKING	Agronomist, PNGOPRA.

EXECUTIVE STAFF

during 1984

DIRECTOR OF RESEARCH	T. Menendez, B.Sc., DPB., M.I. Biol.,
AGRONOMIST	Ir. F.C.T. Guiking
ASSISTANT AGRONOMIST (Higaturu)	P. Navus, B.Ag. Sci.,
ASSISTANT AGRONOMIST (Dami)	P. Sereva, B.Ag. Sci.,
ENTOMOLOGIST	R.N.B. Prior, M.Sc.[1],
PATHOLOGIST	P. Jollands, Ph. D[2]

JUNIOR STAFF

PRIVATE SECRETARY	C. Pa'Agau
SENIOR TECHNICAL ASSISTANT	S. Embupa (from July)
TECHNICAL ASSISTANTS	J. Gorea (Higaturu) (until October) D. Tomare (Higaturu) (from November)
SUPERVISOR	M. Furigi
SENIOR FIELD ASSISTANT	J. Nagi (Hargy)
FIELD ASSISTANT	P. Engio (until December)
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 (from September)
(Clerical)	B. Bubu I. Duna (Higaturu) P. Tarau
DRIVER/HANDYMAN	K. Duke

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

CHAIRMAN'S STATEMENT

The last year has been an extraordinary one for the Oil Palm Industry in Papua New Guinea. The dramatic rise in world market prices for vegetable oils that started in 1983 continued into 1984 reaching a peak of US$935 for a tonne of palm oil. Fresh fruit bunch prices peaked at over K120 per tonne in June, 12 times the price at the start of 1983. The remainder of the year saw prices fall back but they appear to have stabilised at a very satisfactory level around the K70 mark helped by the strength of the United States Dollar. The benefits of research with its long term objectives are easier for producers to appreciate in a healthy economic climate, its results should help producers weather economic storms.

Crops have recovered somewhat from the stress brought on by the pollinating weevil's advent and the drought of 1982, though sex ratios continued to be affected, with high male flower counts in older areas. Crop prediction still remains a problem, the production pattern has not yet stabilised after the ups and downs brought on by the coincidence of weevil and drought. At the Annual General Meeting in 1984 it was agreed that the Research Levy be raised from K0.55 to K0.71 per tonne FFB at which level it was anticipated that all available funds would be consumed. In the event income in 1984 just exceeded expenditure due to a saving of some K13,000 on the latter. The Association has net current liabilities of K10,237 which will have to be carried forward to 1985. The association has a clear need to build up a contingency reserve.

Oil Palm Research in Papua New Guinea is unique in having been funded and controlled by the industry from the outset. Staffing assistance has been provided by the National Government and for this the Association is grateful, but we continue to be disappointed at the lack of financial assistance provided, particularly in view of the growth potential for the industry in PNG and the benefits which will accrue to many new people entering the industry; ranging from large investors to small growers. Our attempts to obtain overseas aid for specific areas of research have so far not succeeded.

Our research programme, although constrained from entering new areas of endeavour from lack of funds, does continue to progress in agronomy (including nutrition), entomology and pathology, also some physiological studies are being conducted. Results of immediate practical significance this year include a strong indication of the need for nitrogen fertilizer during replanting at Hoskins and significant responses to fertilisers at Hargy and Higaturu. The causes of lower fruitsets at Higaturu were shown to be related to low male flower production in young palms rather than any deficiency in the pollinating weevil itself. It continues to perform well. Interesting studies on parasitism of common insect pests may lead to improved methods of control. The programme now includes the use of effluents as organic fertilisers, a subject of considerable interest, the benefits of which will take time to establish.

Two more oil palm projects start in 1985, Milne Bay and Kapiura. An expansion of staff is proposed with the recruitment of an additional expatriate agronomist based at Higaturu for Popondetta and Milne Bay areas. The need for a strong and active research body continues and it is particularly pleasing to me to mention the support and interest given by the Members of the Association. It is interesting to note our Association has been used as an example for other industry-based research programmes in PNG.

I would therefore like to end by thanking my fellow Members for their support in the last year. One Member's representative, Mr. John Langton of Higaturu, departed Papua New Guinea during the year, we wish him and his family well and welcome Mr. Frank McGuire in his stead. My thanks go also to the members of the Scientific Advisory Board and the Managing Agents for all their advice and assistance. Finally I would like to congratulate the Director and his staff on a good year. Results are now beginning to flow and we look forward to seeing publications both in the form of scientific treaties and, more importantly, as grower guides in simple language based on sound research work.

R.A. GILLBANKS, MBE.

CONTENTS

INTRODUCTION

PART I. ADMINISTRATION AND DEVELOPMENT

PART II. RESEARCH

AGRONOMY

Fertilizer trials

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

MANAGEMENT BOARD AND SCIENTIFIC ADVISORY BOARD

There were two business meetings of the Management Board, one in Lae in March and the second at Dami in November. The Third Annual General Meeting of the Association was held in Lae on 30th March when Mr R.A. Gillbanks was re-elected as Chairman for the ensuing year. Messrs. Harrisons and Crosfield (PNG) Ltd were re-elected Managing Agents to hold office until the next Annual General Meeting.

Several changes were seen in the membership of the Management and Scientific Advisory Boards. Mr R. Doery represented the Department of Primary Industry both as the Secretary's alternate and Technical Advisor. Mr F.E. McGuire represented Higaturu Oil Palms Pty. Ltd. as the General Manager succeeding Mr J. Langton. Dr. Guha was welcomed back as Technical Advisor for Hargy Oil Palms Pty. Ltd. and Mr E.A. Rosenquist returned to give his usual valuable contributions to the Scientific Advisory Board. Mr A. Benton, Higaturu Oil Palms' new Field Manager, was in attendance. The Scientific Advisory Board's meeting at Dami on 8th November was preceeded on the previous day by a morning's visit to see the Association's work at Hargy Oil Palms' plantation in West Britain and experiments on plantations of New Britain Palm Oil Development were examined in the afternoon. Technical discussions between individual technical advisors and PNGOPRA staff prior to the gathering were particularly useful and will be encouraged in future. It was planned to meet at Higaturu Oil Palms in Oro Province in 1985.

FINANCE

Income derived from the levy to all intents and purposes equalled actual expenditure leaving a very small surplus for the year but there were overall net current liabilities. This situation was thus similar to that of one year before.

Messrs Price-Waterhouse were re-elected as auditors.

STAFF

The establishment of staff was stable during the year, changes only occuring at the junior staff level.

Both Dr. Jollands and Mr Prior continued their work for PNGOPRA as before, Mr Prior being attached fulltime.

Mr Navus continued in-charge of the Association's sub-station in the Oro Province except for the period of his leave in January when he was relieved by Mr F.C.T. Guiking.

One new recorder was appointed at Dami, chosen from "semi-permanent" casual workers who had been employed previously. A clerical recorder was appointed at Higaturu to mind the meteorological station as well as other records. The technical assistant at Higaturu was replaced towards the end of the year by a previous PNGOPRA employee who had left to work for a spell with Ramu Sugar. New appointees received in-service training as required.

Mr Sereva returned in April from prolonged sick leave and was able to resume full duty. His probationary period was extended.

Mid-year salary increments were paid as appropriate to executive and junior staff. The latter also received a revision of wages in March to meet increases in the cost of living.

The distribution and establishment of staff during 1984 and recommendations for 1985 were as follows:—

Post	Base	Filled as at 13/12/83	Filled as at 31/12/84	Recommended 1985
Director of Research	Dami	1	1	1
Agronomists	Dami	1	1	1
	Higaturu	0	0	1
Assistant Agronomists	Dami	1	1	3
	Higaturu	1	1	0
Pathologist	Keravat	1	1	1
Entomologist	Dami	1	1	1
		6	6	8
Private Secretary	Dami	1	1	1
Clerks	Dami	1	1	1
Recorders (clerical)	Dami	2	2	2
	Higaturu	0	1	1
Driver/handyman	Dami	1	1	1
Supervisors	Dami	1	1	1
Senior technical assistants	Dami	0	1	1
Technical assistants	Higaturu	1	1	1
Senior field assistants	Hargy	1	1	1
Field assistants	Dami	1	0	1
	Higaturu	0	0	1
Technicians	Dami	4	5	5
	Higaturu	5	4	4
		18	19	21

TOURS AND VISISTS

Two international conferences were attended, the Agronomist presenting a paper at the International Conference on Soils and Nutrition of Perennial Crops held in Kuala Lumpur from 13-16th August and the Entomologist attending the Symposium on the Impact of the Pollinating Weevil on the Malaysian Oil Palm Industry on 21-22nd February also in the Malaysian capital city. Whilst on leave the Director of Research visited Unifield T.C. Ltd. at Bedford. U.K., the Department of Tropical Agriculture of the University of Wageningen and consultants at Renkum in Holland as well as the entomological section of the Smithsonian Institution in Washington D.C.

During the course of the Association's work in PNG, the Executive staff based at Dami visited Hargy Oil Palms on ten occasions and Higaturu Oil Palms on six. The Agronomist was at Higaturu for a whole month while relieving the officer in-charge. The Senior Technical Assistant was also based in the Oro Province for a month during the change of staff there. The Managing Agents in Lae were visited twice by the Director of Research who also went to Rabaul to visit the printers of the 1983 Annual Report and to Port Moresby twice for meetings. The Agronomist also visited Port Moresby to obtain information on soils of PNG from the Department of Primary Industry and the University there. The Pathologist visited Dami twice.

PUBLICATIONS AND REPORTS

A paper entitled "Problems in the uptake of potash by the oil palm (E. guineensis) in Papua New Guinea" was presented by the Agronomist at the International Conference on Soils and Nutrition of Perennial Crops and will appear in the proceedings thereof.

The Third Annual Report was published in October. Ten confidential monthly reports were sent to the Managing Agents which were of a largely administrative nature but included summaries of work scheduled and completed for the experiments in the field. Four Quarterly Researh Progress Reports were circulated to all members and their technical advisors. This routine of reporting was satisfactory.

Occasional reports and reports on visits to Popondetta and Bialla were circulated appropriately. The Entomologist sent regular progress reports to the Chief Entomologist of the Department of Primary Industry, with copies to their other senior entomologists.

LIBRARY

The library was re-sited in the NBPOD OPRS building at Dami and has been operated by them with support and some subscriptions from PNGOPRA.

VISITORS

The following visitors were recorded at the Directorate of Research:

N.K. Amu., Twifo Oil Palms Plantations Ltd., Ghana; V. Benn, Awilunga, Lae; A.A. Benton, Higaturu Oil Palms Pty. Ltd., Popondetta; C.J. Breure, Harrisons Fleming Advisory Services Ltd., London, U.K.; E.J. Brough University of P.N.G., Waigani; A. Brownlie, I.C.I., PNG, P/L., Lae; M.J. Chujo, Kyushu University, Japan; T.M. Crabb, Harrisons and Crosfield, Lae; R. Doery, Department of Primary Industry, Konedobu; Dr. Guha, Hargy Oil Palms Pty. Ltd., Bialla; A.M. Gurnah, University of Technology, Lae; M.J. Hadley, Harrisons and Crosfield PLC, London, U.K.; Y. Hirashima, Kyushu University, Japan; H.C. Harries, New Britain Palm Oil Development, Dami; N. Jones, Phosphate Mining Company of Christmas Island, Melbourne, Australia; Takayo Kano, University of Agriculture, Tokyo, Japan; Pikah Joseph Kohun, University of Technology, Lae; F.E. McGuire, Higaturu Oil Palms Pty. Ltd., Popondetta; C.T. Menendez, Kings Stanley, Gloucestershire, England; C. Mercer, University of Technology, Lae: R.W. Orr, Analytical Services Ltd., Cambridge, New Zealand; J. Piggott, Commonwealth Development Corporation, London, U.K.; T.D. Preston, Harrisons and Crosfield PL, 'Sydney, Australia; E.A. Rosenquist, Harrisons Fleming Advisory Services Ltd., London, U.K.; A. Saole, Vovosi, W.N.B.P.; C. Shearing, World Bank, Washington D.C. U.S.A.; Trayambkeshwar P.N. Sinha, World Bank, Washington D.C. U.S.A.; P.D. Turner, Harrisons Fleming Advisory Services Ltd., London U.K.; M.B. Wilson, Harcros Trading Ltd., Kimbe; D.J. Watt, I.C.I. PNG Pty. Ltd., Lae; Toshikatsu Yamamuto, Stettin Bay Lumber Company, Buluma.

PHYSICAL DEVELOPMENT

BUILDINGS

The temporary, entomological buildings at Higaturu remained unchanged but were adequate for the work being carried out. It was agreed that the offices rented at Dami would be substantially modified during 1985. This is an eagerly anticipated change despite the ruptions it will cause. The allocation of rented buildings and rooms is shown below.

	31/12/83	31/12/84
N.B.P.O.D.		
Offices and laboratory (rooms)	7	7
Entomological building	1	1
Storerooms	2	2
'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
Girl's quarters	1	1
HARGY OIL PALMS		
Office	1	1
Bossboi quarters	1	1
HIGATURU OIL PALMS		
Agronomy Building	1	1
Entomological office	1	1
Insectory	1	1
Executive Houses	1	1
Supervisors' quarters	0	1
Bossboi quarters	1	0
IM quarters	1	1
Labour quarters	1	1

MAINTENANCE OF BUILDINGS

Routine maintenance by the landlords kept buildings in a satisfactory condition. The wall dividing the records and secretary's offices at Dami was altered to give common circulation of air to top and bottom and the interconnecting door was removed. Redecoration of the majority of buildings at Dami is due next year.

VEHICLES

One new vehicle was bought, a 4-wheel drive Toyota Hilux single-cab utility being chosen to replace the Agronomist's old one. The Hi-Ace commuter proved a useful and comfortable vehicle which protected both recorders and records from the weather. It had the disadvantages of not being suitable where 4-wheel drive was necessary (Togulo plantation) or for carrying bulky cargo despite normally being operated with the back row of seats removed. Its long roof fitted with a rack was good for carrying ladders. A ladder-rack was also fitted to the Entomologist's utility. It was evident that the third year is indeed the last useful year for running these work vehicles under local conditions.

The fleet of vehicles at the year's end is given below.

Vehicle	Reg. No.	Customary user	Date Purchased	km run
Hilux 4WD single cab utility	ADT-834	Asst. Agronomist	May 1982	80,425
Hi-Ace Commuter	AEA-691	Driver/Handyman	Mar. 1983	64,594
Hilux 4WD twin cab utility	AEJ-558	Director of Research	Nov. 1983	17,999
Hilux 2WD single cab utility	AEJ-601	Entomologist	Dec. 1983	27,461
Hilux 4WD single cab utility	AEJ-621	Agronomist	Jan. 1984	14,950

The Association had a financial interest in four motorcycles at the end of the year. These had been bought for and were being repaid regularly by the Technical Assistant at Higaturu, Senior Field Assistant at Hargy, Supervisor at Dami and Research Recorder at Bebere plantation. Motor vehicle allowances were paid on three executive staff vehicles.

OFFICE AND LABORATORY EQUIPMENT

The Nashua photocopier was replaced in January with a Ricoh FT4060. The extra facilities - reduction, enlargement and A3 capacity proved very useful, especially for preparing field plans and tables and figures for reports. What did one do without them? An airconditioner was installed to cool the records and secretary's offices at Dami.

Once a fresh typewriter was installed no further trouble was experienced with this equipment. One Hewlett Packard 15C programmable calculator was allocated to the office at Higaturu. A Hewlett Packard 42CX with card reader and statistics pack were purchased together with a third HP15C for use at Dami. All this equipment was functioning well at the year's end although earlier the copier had been out of action for a while through no fault of its own.

OTHER SERVICES

The exclusive use of one of the two lines at Dami was continued but the service provided by the Post and Telecommunication Corporation was not always satisfactory. It is anticipated that an additional VHF line and a PBX will be installed during 1985 to serve all offices at Dami. Also at Dami electricity was generally satisfactory but the piped water supply was inadequate and caused considerable difficulties and dissatisfaction for the junior staff who were most affected. By the end of the year improvements were in hand.

Medical services provided by the companies met the majority of needs but the Agronomist's wife spent a period in Holland for diagnosis and treatment of a back injury and the Director of Research's wife found local X-ray facilities inadequate to provide clear pictures of a broken leg. In both cases the lack of local physiotherapeutic facilities or advice was felt. Local medical facilities in West New Britain deteriorated apart from the regular visits by the Company's doctor. Staff requiring treatment at local hospitals or clinics were transported as necessary.

For the first time, at last, (sic), the roadway between Kimbe and Bialla was completed and open to traffic. This enabled mobile recorders to visit Hargy to assist for special work and for the Association's vehicles to be used during visits by executive staff for applying treatments.

In general communications between the Direction of Research and it's substations were unsatisfactory. Telephonic links with Hargy and Higaturu were dreadful and mail or express air cargo services to Popondetta protracted. This hindered administration of research and delayed its reporting.

PART II. RESEARCH

AGRONOMY

(F.C.T.G.)

WEST NEW BRITAIN PROVINCE

EXPERIMENT 101b, Bebere leaf nutrient monitoring plots

Planted in August 1968 at 143 palms/ha; thinned by ⅓ in October 1976.

Design: 6 plots of 9, 10 or 11 palms each. Plots were part of a concluded fertilizer experiment with a total of 64 plots of 16 palms each, thinned to 10 or 11 palms per plot. Plots had no guard rows, but were separated on all sides by trenches.

From April 1982 leaf samples have been taken from the six selected plots of the concluded fertilizer experiment on a monthly basis, but this was changed in March 1983 to bi-monthly. Fertilizers were applied up to 1979 at the following rates:

fertilizer regime	*kg fertilizer/palm. year*						
	plot	N	P	K	Mg	S	Mn
low	47	0	0	0	0	0	0
	24	0	0	0	0	1.0	0.2
	17	0	0.75	0	0	1.0	0
high	62	2.25	0.75	3.0	3.0	1.0	0.2
	10	2.25	0.75	4.5	0	1.0	0
	44	1.50	0.75	4.5	3.0	1.0	0

Nitrogen was given as urea, phosphate as disodium phosphate, potassium as muriate of potash, magnesium as magnesium chloride, sulphur as flowers of sulphur, and manganese as manganese chloride. No fertilizer has been applied since 1979.

Originally the main purpose of continuing measurements was to monitor trends in leaf nutrients following the advent of the weevil, but later the emphasis came more on the study of the dynamics of leaf nutrient contents. Yield recording of these six selected plots continued as a concomitant observation.

Results: Leaf analysis results for 1983, averaged for each set of three plots, are given in Table 1; for some nutrients the results since April 1982 are plotted in Figure 1. The associated yield data are given in Figure 2. Since harvesting was on a weekly basis some months had relative peak yields due to occurrance of 5 harvests instead of the usual 4. This bias has been eliminated in the data presented here by multiplying those month's production by 4/5.

Table 1: *Experiment 101, leaf nutrient levels during 1984 in leaf 17 for plots previously with a low or high fertilizer regime.*

Element %	*Fertilizer regime*	*JAN*	*MAR*	*MAY*	*JUL*	*SEP*	*NOV*
N	low	2.4	2.4	2.3	2.4	2.4	2.4
	high	2.4	2.4	2.4	2.4	2.4	2.4
P	low	.15	.16	.14	.14	.15	.15
	high	.15	.15	.15	.15	.15	.15
K	low	.88	.95	.83	.85	.80	.95
	high	.79	.82	.77	.85	.80	.94
S	low	.13	.19	.15	.16	.16	.17
	high	.13	.18	.17	.16	.14	.17
Ca	low	.93	.91	.90	.92	.87	.87
	high	.99	.99	.93	.89	.91	.87
Mg	low	.15	.14	.16	.14	.14	.16
	high	.16	.15	.16	.17	.16	.17
Na	low	.03	.00	.01	.01	.01	.01
	high	.02	.00	.01	.01	.01	.01
Cl	low	.34	.31	.31	.34	.36	.37
	high	.48	.42	.42	.46	.47	.47
ppm							
Fe	low	64	57	58	62	57	66
	high	67	55	56	54	67	78
Mn	low	59	61	63	77	61	68
	high	77	83	83	69	75	79
Zn	low	19	18	18	20	21	23
	high	18	18	18	19	19	22
Cu	low	7	5	5	6	6	7
	high	7	6	5	6	6	6
B	low	16	17	15	15	18	15
	high	15	17	16	15	14	15

Figure 1: *Experiment 101, leaf nutrient contents in leaf 17, April 1982 - November 1984 for plots with a previously low, or high fertilizer regime.*

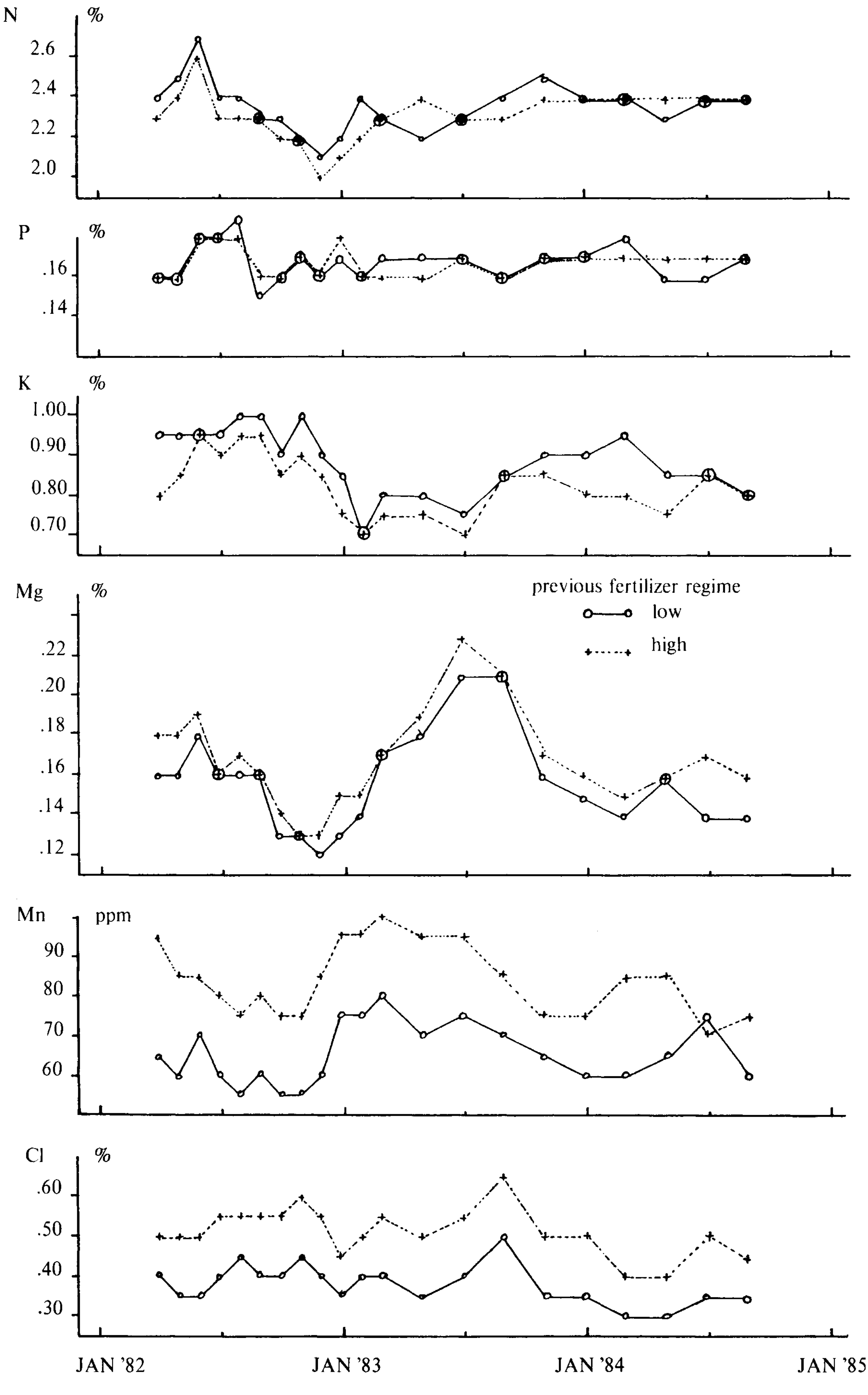
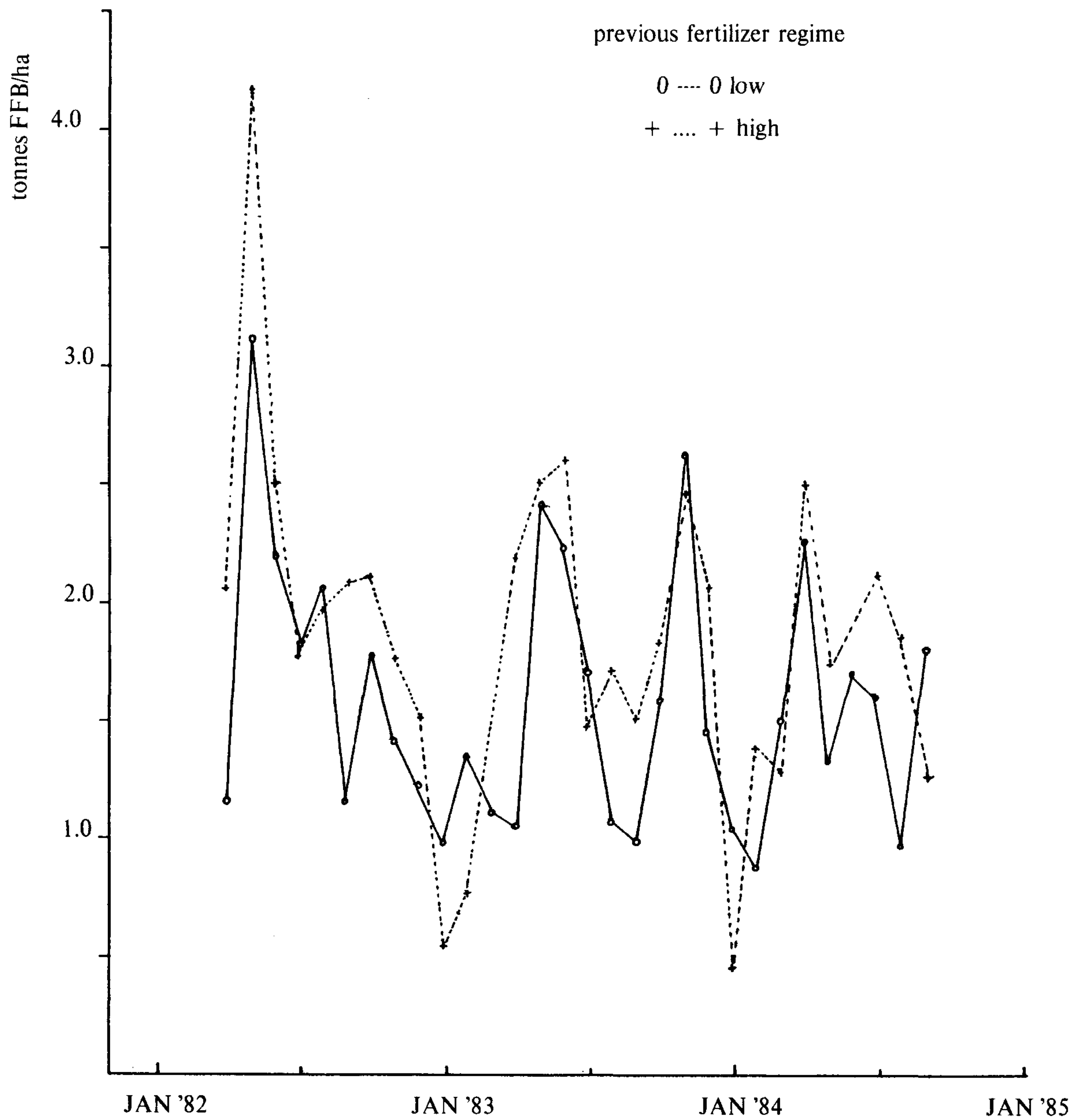


Table 2: *Experiment 101, leaf Mn (average of 30 months) as influenced by previous fertilizer regime.*

Plot	*Fertilizers applied* *Mn*	*S*	*overall*	*leaf Mn ppm*
62	high	high	high	87
24	high	high	low	78
44	low	high	high	82
10	low	high	high	85
17	low	high	low	66
47	low	low	low	52

Figure 2 - *Experiment 101, monthly yield data, April 1982 - December 1984, for plots with a previously low or high fertilizer regime.*



Fluctuations in leaf nutrient levels and monthly yield did occur, but a relation between the two was not obvious. Fluctuations were following the same pattern for both fertilizer regimes, but a difference was found in overall levels. When the fertilizer experiment as such was concluded at the end of 1983 no significant effect of fertilizers on yield had been found, but trends were present. In the current exercise three of the best fertilized plots are compared with three plots that received little or no fertilizer. For the 33 months period April 82 — December 84 the high fertilizer plots produced 15% more. Residual effects of fertilizer on leaf nutrient levels were:

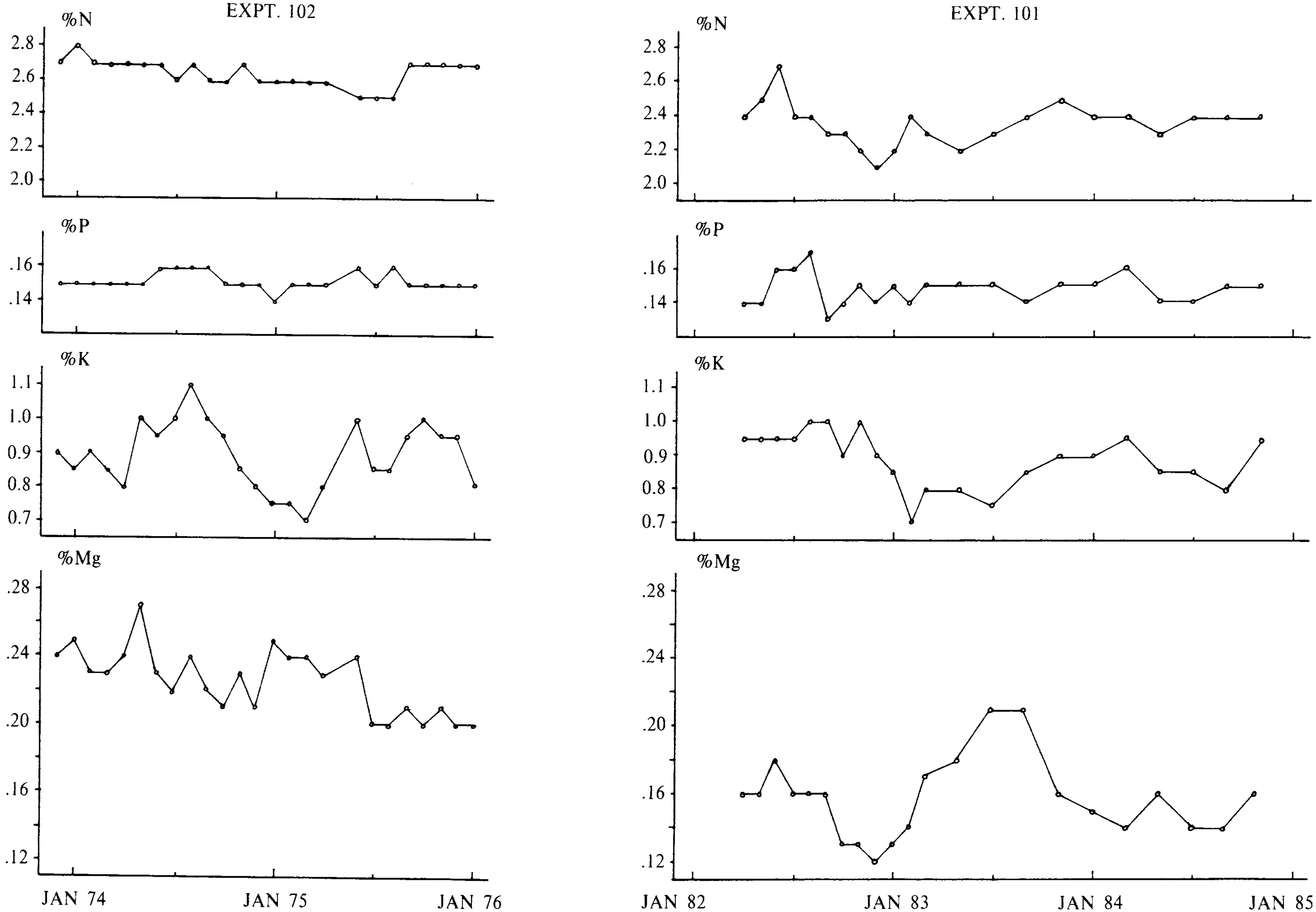
- no clear effect on leaf N;
- no effect on leaf P;
- a negative effect on leaf K (as usual in this area muriate of potash (KCl) depressed leaf K levels and raised leaf Cl levels);
- a positive effect on leaf Mg. This is probably due to the K/Mg antagonism;
- a positive effect on leaf Cl; this is a direct effect of fertilizers. In two of the three high fertilizer plots MgCl was used as well;
- a positive effect on leaf Mn; this is an indirect effect which is shown in Table 2. An overall high fertilizer regime enabled the palms to reach leaf nutrient levels over 80ppm Mn, whether or not Mn was included in the fertilizers applied. With only Mn and S applied, approximately the same level could be reached. Sulphur is thought to make soil Mn better available through lowering the pH of the soil. Some proof of this is found in comparing leaf Mn levels in plot 17 (S only) with plot 47 (Nil), yielding 66 and 52 ppm Mn respectively. It is however not yet clear what a desirable leaf Mn level is; samples taken in 1984 from different experiments show a range from 30 to 350 ppm Mn.

The conclusions from this experiment are as follows:

- Leaf N and P are pretty stable throughout the year; some pertubation occurred around the peak production in 1982, which was partly due to the activity of the weevil.
- leaf K fluctuations of up to 15% of the average occur. The main cause is unknown, but obviously levels drop during wet periods (leaching from the leaves).
- leaf Mg shows fluctuations of more than 25% of the average during the year. This fluctuation might be partly due to the antagonistic effect of K.
- leaf Mn levels deviate by more than 10% from the average, but results are difficult to compare with those from nearby areas given the wide range between areas.
- leaf Cl levels show deviations of about 20% from the average. It is more or less following the same pattern as Mg, i.e. negatively correlated with K.

The data for N,P,K,Mg were compared (figure 3) with data from Expt. 102 (Breure, Dami OPRS 1971 - 1977). The conclusions drawn above appear to apply to those data as well.

Figure 3 - *Fluctuations in leaf nutrients (frond 17) in Expt. 102 (1974 - 1975) and Expt. 101 (1982 - 1984)*



Where fluctuations do occur, leaf nutrient levels are — except for potassium — usually lowest just before the rainy season. This would therefore be the best time for sampling. For interpretation of data the negative correlation should be kept in mind between leaf potassium at one side and the levels of magnesium, manganese, and chloride at the other.

EXPERIMENT 106, Fertilizer experiment on young replanted palms, Bebere

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

Design: Two replicates of a 3 x 2 x 3 x 2 factorial (N, P, K/Mg, 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: Planting material was seedlings either 16 or 24 months of age. Fertilizers were to be applied twice yearly at rates increasing with age:

months from planting	*kg fertilizer/palm*										
	N			*P*		*K*			*Mg*		
	0	*1*	*2*	*0*	*1*	*0*	*1*	*2*	*0*	*1*	*2*
3	0.25	0.25	0.4	—	—	—	—	—	—	—	—
6	0	0.3	0.6	0	0.2	0	0.5	1.0	0	0.2	0.4
12	0	0.6	1.2	0	0.2	0	1.0	2.0	0	0.4	0.8
18	0	0.6	1.2	—	—	0	1.5	3.0	0	0.6	1.2
24	0	1.2	2.4	—	—	0	2.5	5.0	0	1.0	2.0
30	0	1.2	2.4	—	—	0	2.5	5.0	0	1.0	2.0

Nitrogen was given as sulphate of ammonia, phosphate as triple super phosphate, potassium as bunch ash, and magnesium as kieserite. Phosphate was applied during the first year only. Bunch ash was applied 3 months after the nitrogen to avoid volatilization of ammonia. The ratio K/Mg was kept constant in plots fertilized with K and Mg. The actual application of treatments lagged 3 months behind schedule; a typically long drought immediately after planting caused a stand still in development, and the 3 months nitrogen application was deliberately postponed by 3 months, all subsequent applications following this shift.

The 18 and 24 months fertilizer applications (N and Mg only) were done in June and December, bunch ash was applied in March (12 months) and September (18 months).

With effect from 1985 bunch ash will be replaced by muriate of potash. This is because of the new NBPOD policy to apply empty bunches to the field instead of incinerating them to bunch ash.

Recording: Petiole cross section was measured at 3 monthly intervals on frond 1: leaf production was recorded at the same time. Flowering precocity surveys were done every 3 months starting in June. The presence of male and female inflorescences was scored, the latter being split up into two classes; 1 or 2 female, and 3 or more. This was based on the policy that 23 months after planting all palms with less than 3 female flowers should be replaced according to the standard practice of this plantation. Leaf samples were taken in October. Harvesting and recording of yield started in December.

Results: Data for petiole cross section are given in Table 3. The difference between young and old seedlings had such an overriding influence that initially a separate analysis was needed for each class; this difference became less in August and disappeared in November, thus allowing a combined analysis for the two types of seedlings.
For the younger seedlings the response to nitrogen, found previously, continued in February and May, but disappeared in August and November although the trend was still present at the end of the year.

Table 3: *Experiment 106, Petiole cross section at 3 monthly intervals during 1984 (frond 1)*

TREATMENT	*W x T, cm²*												
	FEBRUARY			*MAY*			*AUGUST*				*NOVEMBER*		
	1yr		*2yrs*	*1yr*		*2yrs*	*1yr*	*2yrs*		*average*	*1yr*	*2yr*	*average*
N0	9.3	a	8.4	11.0	a	9.4	10.8	10.7		10.7	12.4	12.2	12.3
N1	9.8	b	8.4	11.4	b	9.8	11.3	10.8		11.0	12.8	12.6	12.7
N2	10.0	b	8.3	11.8	b	10.0	11.4	10.8		11.1	13.0	12.4	12.7
P0	9.6		8.3	11.3		9.7	10.9	10.7		10.8	12.7	12.3	12.5
P1	9.8		8.4	11.5		9.8	11.4	10.9		11.1	12.7	12.5	12.6
K,Mg 0	9.4		8.3	11.0	a	9.6	10.8	10.6	a	10.7	12.3	12.4	12.4
K,Mg 1	10.0		8.4	11.8	b	9.7	11.5	10.6	a	11.1	12.9	12.2	12.6
K,Mg 2	9.6		8.4	11.4	b	9.9	11.2	11.1	b	11.2	12.9	12.5	12.7
Average	9.7		8.4	11.4		.9.7	11.2	10.8		11.0	12.7	12.4	12.5

A combined effect of potassium and magnesium was found in May for the younger seedlings, and in August for the older seedlings. In November no significant differences were found, neither due to treatments, nor between seedlings of different age.

Flowering precocity data are given in Table 4. The trend is that nitrogen enhanced flowering, both for young and old seedlings. By the end of the year nearly all younger palms had 3 or more bunches, of the older palms 20% did not meet this.

Treatments had little or no effect on leaf nutrient levels of nitrogen (2.6 - 2.7 % N), phosphorus (0.16%P), potassium (1.2%K) and magnesium (0.18 - 0.2%Mg). Levels of manganese were influenced positively by the use of N fertilizer, the effect being more pronounced for the 2 years old seedlings (Table 5). Levels of chloride, on the average 0.34% Cl, dropped to 0.25% Cl in the absence of bunch ash and kieserite and were increased to 0.42% Cl when both fertilizers were given at the highest rate. Since the rates of both fertilizers were linked it is not possible to distinguish between the two, but the effect on leaf levels of chloride is supposed to be due to kieserite (see also the results of Expt. 306).

In the presence of bunch ash and kieserite levels of calcium dropped from 1.08 to 1.01% Ca. Levels of iron varied between blocks from 62 to 82 ppm Fe. Levels of other nutrients were fairly constant: sulphur on the average 0.19% S, zinc 20 ppm Zn, copper 7 ppm Cu and boron 13 ppm B.

It is too early to comment on yield data (December 1984 first month recorded).

Based on the flowering precocity data the older seedlings were still lagging behind in November 1984, but the difference was becoming less (Table 3).

The ultimate effect of fertilizer treatments will have to be derived from next year's yield data. It has to be remembered then that conditions at time of planting of Experiment 106 were atypical. Results can be extrapolated to other types of stress conditions just after planting especially in the smallholdings and where oversized seedlings are planted.

Table 4: *Experimental 106, Flowering precocity, June, September, December 1984.*

TREATMENT	*Palms with inflorescences, %*																	
	JUNE						*SEPTEMBER*						*DECEMBER*					
	Age 1 yr			*Age 2 yrs*			*Age 1yr*			*Age 2yrs*			*Age 1yr*			*Age 2yrs*		
	1 or 2 ♀	*3 or more ♀*	*♂*	*1 or 2 ♀*	*3 or more ♀*	*♂*	*1 or 2 ♀*	*3 or more ♀*	*♂*	*1 or 2 ♀*	*3 or more ♀*	*♂*	*1 or 2 ♀*	*3 or more ♀*	*♂*	*1 or 2 ♀*	*3 or more ♀*	*♂*
N 0	16	20	38	4	4	19	21	68	26	24	28	21	3	94	6	9	69	18
N 1	16	28	30	9	3	22	15	80	27	23	42	29	2	98	9	6	82	22
N 2	20	29	35	8	6	19	24	73	27	28	47	29	2	98	15	6	87	23
P 0	16	25	40	5	6	20	21	73	29	22	40	27	2	96	11	7	78	24
P 1	18	26	29	9	2	20	19	74	25	28	38	26	2	97	10	7	80	18
K,Mg 0	15	24	34	6	4	19	19	70	29	27	40	26	3	94	9	4	83	19
K,Mg 1	19	29	33	10	4	22	23	74	23	21	44	24	2	97	9	7	79	20
K,Mg 2	18	24	36	4	4	19	19	76	28	28	33	29	1	98	13	9	76	25
Average	17	24	34	7	4	20	20	73	27	25	39	26	2	97	10	7	79	21

Table 5: *Experiment 106, Leaf levels of manganese as influenced by the use of sulphate of ammonia, October 1984*

TREATMENT	*Leaf level of Mn, ppm*	
	Age 1 yr	*Age 2 yrs*
N 0	30	30
N 1	39	44
N 2	55	67

EXPERIMENT 107, Fertilizer experiment on mature, replanted palms, Bebere.

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

Design: A 3^2 x 2^3 factorial (N,P,K,Mg, 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 were of 16 different progenies arranged in the same array in each plot.

Treatments: Three months after planting all plots received 0.25kg sulphate of ammonia per palm. At 12 months, in January 1984, half the plots received 0.6kg sulphate of ammonia per palm (treatment "establishment N"). The other treatments, to be applied from 24 months onwards, will be as follows (half the amount being applied twice yearly):

	kg fertilizer/palm. year		
level	*0*	*1*	*2*
sulphate of ammonia	0	1	2
triple super phosphate	0	0.5	1
sulphate of potash	0	1.8	—
kieserite	0	2	—

Potassium was originally thought to be given as bunch ash but since the NBPOD policy changed from incinerating to direct application of empty bunches another source of potash was needed. To avoid confusing effects of chloride, observed frequently, it was decided to use potassium sulphate instead of muriate of potash.

Recording: Petiole cross section was measured every three months on frond 1. Leaf production was recorded for the same intervals. Flowering precocity surveys were done every three months, starting in June as for Expt. 106. A crown disease survey was done in August. Harvesting had not started at the year's end.

Results: The only differential treatment so far was establishment nitrogen, given in January 1984. This did not result in differences in petiole cross section or flowering precocity (Tables 6 and 7).

This contrasts with Expt. 106 which was, however, planted under dry and windy conditions in August 1982 and shows a stronger reaction to nitrogen. Expt. 107 was planted in November and December of the same year after the drought had broken and a leguminous cover quickly became well established. This doubtless accounts for the contrasts.

Table 6: *Experiment 107, Petiole cross section (cm^2* frond 1), 1984

TREATMENT	*MARCH*	*JUNE*	*SEPTEMBER*	*DECEMBER*
−N	8.4	9.5	10.7	12.0
+N	8.4	9.5	10.6	11.9

Table 7: Experiment 107, Flowering precocity (%) 1984

TREATMENT	JUNE 1 or 2 ♀	JUNE 3 or more ♀	JUNE ♂	SEPTEMBER 1 or 2 ♀	SEPTEMBER 3 or more ♀	SEPTEMBER ♂	DECEMBER 1 or 2 ♀	DECEMBER 3 or more ♀	DECEMBER ♂
−N	9	5	37	18	33	61	10	77	31
+N	10	7	35	18	31	59	10	75	26

Some differences between progenies did occur. Results have been split out into HBN (high bunch number) and MSR (medium sex ratio) material. Petiole cross section data are given in Table 8; however, the variation within each progeny -based on the average per block-was wider than the difference between progenies.

Flowering precocity data are given in Table 9. An obviously low score was found for progeny 5. High scores were obtained for progenies 2,3,12, and 16. Progenies 6,9,10,13, and 14 scored above average. No difference was found between HBN and MSR material. Data for the crown disease survey are given in Table 10. Remarkable is the high score for progeny 15.

Table 8: *Experiment 107, Petiole cross section for 16 different progenies during 1984.*

Progeny	March	WxT, cm^2 June	September	December
1	8.4	9.6	10.9	12.1
2	8.7	9.5	10.7	12.3
3	8.2	9.3	10.5	11.9
4	8.3	9.2	10.1	11.1
5	8.5	10.2	11.1	12.5
6	8.8	10.0	12.2	13.5
7	8.6	9.2	10.2	11.3
8	8.4	9.4	10.5	11.8
9	8.4	9.3	10.6	12.0
10	8.2	9.2	10.6	11.9
11	8.2	8.8	10.1	11.7
12	8.0	8.6	9.3	9.9
13	8.6	9.5	11.1	12.5
14	8.7	10.0	11.4	12.9
15	8.1	9.5	9.9	11.4
16	7.8	9.4	10.8	12.0
HBN	8.4	9.5	10.8	12.0
MSR	8.2	9.3	10.4	11.7
average	8.4	9.4	10.6	11.9

Table 9: *Experiment 107, Flowering precocity for 16 different progenies during 1984.*

Progeny	JUNE			SEPTEMBER			DECEMBER		
	1 or 2 ♀ %	*3 or more* ♀ %	♂ %	*1 or 2* ♀ %	*3 or more* ♀ %	♂ %	*1 or 2* ♀ %	*3 or more* ♀ %	♂ %
1	13	3	24	15	32	38	14	72	7
2	17	7	60	24	42	90	6	92	35
3	14	11	64	19	57	85	4	93	29
4	8	6	43	15	26	57	8	75	17
5	4	3	8	21	11	15	26	39	4
6	7	4	19	26	31	50	6	78	24
7	0	6	61	15	17	93	18	69	72
8	7	6	17	14	22	39	14	67	17
9	17	7	28	21	38	50	15	78	21
10	10	7	25	18	36	49	7	79	29
11	4	1	29	22	19	53	11	71	36
12	19	10	35	15	60	57	10	86	17
13	6	8	60	19	26	85	4	78	58
14	7	8	40	13	35	74	10	82	49
15	10	4	24	15	19	49	6	69	17
16	8	4	40	19	42	72	6	90	29
HBN	10	6	35	19	31	57	12	74	25
MSR	9	6	38	17	34	65	8	79	34
average	9	6	36	18	32	60	10	76	29

* Progenies 1 to 10 are HBN, 11 to 16 MSR

Table 10: *Experiment 107, palms affected by crown disease, arranged by progeny, August, 1984.*

Progeny	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
affected, %	1	3	3	8	7	3	4	3
Progeny	*9*	*10*	*11*	*12*	*13*	*14*	*15*	*16*
affected, %	11	7	6	6	0	1	24	0

EXPERIMENT 109, Mill waste useage experiment, Bebere

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

Design: 5 replicates of randomised blocks, 5 treatments plus 1 extra nil plot per block; 36 palms per plot of which the central 16 are recorded.

Treatment: Treatments include the use of mill effluent and munched bunches at the following rates:

1. Nil
2. Nil
3. raw effluent 500 l/palm
4. raw effluent 1000 l/palm
5. munched bunches 100 t/ha
6. munched bunches 100 t/ha + raw effluent 500 l/palm.

Treatments 3 and 4 were applied in October - November; treatments 5 & 6 were not applied since munched bunches were not yet available. Treatments of effluent to be applied once a year. 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.

The area was surveyed in April - May. Pre-treatment soil and leaf samples were taken in July - August, but treatment to the experiment could not be done and had to be delayed until October because of problems with the equipment. Yield recording started in August. Height measurements were done in June and petiole cross section was measured in November in all plots.

Ten selected plots (the high rate effluent plot and one Nil plot from each block) were recorded more intensively and in June subsoil samples were taken as well (other plots only top soil), and petiole cross section measured. Another round of leaf sampling was done in November in these plots.

Results: Only pre-treatment measurements are available; they can be used as covariables when interpreting future results.

EXPERIMENT 110, Fertilizer-mulch experiment on young, replanted palms, Bebere

Planted in February 1984 at 135 palms/ha; 1152 palms (total and recorded). Area 8.5 ha. The site had previously been under oil palm for 15 years.

Design: Two replicates of a 3 x 2 x 3 x 2 factorial (N,P,K/Mg, mulch). The 72 plots were arranged in 6 blocks of 12 plots, each with 16 recorded palms, without guard rows between plots. The design is equivalent to Expt. 106 but with a factor of mulch of empty bunches around the palm replacing age of seedling at planting.

Treatments: Fertilizers were applied at the following rates:

Months from planting	kg fertilizer/palm										
	N			P		K			Mg		
	0	1	2	0	1	0	1	2	0	1	2
3	0.25	0.25	0.4	0	0	0	0	0	0	0	0
6	0	0.3	0.6	0	0.2	—	—	—	0	0.2	0.4
9	—	—	—	—	—	0	0.5	1.0	—	—	—

Nitrogen was given as sulphate of ammonia, phosphorus as triple super phosphate, potassium as bunch ash (applied 3 month later due to incompatibility with sulphate of ammonia), magnesium as kieserite. The ratio of potassium to kieserite was the same for levels 1 and 2 (combined factor).

The fourth factor was presence or absence of a mulch layer of empty bunches around the seedling, at a rate of about 100kg per palm. Mulching was not done until May, i.e. three months after planting, due to field conditions.

Recording: Petiole cross section was measured on frond 1, as marked in November.

Results: This experiment was planted as a back-up for Expt. 106 that was planted under unfavourable conditions. Given the promising results of Expt. 106 the need for Expt. 110 became less. At the meeting of the Scientific Advisory Board in November it was decided to change the treatments to examine the effect of different anions. Results of the experiment under the old design showed a significant, positive effect of mulch on petiole cross section. The other treatments had no effect (Table 11).

Table 11: *Experiment 110, Petiole cross section, frond 1, November 1984.*

TREATMENT	*WxT, cm²*	*TREATMENT*	*WxT, cm²*
N 0	4.8	K,Mg0	4.9
N 1	4.9	K,Mg1	4.9
N 2	5.0	K,Mg2	4.8
P 0	4.9	no mulch	4.7 a
P 1	4.8	mulch	5.0 b

Leaf nutrient levels were not affected by treatments. Some random variation occurred. Nitrogen varied from 2.0 to 2.7% N for individual plots but only 14% of the plots had less than 2.4% N and must be considered as N deficient. The average level was 2.5% N. Levels of phosphorus were all in the range 0.14 — 0.16% P, with an average of 0.15% P. These figures do not indicate a P deficiency although it is this fertilizer which has given a response. Levels of potassium were fairly high at 0.94—1.22% K, with an average of 1.08% K. The usual depression in leaf K at higher rates of fertilizer was not found here, since bunch ash was used instead of muriate of potash. Levels of magnesium were all very low, ranging from 0.09 to 0.17% Mg, with an average of 0.13% Mg. Levels of chloride were also very low with an average of 0.19% Cl, ranging from 0.12 to 0.32% Cl, but with 85% of the plots in the range 0.17-0.25% Cl. The average level of sulphur was 0.16% S, for calcium 0.91% Ca. Average values for the micronutrients were: Iron 57 ppm Fe, Manganese 65ppm Mn, Zinc 23 ppm Zn, Copper 6 ppm Cu, Boron 19 ppm B. Iron falls just below the tentative critical level of 60 ppm Fe, the other micronutrients were good.

EXPERIMENT 201, Fertilizer experiment on mature palms, Hargy

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

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 of fertilizers were given in the Annual Report 1983. Fertilizers were to be applied twice yearly; bunch ash following the other fertilizers by 3 months because of incompatibility with sulphate of ammonia. Actual applications this year were in February (bunch ash) and June (N,P,Mg), the second application being carried over to 1985.

Recording: Production continued to be recorded. Leaf sampling of the whole experiment in November had to be restricted to two blocks due to lack of manpower. Sampling of the third block was carried over to January 1985, but results are included here.

Results: Production is given in Table 12. The significant response to P continued giving 1.7 tonnes FFB per ha per year extra when applying 0.8kg TSP per palm per year. In economic terms this could mean a profit return of K29.20 per ha per year, using the following prices: 1 tonne FFB = K43.000, 50kg bag TSP = K18.000, 1 manday per ha = K3.60 for the application of fertilizer, 2 mandays = K7.20 to harvest extra bunches. The response to TSP in 1983 (0.9 tonne FFB/ha) just failed to show a profit. In 1984 also a significant response to Mg was found (1.2 tonne FFB per ha per year). At a price of K9.70 per 50kg bag of kieserite this would give a net loss of K2.00 per ha per year. Interactions between fertilizers were not found.

Table 12: *Experiment 201, Yield per hectare 1984, and since June 1982 (31 months)*

TREATMENT	*1984*			*Since June '82*
	No. of bunches	*Wt. of bunches t*	*s.b.w. kg*	*Wt. of bunches t*
N0	1355	26.8	19.7	68.5
N1	1323	26.3	19.9	67.0
N2	1390	27.0	19.4	69.1
P0	1308	25.7 a	19.6	65.6
P1	1398	27.4 b	19.6	68.8
P2	1363	27.0 b	19.8	70.3
K0	1356	26.5	19.6	67.7
K1	1338	26.7	19.9	68.3
K2	1375	26.9	19.6	68.7
Mg0	1322	26.3 a	19.9	67.8
Mg1	1344	26.3 a	19.6	68.0
Mg2	1402	27.5 b	19.6	68.9

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 were recorded.

Treatments:

1 & 2	Nil
3	50 tonnes empty bunches per ha
4	100 tonnes empty bunches per ha
5	100 tonnes empty bunches per ha plus 1kg sulphate of ammonia per palm
6	25 tonnes empty bunches per ha.

The sixth treatment was added at the end of 1984. The other treatments were applied from August 1984 onward and continued into 1985. Bunches were laid alongside the harvest paths in strips varying from 1 to 2m wide.

Recording: The area was surveyed and marked out in February. Yield recording started in March. Pre-treatment leaf and soil samples were taken in September.

Results: Leaf analysis results showed no deficiencies for nitrogen (2.4% N), phosphorus (0.15% P), and potassium (1.1% K). Leaf levels of magnesium were very low (0.13% Mg), and leaf levels of chloride low (0.20% Cl). The soil analysis results showed a very high phosphate retention (88%) despite a high organic matter content (7.8%); both are probably related to the volcanic nature of the parent material. The available P (1 µg/ml) and K (0.15 meq/100g, or only 0.8% of the base saturation) are very low.

ORO PROVINCE

EXPERIMENT 305, Fertilizer experiment on A soil, Arehe

Planted in December 1978 on type "A" soil (andesitic loam), at 130 palms/ha; 2587 palms total, 1152 recorded. Area 25.4 ha.

Design: 2 replicates of 3x2x3x2 (N,P,K,Mg) factorial, each with 3 blocks of 12 plots; 36 palms per plot of which the central 16 are recorded.

Treatments: Treatments were applied twice yearly since September 1981. Rates of fertilizers were given in the Annual Report 1983. Fertilizers were applied in February/March and September.

Recording: Production continued to be recorded. Leaf samples from the whole experiment were taken in May; since January 1984 leaf samples were taken monthly, except in July, from 4 selected plots: 2 plots where no fertilizer was applied and 2 plots where all four fertilizers were applied at the highest rate used in this experiment. Coded treatments for these plots are:

plot	*treatment code*			
	N	*P*	*K*	*Mg*
18	0	0	0	0
61	0	0	0	0
20	2	1	2	1
52	2	1	2	1

Petiole cross section in the whole experiment was measured on leaf 25 in November; this is more or less equivalent to leaf 17 in August, the month in which this measurement is usually done in this experiment. In the selected plots petiole cross section was measured in February as well.

Results: Production is given in Table 13. A highly significant and stimulating effect on yield was obtained at a rate of 2.9kg muriate of potash per palm per year; higher rates did not increase yield further. The extra yield of 2.2 tonne FFB/ha would give a profit return of K18.00 per ha per year, using the following figures: 1 tonne FFB = K43.00, 50kg bag muriate of potash = K14.07, 1 manday/ha = 3.60 for fertilizer application, 1 manday/tonne to harvest the extra yield. The effect on yield was largely due to a below average single bunch weight at treatment K—0 and an above average one for plots fertilized with muriate of potash, not to more bunches.

Other significant effects were found for the NxP interaction (P = 0.05) and for the PxK interaction (P = 0.10). Stimulating effects of sulphate of ammonia and triple superphosphate were only found if both fertilizers were used. Triple superphosphate gave higher yields in the absence of muriate of potash but the effect of the latter was independent of the use of triple superphosphate. In practical terms this means that application of sulphate of ammonia alone or TSP alone had no effect. The combinations P1N1 and P1K1 however showed a significant yield increase.

Table 13: *Experiment 305, Yield per hectare for 1984, and since October 1981 (39 months).*

TREATMENT	*1984*			*since Oct. '81*
	No. of bunches	*Wt. of bunches t/ha*	*s.b.w. kg*	*Wt. of bunches t/ha*
N 0	2641	34.6	13.1	96.1
N 1	2695	35.8	13.3	98.4
N 2	2680	35.7	13.3	99.2
P 0	2682	35.1	13.1	97.0
P 1	2661	35.7	13.4	98.8
K 0	2674	33.9 a	12.7	95.0
K 1	2660	36.1 b	13.6	99.1
K 2	2681	36.2 b	13.5	99.5
Mg0	2660	35.3	13.3	97.6
Mg1	2684	35.4	13.2	98.2

Table 14: *Experiment 305, Yield (t/ha) for 1984, as influenced by the interactions between N and P, and K and P*

	N0	*N1*	*N2*	*K0*	*K1*	*K2*
P0	35.2	34.5	35.5	32.8	36.2	36.3
P1	34.1	37.1	35.9	35.0	36.0	36.1

Results of the leaf sampling in May revealed that type and rate of fertilizer had no influence on leaf N (2.6% N), leaf P (0.16% P), and leaf Mg (0.19-0.20% Mg). Fertilizing with N.P, or Mg had no influence on leaf K (0.86-0.88% J) and leaf Cl (0.38-0.39% Cl). Fertilizing with K (as KCl) did affect leaf levels of K,Cl, and Mn (Table 15). Leaf Mn was not affected by fertilizing with P or Mg (96-98 ppm Mn), and for treatment N-1 an erratic value of 93 ppm Mn was found vs. 99 ppm Mn for N-0 and N-2.

Table 15: *Experiment 305, Leaf nutrient contents of K, Cl, Mg, and Mn, in leaf 17 (May '84) as influenced by the rate of KCl applied.*

TREATMENT	*K %*	*Cl %*	*Mg %*	*Mn ppm*
K 0	0.93	0.20	0.19	92
K 1	0.86	0.44	0.20	96
K 2	0.84	0.52	0.20	103

Results of the monthly leaf sampling are given in Table 16; also given are the results for August 1981 (pre-treatment) and May 1982 (8 months after the first differential fertilizer application). Fairly consistent differences in leaf nutrient contents between nil and high rate plots were found for K,Mg,Cl and Mn. The usual high Cl/low K combination was found for the high rate plots where KCl was used. The higher levels of Mg and Mn there were probably a result of the antagonistic effect of K.

Petiole cross section data for the whole experiment are given in Table 17. A highly significant larger value for WxT was found in plots treated with muriate of potash. The difference found in the selected plots was even larger. 29.6 cm^2 for the high rate plots vs. 25.1 cm^2 for the low rate plots; in February these figures were 24.2 cm^2 and 21.8 am^2, respectively.

Table 16: *Experiment 305. Leaf nutrient contents in leaf 17 for selected plots (average for 2 plots), during 1984, in May 1982, and in August 1981 (pre-treatment).*

ELEMENT %	*TREATMENT CODE*	*AUG '81*	*MAY '82*	*JAN '84*	*FEB*	*MAR*	*APR*	*MAY*	*JUNE*	*JULY*	*AUG*	*SEP*	*OCT*	*NOV*	*DEC*
N	0000	2.8	2.8	2.6	2.6	2.5	2.5	2.5	2.6	—	2.5	2.6	2.6	—	2.7
	2121	2.8	3.0	2.7	2.7	2.6	2.6	2.6	2.7	—	2.6	2.7	2.9	—	2.8
P	0000	.17	.18	.16	.16	.16	.16	.17	.17	—	.16	.16	.16	—	.17
	2121	.18	.17	.17	.17	.17	.17	.17	.16	—	.16	.16	.16	—	.17
K	0000	1.08	1.20	1.11	1.03	.99	.98	.97	.86	—	1.02	1.07	1.02	—	1.10
	2121	1.11	1.00	0.98	.95	.90	.84	.87	.86	—	.96	.99	.95	—	1.02
S	0000	.20	.20	.19	.18	.16	.17	.18	.19	—	.16	.15	.14	—	.17
	2121	.20	.21	.19	.17	.17	.19	.20	.19	—	.16	.16	.15	—	.19
Ca	0000	.94	.91	.92	.94	.94	.91	.94	.86	—	.86	.82	.83	—	.90
	2121	.96	.94	.93	.96	.93	.87	.93	.89	—	.85	.87	.85	—	.92
Mg	0000	.26	.23	.17	.19	.18	.18	.20	.18	—	.20	.18	.19	—	.17
	2121	.26	.26	.20	.23	.21	.20	.22	.22	—	.22	.21	.20	—	.19
Na	0000	.01	.01	.01	.01	.01	.01	.01	.01	—	.00	.01	.01	—	.00
	2121	.01	.01	.02	.01	.01	.01	.01	.01	—	.00	.01	.01	—	.02
Cl	0000	.39	.21	.25	.24	.23	.23	.24	.23	—	.20	.20	.20	—	.21
	2121	.35	.40	.55	.55	.53	.56	.54	.59	—	.54	.47	.51	—	.61
ppm															
Fe	0000	56	59	66	71	61	65	74	80	—	76	61	66	—	65
	2121	60	59	65	62	56	58	73	90	—	60	61	62	—	60
Mn	0000	75	71	78	76	81	81	82	78	—	73	72	77	—	81
	2121	80	91	99	97	104	105	103	109	—	95	98	101	—	111
Zn	0000	16	16	19	22	19	20	18	18	—	18	18	21	—	17
	2121	16	16	18	18	19	21	18	18	—	17	19	19	—	16
Cu	0000	7	6	6	6	5	6	5	5	—	7	6	6	—	5
	2121	7	5	6	6	6	5	6	6	—	7	6	6	—	5
B	0000	14	16	21	18	18	20	17	16	—	20	17	15	—	20
	2121	16	23	17	17	18	21	17	15	—	15	16	14	—	19

Table 17: *Expt. 305, petiole cross section, leaf 17, August 1984.*

TREATMENT	*WxT, cm²*
N 0	27.5
N 1	27.9
N 2	28.2
P 0	27.9
P 1	27.9

TREATMENT	*WxT, cm²*
K 0	26.9 a
K 1	28.2 b
K 2	28.5 b
Mg0	27.7
Mg1	28.0

EXPERIMENT 306, Fertilizer experiment on L soil, Ambogo

Planted in April 1980 on "L" type soil (grey-yellow sand soil) at 143 palms/ha; 2916 palms total, 1296 recorded. Area 21 ha.

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

Treatments: Treatments were applied twice yearly since April 1983. Rates of fertilizer, were given in the Annual Report 1983. Fertilizers were applied in May/June; the application scheduled for December had to be postponed because of heavy rains.

Recording: Production continued to be recorded. Leaf samples from the whole experiment were taken in October; since April 1984 leaf samples were also taken monthly from five selected plots.

Coded treatments for these plots are:

plot	*treatment code*			
	N	*P*	*K*	*Mg*
10	0	0	0	0
30	1	0	0	0
12	2	0	0	0
17	2	2	2	2
32	2	1	2	2

The first two are combined and presented as a low fertilizer regime. The last two stand for a high fertilizer regime. The plot with N only was added because of an expected response to nitrogen.

Petiole cross section in the whole experiment was measured on leaf 17 in August; in the selected plots also in April.

Results: Production is given in Table 18. Significant effects due to nitrogen and potassium were found.

Fertilizer applications of nitrogen did increase yield (3.4t per ha), but only at the higher level of fertilizer (3.0kg sulphate of ammonia/ha. year). The increase in yield due to potassium (3.3 tonne/ha) was achieved at the low level of application (2.5kg muriate of potash per ha. year). Higher levels did not increase yield compared with the control. For treatments N and K higher yields were a result of higher number of bunches combined with a higher single bunch weight. Interactions between fertilizers were not found. In economic terms the nitrogen response means a net profit return of K6.40 per ha per year, the potassium response: K25.80 (using the same figures as in expt. 305, 50kg SA = K14.20).

As may have been expected Experiment 306 on the "L" type soil (classified as rather poor, sandy) shows more response to fertilizers (nitrogen and potassium) than Expt. 305 on the "A" type soil (classified as good, humic) which only showed a response to potassium.

Table 18: *Experiment 306, yield per hectare for 1984, and since May 1983 (20 months)*

TREATMENT	*1984*			*since May '83*
	No. of bunches	*Wt. of bunches t/ha*	*s.b.w. kg*	*Wt. of bunches t/ha*
N 0	2523	22.3 a	8.8	31.9
N 1	2567	23.0 a	9.0	33.0
N 2	2720	25.7 b	9.5	36.1
P 0	2713	24.3	8.9	34.2
P 1	2565	23.5	9.2	33.6
P 2	2531	23.3	9.2	33.1
K 0	2511	22.0 a	8.8	31.3
K 1	2705	25.3 b	9.3	35.4
K 2	2594	23.8 ab	9.2	34.3
Mg0	2591	23.1	8.9	33.1
Mg1	2737	25.4	9.3	35.5
Mg2	2482	22.6	9.1	32.4

The fertilizer treatments had no effect on leaf levels of nitrogen (2.8% N), phosphorus (0.17% P) and magnesium (0.28% Mg). Leaf levels of potassium and chloride were affected by the use of muriate of potash (Table 19). In the absence of muriate of potash the use of kieserite had a slightly stimulating effect on leaf levels of chloride (Table 20). A combined, stimulating effect of the treatments nitrogen and potassium was found for leaf levels of manganese (Table 21). Differences in leaf levels of calcium, found for the selected plots, do not come out when all 81 plots are considered. The results of the monthly leaf sampling in the selected plots are given in Table 22. From July to October leaf levels of magnesium dropped by about 10%, leaf levels of manganese by more than 30%. A slight increase (5%) of leaf potassium was observed. When compared with pre-treatment data the sudden drop in leaf levels of manganese is remarkable. Leaf levels of potassium dropped slightly for the low fertlized plot and more for the high ones. Leaf levels of chloride dropped in the low fertilized plots, but increased in the fertilized ones.

These effects on leaf potassium and chloride can be wholy ascribed to the absence or presence of muriate of potash. But within the group of low fertilized plots the effect of kieserite should be mentioned. The stimulating effect of kieserite on leaf levels of chloride (see also Table 20) was seen during all months, and since May the treatment combination with only kieserite (0001) had a level of about 0.20% Cl, which was 60-150% higher than in the complete control where the level was between 0.08 and 0.13% Cl.

Table 19: *Experiment 306, Leaf levels of potassium and chloride as affected by the use of muriate of potash (Leaf 17, October 1984).*

TREATMENT	*Leaf K %*	*Leaf Cl %*
K 0	1.18	0.13
K 1	1.11	0.38
K 2	1.09	0.48

Table 20: *Experiment 306, Leaf levels of chloride as affected by kieserite in the presence and absence of muriate of potash (leaf 17, Oct. 1984).*

TREATMENT	*Leaf Cl, %*		
	Mg-0	*Mg-1*	*Mg-2*
K 0	0.11	0.13	0.16
K 1	0.37	0.41	0.37
K 2	0.47	0.48	0.49
0000	0.10	—	—
0001	—	0.19	—

Table 21: *Experiment 306, levels of manganese as affected by nitrogen and potassium fertilizers (leaf 17, October 1984)*

TREATMENT	*Leaf Mn, ppm*		
	N-0	*N-1*	*N-2*
K 0	30	30	48
K 1	31	35	52
K 2	38	42	50

Petiole cross section data for the whole experiment are given in Table 23; for plots treated with muriate of potash or with the high level of nitrogen significantly higher values for WxT were found. Petiole cross section was not influenced by interactions between fertilizers. Data for the selected plots are given in Table 24; the plot with N only is at least as good as the high fertilized plots.

Table 22: *Experiment 306, Leaf nutrient contents in leaf 17 selected plots, April—Dec. 1984 and Pre-treatment.*

Element %	*Fertilizer regime*	*Aug '82*	*Apr '84*	*May*	*June*	*July*	*Aug*	*Sept*	*Oct*	*Nov*	*Dec*
N	low	2.5	2.8	2.7	2.8	2.7	2.8	2.8	2.8	—	2.6
	high	2.7	2.8	2.8	2.8	2.7	2.8	2.9	2.7	—	2.5
	N only	2.7	2.7	2.8	2.8	2.7	2.7	2.7	2.8	—	2.4
P	low	.17	.18	.18	.18	.17	.18	.17	.18	—	.18
	high	.20	.17	.19	.18	.17	.18	.18	.18	—	.18
	N only	.18	.17	.17	.17	.17	.18	.17	.17	—	.17
K	low	1.2	1.13	1.10	1.11	1.08	1.20	1.18	1.20	—	1.24
	high	1.3	0.98	0.99	1.01	0.99	1.12	1.09	1.12	—	1.22
	N only	1.3	1.15	1.12	1.19	1.15	1.21	1.22	1.22	—	1.25
S	low	.20	.17	.21	.20	.19	.15	.15	.16	—	.19
	high	.23	.17	.21	.19	.18	.15	.15	.19	—	.20
	N only	.23	.20	.18	.19	.18	.15	.15	.15	—	.19
Ca	low	.78	.87	.83	.82	.81	.74	.75	.77	—	.80
	high	.87	.97	.96	.93	.87	.79	.83	.80	—	.83
	N only	.91	.95	.94	.94	.86	.82	.83	.85	—	.84
Mg	low	.30	.33	.31	.30	.32	.30	.29	.28	—	.29
	high	.26	.29	.30	.30	.31	.28	.28	.26	—	.25
	N only	.23	.27	.27	.28	.29	.28	.25	.24	—	.24
Na	all plots	.00-.01	.01	.01	.01	.01	.01	.01	.00-.01	—	.00
Cl	low	.25	.19	.18	.17	.17	.14	.14	.15	—	.22
	high	.12	.43	.43	.48	.52	.46	.48	.48	—	.57
	N only	.24	.16	.17	.17	.16	.11	.10	.12	—	.19
ppm											
Fe	low	75	66	63	63	65	75	78	72	—	76
	high	88	64	64	70	77	69	72	89	—	63
	N only	72	69	66	68	81	64	65	71	—	70
Mn	low	135	43	39	42	52	42	45	32	—	37
	high	125	57	54	57	66	59	57	47	—	50
	N only	100	44	38	41	49	44	39	34	—	31
Zn	low	17	16	15	15	18	20	19	18	—	24
	high	13	14	14	15	16	18	18	17	—	15
	N only	13	13	16	14	16	18	18	21	—	15
Cu	low	7	7	8	7	8	7	7	7	—	7
	high	7	8	7	8	8	7	7	6	—	7
	N only	6	6	6	6	6	6	6	6	—	5
B	low	20	17	18	19	13	16	15	15	—	18
	high	28	15	23	15	12	14	13	16	—	17
	N only	13	17	16	15	13	14	13	13	—	16

Table 23: *Experiment 306, petiole cross section of leaf 17, August 1984.*

TREATMENT	*WxT, cm²*	*TREATMENT*	*WxT, cm²*
N 0	20.1 a	K 0	19.7 a
N 1	20.3 a	K 1	21.0 b
N 2	21.0 b	K 2	20.6 b
P 0	20.3	Mg0	20.4
P 1	20.7	Mg1	20.8
P 2	20.4	Mg2	20.2

Table 24: *Experiment 306, petiole cross section in the selected plots, April and August, 1984.*

FERTILIZER REGIME	*WxT, cm²*	
	APRIL '84	*AUGUST '84*
low	15.6	18.6
high	18.5	22.0
N only	19.0	22.4

EXPERIMENT 307, Smallholders' fertilizer trial, Oro Province.

The experiment is located at 7 smallholder blocks, planted between March 1978 and August 1981, at 130 palms/ha. Previously the areas had been under kunai grass.

Design: Seven replicates of randomised blocks. Each block consisted of 3 plots, varying from 26 to 45 recorded palms, with double guard rows between plots.

Treatments: Treatments are Nil, Nitrogen, Nitrogen plus Phosphate. Nitrogen is given as sulphate of ammonia at a rate of 1 kg per palm twice a year, phosphorus as triple super phosphate at a rate of 0.5 kg per palm once a year. Nitrogen was first applied in November 1984, and phosphorus in October 1984.

The experiment is carried out on the following smallholder blocks:

Area	*block*	*plots*	*planted*	*in production since*
Ahora	230039	1 — 3	Nov. '78	June '82
Soputa	251013	4 — 6	Mar. '79	June '81
Girua	010184	7 — 9	Mar. '78	Feb. '81
Girua	010182	10 — 12	Mar. '79	Jan. '82
New Warisota	500619	13 — 15	Mar. '78	Dec. '80
New Warisota	500625	16 — 18	Mar. '78	Jan. '81
Sakita	410021	19 — 21	Aug. '81	Feb. '83

Blocks had been fertilized previously, mainly with sulphate of ammonia, but occasionally also with an NPKMg compound fertilizer. Fertilizer rates used by DPI (kg/palm) for the blocks at Ahora, Soputa and Girua (East of Ambogo river) and at New Warisota and Sakita (West of Ambogo river) were:

Age months	kg fertilizer East of Ambogo	West of Ambogo
1	0.1	0.1
3	0.2	0.2
6	0.2	0.4
9	0.2	0.4
12	0.2	0.4
18	0.2	0.4
24	0.4	0.4
30	0.4	0.4
36	1.0	1.0

At 24 months all blocks received potassium at 4 kg fertilizer/palm (muriate of potash).

Recording: Yield recording started in October 1984. Pre-treatment leaf and soil samples were taken in August/September. Petiole cross section was measured at 13 - 23 palms in each plot in December.

Results: Leaf analysis results by area are given in ranked order in Table 25. Only at Sakita the desired level of nitrogen was reached (2.5% N); the other areas were deficient. Levels of phosphorus at those blocks were also low (0.14% P), although at Soputa and New Warisota the available phosphorus in the soil was high (Table 26). The leaf levels of potassium and magnesium were good. Levels of chloride were very low (0.11-0.16% Cl). Levels of manganese varied from 150 to 500 ppm Mn, zinc from 17 to 21 ppm Zn, copper 6 - 7 ppm Cu, and boron 11 - 12 ppm B, except at Sakita where it was 1.5 ppm B.

The soil analysis results showed differences in organic matter content (Table 26); as in Experiment 202 this was inversely related with P-retention. The CEC varied between 14 and 17 meq/100g at Ahora and Girua, for the other areas this was 17 - 24 meq/100g. The base saturation was just over 50%, except at New Warisota, where it was only 20%.

Data for petiole cross section showed a large variation within each plot. Except for the youngest Girua block (plots 10 - 12) plot averages varied between 16 and 24 cm². Ranked by the overall average per block the order is from high to low: Ahora, New Warisota, Soputa, Sakita, Girua. This is more or less the order due to age; the Girua blocks scored very low in this respect.

Table 25: *Experiment 307, Leaf analysis results, August 1984, grouped by area and ranked by leaf nitrogen contents*

AREA	N %	P %	K %	Mg %	Ca %	S %	Cl %	Fe ppm	Mn ppm
New Warisota	1.9	.13	.88	.21	.83	.14	.13	46	441
Soputa	2.0	.14	.95	.24	.81	.14	.16	46	257
Ahora	2.2	.14	.96	.30	.76	.14	.11	75	151
Girua	2.3	.14	.94	.29	.86	.15	.12	59	389
Sakita	2.5	.16	.99	.27	.97	.15	.12	69	257

Table 26: *Experiment 307, Soil analysis results, September 1984, grouped by area and ranked by organic matter content*

AREA	organic matter %	phosphate retention %	phosphorus ug/ml	bulk density g/ml	pH	CEC meq/100g	base saturation %
New Warisota	13.1	95	21	.78	5.7	20	20
Sakita	10.0	71	4	.86	5.5	23	54
Soputa	7.7	41	17	.86	5.6	20	54
Ahora	7.5	51	5	.86	5.9	16	51
Girua	5.5	32	6	.92	5.7	15	51

EXPERIMENT 308, Mill effluent manurial experiment, Arehe

Planted in 1977 at 130 palms/ha; 540 palms total, 240 recorded. Area 4.2 ha.

Design: Five replicates of randomized blocks with three treatments each; 36 palms per plot of which the central 16 were recorded.

Treatments: Nil, 500, or 1000 l effluent applied once a year on the stacked fronds between a set of 4 palms (9 plots of application per plot).

Treatments were not applied during 1984 because the necessary equipment was not available.

A test application outside the experimental area was done in May. It was repeated in September.

Recording: The site was surveyed and marked out in January/February. Yield recording started in April. Pre-treatment leaf and soil samples were taken in May and July, respectively. Vegetative measurements in all plots were done in July.

Results: The soil and leaf analysis results revealed that the area was not uniform and based on this plots were re-arranged into blocks in such a way that differences within each block were minimized and the substantial differences occurred between blocks. Pre-treatment yield data for April—December and petiole cross section data for July confirmed the difference between blocks (Table 27). The consistency in ranking was remarkable.

During the test application there was a normal to considerable run off (depending on the terrain). Smothering of vegetation occurred, with regrowth some weeks later. There was no excessive smell and no attraction of flies.

Table 27, *Experiment 308, Some soil and leaf data, petiole cross section, and yield (all pre-treatment) as found in the different replicates*

Rep.	*org. matter* %	*P-retention* %	*leaf K* %	*leaf Ca* %	*leaf Mg* %	*Leaf Cl* %	*WxT* cm^2	*yield, Apr—Dec '84* *t/ha*
1	14.4	93	.71	.96	.31	.29	23.8	11.1
4	12.1	90	.79	.96	.27	.29	24.9	11.6
5	9.4	69	.86	.89	.21	.23	26.9	13.1
2	6.3	45	.94	.86	.20	.23	26.7	16.3
3	5.2	39	.97	.79	.19	.23	28.5	16.8

EXPERIMENT 309, Bunch refuse manurial experiment, Ambogo

Planted in 1980 at 143 palms/ha; 900 palms total, 400 recorded. Area 6.3 ha. The areas had been previously under Kunai grass.

Design: Five replicates of randomized blocks, each with 3 treatments plus 2 nil plots; 36 palms per plot of which the central 16 were recorded.

Treatments:

1 & 2 Nil

3. 50 tonnes empty bunches per ha.

4. 100 tonnes empty bunches per ha.

5. 100 tonnes empty bunches per ha plus 1 kg sulphate of ammonia per palm.

Empty bunches were applied for the first time in the period September - December 1984 with the idea of repeating this 1 or 2 years later. Bunches were applied in the interrows (where the fronds are stacked), and not along the harvest paths and between palms, as in Experiment 202. The application of sulphate of ammonia onto the empty bunches was carried over to early 1985.

Recording: The area was surveyed in January, and marked out in April. Yield recording started in June. Pre-treatment leaf and soil samples were taken in May and July, respectively.

Results: No deficiencies or irregularities between blocks were found from the pre-treatment data.

PHYSIOLOGY

(T.M.)

EXPERIMENT 102, Density and fertilizer trail at Dami

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

Design: Essentially density trials, the layout consisted of four replicates of four triangular spacings but these were split for four levels of fertilizer which for practical reasons were limited to two levels at the widest spacing. Plots consisted of from 49 to 169 palms. The central palms of each sub plot of all but the widest spacing were recorded leaving a single guard row of unrecorded palms around.

Treatments: Density:

Palms/ha	*Spacing m*	*Recorded palms per plot*
56	14.40	20
111	10.23	36
148	8.82	48
185	7.88	80

Fertilizer:

Proportion estate practice %	*Density 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 /palm. The densest plot was partly thinned in October 1981 in the course of research into effect of competition (Expt. 702).

Results: As part of NBPOD's experimental work prior to the formation of PNGOPRA growth, flowering and production were extensively recorded and results of this work have been summarised or published elsewhere (Rosenquist (1980) Breure (1977, 1982, 1985) Breure and Corley (1983), PNGOPRA Annual Reports (1982, 1983, 1984)). Interest has continued to be centred on how these different densities of palm have reacted to two marked periods of stress. These were caused by the heavy period of bearing following the advent of good insect pollination towards the end of 1981 and the relatively severe drought from May to November 1982. Furthermore, the palms had passed the phase of maximum leaf area which occurred around 1980 - 1981, and this was expected to have influenced light penetration and therefore optimum density for current yield.

In Tables 28 and 29 production during the period 1982 - 1984 and for 1984 is summarised. Figure 4 shows the monthly trends.

During 1983 yield peaked from February to June but this peak was flattened in response to abortion caused by the pollinating weevil closely followed by the drought. As these effects wore off yield rose sharply during the last quarter year but by the beginning of 1984 low bunch numbers caused by changes in sex ratio had their effect and the resulting decline slid into 1985. Compared to the trends before 1982, the peaks and troughs of 1984 were not atypical. However the timing of peaks and more pronounced double peaks in, roughly, March and October of the last two years is unusual in comparison at Dami. The effects of the drought should be mitigated in 1985 as very favourable weather with well spread rainfall obtained since November 1982. Yielding patterns had yet to stabilise since 1982 because of the interaction of stresses caused by both overbearing and drought.

The effect of spacing on current production remained as documented previously with very highly significant negative linear regressions of single bunch weight, number and weight of bunches and yield during 1984 (Fig. 5). The resulting yield per hectare was not significantly different between 110, 148 and 186 palms/ha, all of which were significantly better than 56 palms per hectare. For the period 1982 - 84, significantly greate production was obtained at 110 palms/ha. The trend of production per hectare with density is given in Figure 6 which shows the calculated parabolic curve.

At the end of 1984 the palms at highest density were seen to have yielded relatively well for the year, especially during the latter half, actually giving the highest yield/ha for the last quarter, but production at 148 palms/ha was lower than expected. The optimum for current yield was higher than at any time during the last 6 years at 131 palms/ha but for cumulative yield remained at 142 (if 56 palms/ha treatment is included) or 131 (based on 110, 148 and 186 palms/ha). The results are presented in Table 30. In the Annual Report for 1983 methods were described for calculating optimum for current and cumulative yield.

Table 28: *Experiment 102, Yield per hectare in 1982 to 1984.*

TREATMENT	*1984*		*1982 - 1984*	
Palms/ha	*No. of bunches*	*Wt. of bunches t*	*No. of bunches*	*Wt. of bunches t*
56	626 a	15.3	2074 a	49.6 a
110	991 b	22.1	3356 b	73.7 b
148	930 b	19.3	3270 b	65.9 c
186	1089 b	22.6	3310 b	63.1 c
linear regression	**	**	**	**
quadratic regression	NS	NS	**	**
Fertilizer[1] % estate practice				
0	1045	21.6	3645 a	71.8
50	966	20.8	3239 b	70.6
100	845	19.1	3175 b	69.9
150	874	19.4	3069 b	66.8
linear regression	*	NS	**	NS
quadratic regression	NS	NS	NS	NS

Means with a similar letter do not differ significantly

(1) Calculated for densities of 110 and 148 p/ha.

Table 29: *Experiment 102, Yield per palm in 1982 to 1984.*

TREATMENT	*1984*			*1982 - 1984*		
Palms/ha	*No. of bunches*	*s.b.w. kg*	*Wt. of bunches kg*	*No. of bunches*	*s.b.w. kg*	*Wt. of bunches kg*
56	11.2 a	24.5 a	272 a	37.0 a	24.0 a	885 a
110	9.0 b	22.4 b	201 b	30.5 b	22.1 ab	670 b
148	6.3 c	20.8 b	131 c	22.1 c	20.2 b	445 c
186	5.9 c	20.8 b	122 c	17.8 d	19.2 b	339 d
r^2	1.00	0.96	0.97	0.98	0.99	0.99
linear regression	**	**	**	**	***	***
quadratic regression	NS	NS	*	**	*	**
Fertilizer[1] *% estate practice*						
0	7.8	20.7 a	163	28.9 a	19.8 a	570
50	7.2	21.6 ab	157	26.7 ab	21.0 b	563
100	6.9	22.2 b	154	25.4 b	22.0 c	560
150	7.3	21.9 b	159	24.4 b	21.9 c	536
linear regression	NS	*	NS	**	***	NS
quadratic regression	NS	NS	NS	NS	*	NS

Means with a similar letter do not differ significantly

(1.)Calculated for densities of 110 and 148 p/ha.

* P = 0.05

** P = 0.01 Significance of regression mean square

*** P = 0.001

Figure 4, *Experiment 102, Monthly variations in yield at each density.*

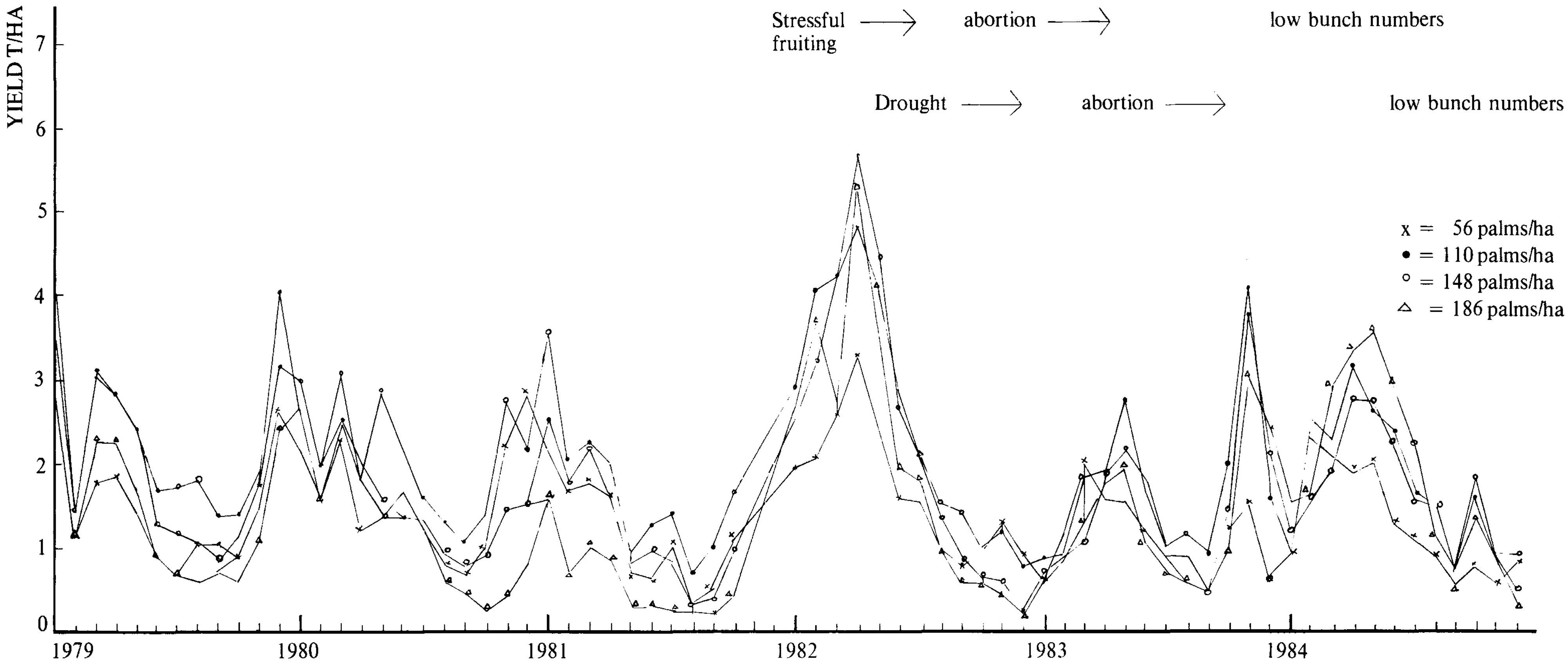


Table 30: *Experiment 102, Annual and cumulative yield per palm and optimum densities for current and cumulative yield Nov. 1973 - Dec. 1984*

Year from planting		3½	4½	5½	6½	7½	8½	9½	10½	11½	12½	13½	14½
Harvest year		1	2	3	4	5	6	7	8	9	10	11	12
period		73/74	74/75	75/76	76/77	77/78	78/79	79/80	80/81	5/81-10/81	'82	'83	'84
kg/palm per year	*56*	83	238	250	280	260	262	297	319	77	363	248	272
	110	82	233	243	241	219	218	232	224	64	282	188	201
	148	81	212	223	192	156	144	149	123	29	194	121	131
	186	78	191	163	138	100	94	88	57	10	133	85	122
Cumulative kg/palm	56	83	321	571	851	1111	1373	1670	1989	2066	2429	2677	2949
	110	82	314	557	798	1017	1235	1467	1691	1755	2037	2225	2426
	148	81	293	516	708	864	1008	1157	1280	1309	1503	1624	1755
	186	78	269	432	570	670	764	852	909	919	1052	1137	1259
Optimum for current yield/ha		a b	a b	a b	a b	a b	a b	a b	a b		a b	a b	a b
	n = 4	—	—	b: 241	160 161	136 137	130 129	121 120	106 104	/	130 128	124 122	136 131
	n = 3	—	a: 266	174 180	144 145	125 124	121 118	115 113	105 102	/	126 123	122 118	147 132
Optimum for yield/ha	*n = 4*	—	440	315	238	201	181	166	151	/	145	143	142
	n = 3	—	321	230	192	168	155	145	136	/	132	131	131

a = calculated from a linear regression

b = calculated from $D_o = \frac{P_1 + D_1 C}{2C}$

Figure 5: *Experiment 102, Yield per palm, 1982.*

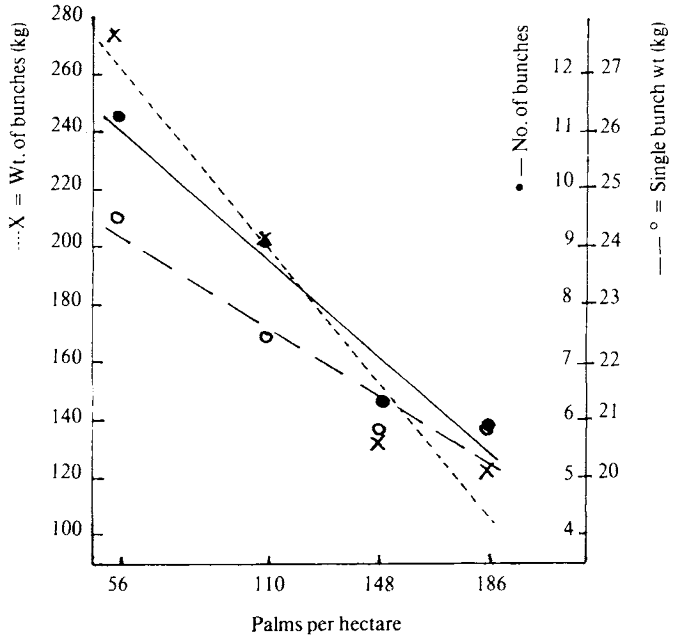
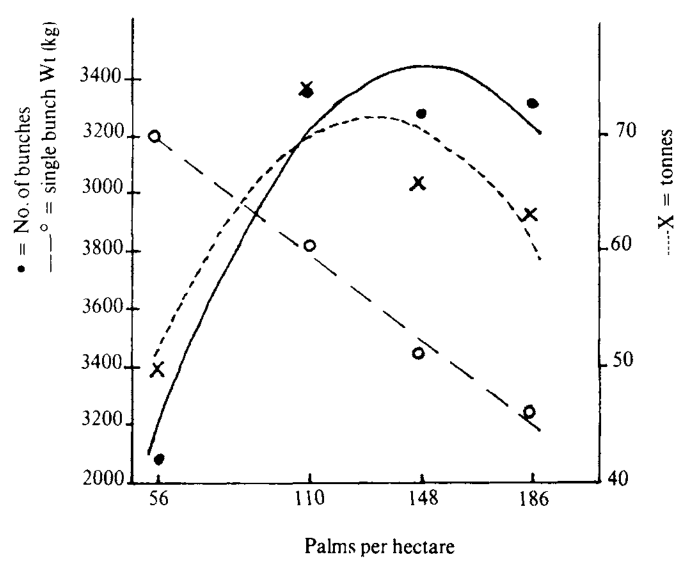


Figure 6: *Experiment 102, Yield per hectare, 1982-84*



EXPERIMENTS 104 and 105, Thinning trials at Bebere

When it was decided that the planting density of 143 palms/ha at which palms on New Britain Palm Oil Development had been planted was too great, they were thinned systematically by one seventh. Two field trials were initiated in 1978 and 1980 on palms planted in 1970 to test the effects of thinning and evaluate the practice. These trials were small in the sense of having relatively few replicates and so could not discriminate sensitively the differences due to treatments which were however expected to be quite large. They were planted on a flat area which has subsequently become one of the poorer yielding areas of Bebere plantation. These experiments were concluded at the end of December 1984.

Designs: Randomised blocks of 3 treatments were replicated 3 times (Expt. 104) and 4 times (Expt. 105). Plots were of from 51 to 81 palms of which the perimeter palms of each plot formed unrecorded guard rows. Two treatments were common to the two trials.

Treatments:

		Palms per ha	
		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 vacancy	—	122

Results: In common with trends elsewhere (for example Expt. 102) production declined sharply during the last quarter and was very poor for the year at 10t/ha in Expt. 105 and 14t/ha in Expt. 104. The layer of topsoil appeared particularly depleted and this site had been subject to gradual erosion through the years.

There was a marked mid-year drop in single bunch weight and the number of bunches per palm declined throughout the year. These experiments were reflecting a strong reaction to the drought of 1982. Visual inspection found the palms very unproductive and the overall poor yields were attributed largely to this drought. Cumulative production and production during 1984 are summarised in Table 31.

During 1984 each palm's production continued to favour thinning in a highly significant way. Palms thinned by one third yielded 190% of the unthinned ones, this being due to harvesting approximately 70% more bunches weighing 15% more. Converted to yield per hectare, the difference at no time reached a level of statistical difference in Expt. 104 but did in Expt. 105 during 1983 and 1984. Over the whole period of these trials, despite 19% greater tonnage being harvested on the older Expt. 104 and 70% more in Expt. 105, differences were not significant. This was due to the wide variation between plots within treatments. An analysis of cumulative yield for the first 54 months after thinning using combined data of the two common treatments from both experiments also failed to show the difference of 6% to be significant.

The dynamics of the effects of thinning are shown in Figures 7 and 8 which indicates the pattern of production and its components and how changes have affected both quarterly trends and cumulative yield. Loss in cumulative yield per hectare caused by thinning in both trials recovered approximately 36 months later. By extrapolation of the linear trends in these experiments, the divergence in yields would not be expected to be statistically significant at the 5% level until about the thirteenth year.

While thinning has caused no overall loss yield and thinning hexagonally by a third was numerically better than the control by 7%, thinning by a seventh or cutting out every third row showed no advantage and unless one emerges when the data is analysed on an economic basis the practice of thinning by a seventh appears to have had little value.

The increase in frond production and petiole cross section caused by thinning was reported in the Annual Report for 1983 together with data to show that improved single bunch weight was largely caused by bunches having more spikelets with slightly more flowers on them after thinning.

Levels of nutrients in leaf seventeen were sampled in September and the results of analysis are given in Table 32. Consistent, significant differences between treatments for major or minor nutrients were not found with the exception of Magnesium. Significantly more of the latter (12% and 15%) was found in the plots that had not been thinned and were more shady. In general, the palms in these experiments were low in nitrogen and phosphate but otherwise satisfactory levels obtained.

Table 31: *Experiments 104 and 105, Yields for 1984 and cumulative*

TREATMENT	*PER PALM*			*PER HECTARE*			
	1/84 — 12/84			*1/84 — 12/84*		*4/78 — 12/84*	
	No. of bunches	*Wt. of bunches kg*	*s.b.w. kg*	*No. of bunches*	*Wt. of bunches t*	*No. of bunches*	*Wt. of bunches t*
Not thinned	4.6 a	84.8 a	18.6	678	12.5	6,969	116.5
⅓ thinned hexagonally	7.0 b	146.2 b	20.9	667	13.9	6,545	124.2
⅓ rows thinned	6.8 b	137.0 b	20.0	658	13.1	6,349	116.4
EXPT. 105						*5/80 — 12/84*	
Not thinned	3.6	63.8	17.9	510	9.1	3,912	66.1
⅓ thinned hexagonally	6.0	123.6	20.8	568	11.8	3,643	70.5
⅐ thinned	4.3	81.7	19.0	526	10.0	3,716	65.3

Table 32: *Experiments 104, 105, Leaf nutrient content, September 1984.*

	%								ppm				
EXPT. 104	*N*	*P*	*K*	*Mg*	*Ca*	*S*	*Na*	*Cl*	*Fe*	*Mn*	*Zn*	*Bo*	*Cu*
Not thinned	1.9 a	0.13	0.90	0.25 a	0.94	0.14	0.01	0.28	52	55	22	14	6
⅓ thinned hexagonally	2.1 b	0.14	0.93	0.22 b	0.94	0.14	0.00	0.32	57	55	23	13	6
⅓ thinned	2.1 b	0.14	0.93	0.21 b	0.95	0.14	0.00	0.28	61	55	23	14	6
EXPT. 105													
Not thinned	1.8	0.13	0.95	0.27 a	0.87	0.14	0.00	0.35	64	58	23	14	6
⅓ thinned hexagonally	2.4	0.14	1.00	0.23 b	0.87	0.14	0.00	0.36	50	62	24	14	6
⅐ thinned	1.8	0.13	0.95	0.23 b	0.84	0.15	0.00	0.35	55	61	23	16	5

Means with the same letter do not differ significantly

Figure 7: *Experiment 104 and 105, Cumulative yield per hectare.*

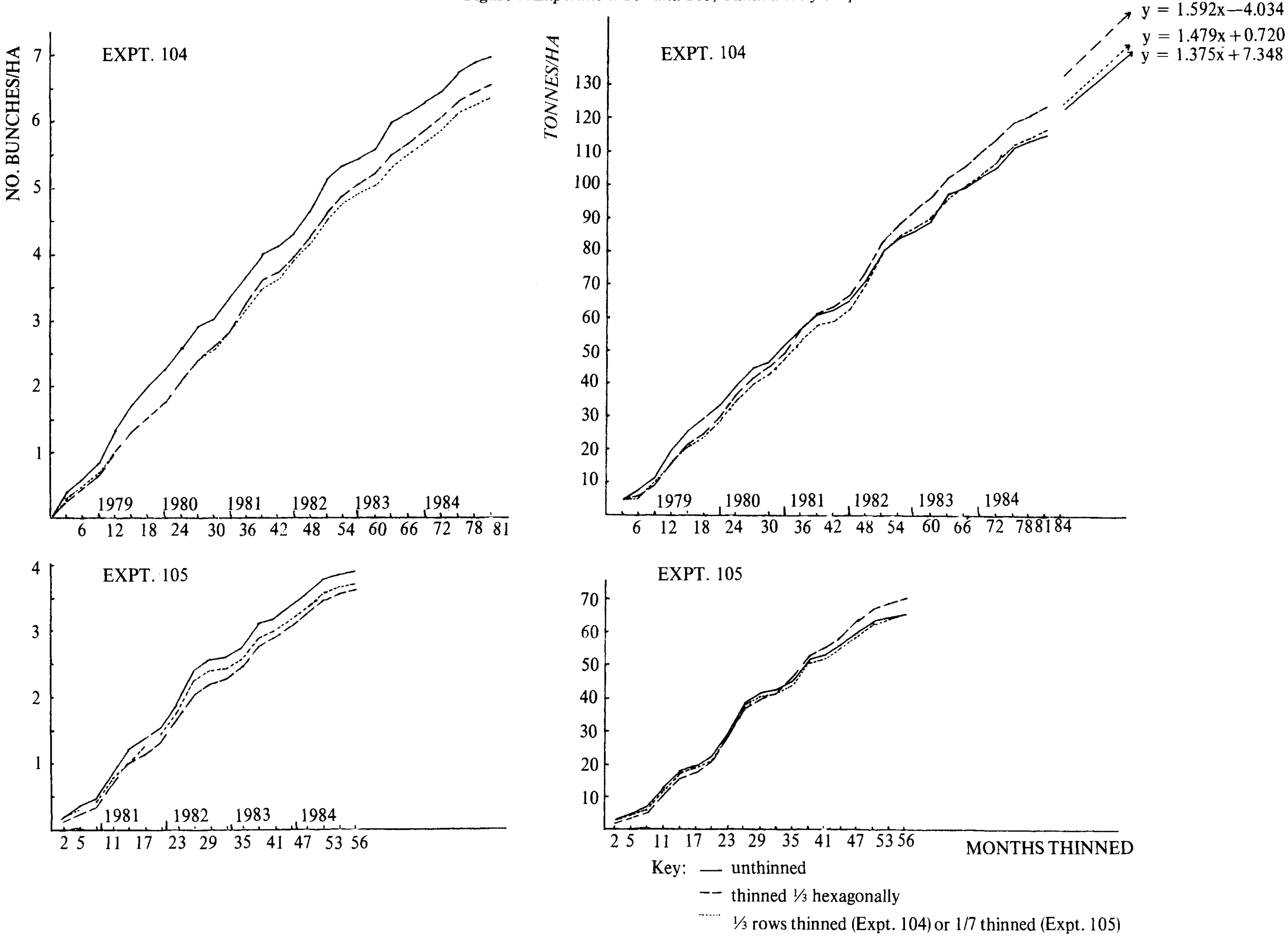
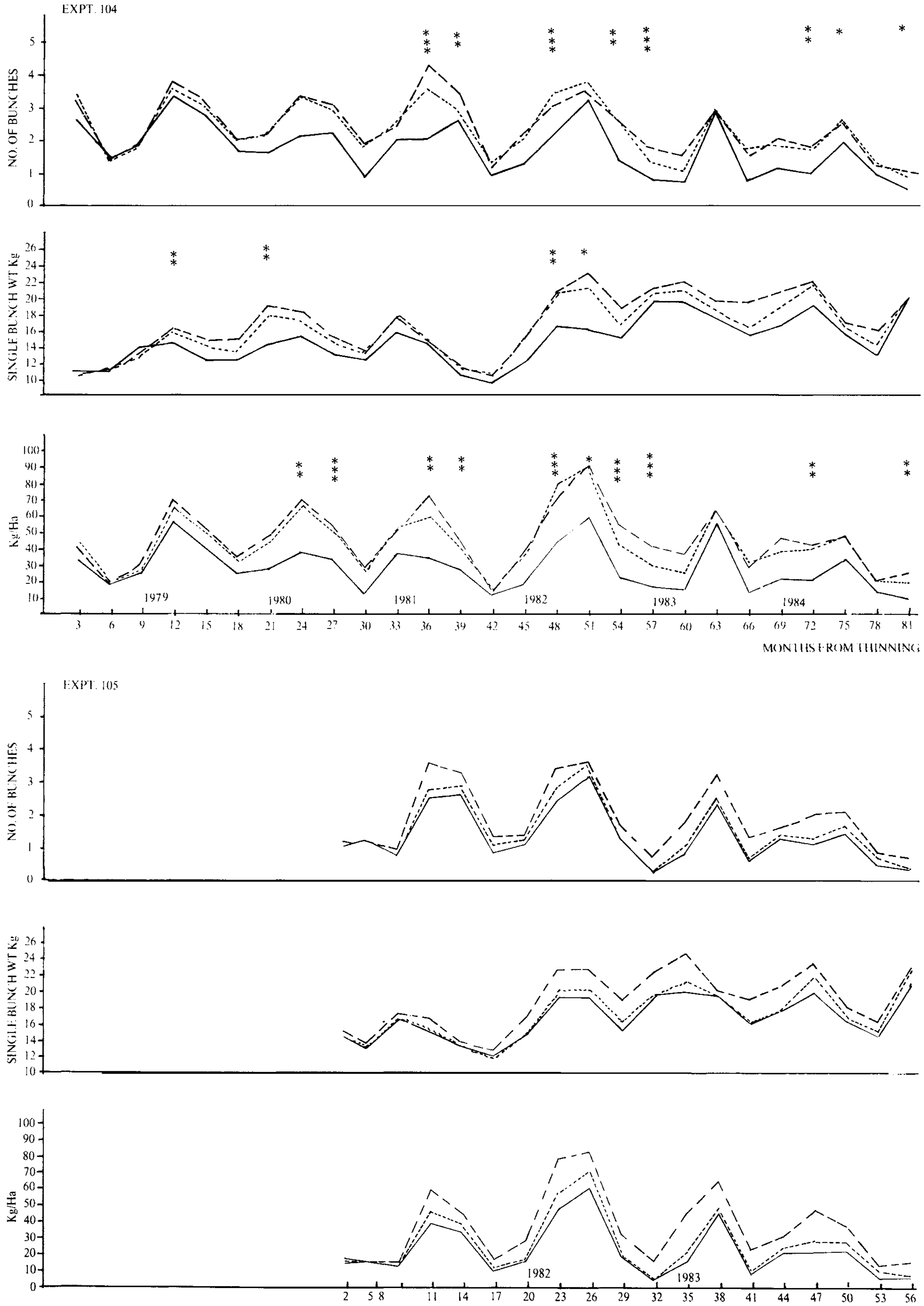


Figure 8: *Experiment 104 and 105, Three-monthly yield of FFB and components of yield per palm*



Key: See Figure 7

INVESTIGATION 702, *Effects of competition*

Palms planted at the high density of 186 palms to the hectare in Expt. 102 and for which detailed and lengthy records of growth, flowering and production existed were available for further research in 1981. This presented an opportunity to examine how they would respond if inter palm competition were to be removed suddenly in half of them. The kind of response expected would elucidate initiation and development of inflorescences, flowers and bunches under conditions in Papua New Guinea. Previously published data on these phenomena was not considered decisive. Corley's work (Corley 1976) was so far the most thorough and his approach was followed in the larger experimental population that was available at Dami. It was possible not only to study the effect on flowering but also to relate this to the developmental morphology of inflorescences and flowers in samples dissected from palms that had to be felled at the outset of the investigation. This study therefore comprised descriptive botany and the dynamics of responses to competition with the objective of improving our ability to forecast yields and understand their fluctuations under local conditions.

The methods used were described in the Annual Reports for 1982 and 1983 as was an evaluation of the contemporary data. Analysing bunch components continued until November 1984 by which time the appropriate developmental stages affected by the sudden removal of competition had been covered. Flower censuses were continued and are continuing so that their trends can be better understood, complicated as they have been by other environmental changes.

The investigation was divided into three sections, which represent the three topics intended for publication by Breure and Menendez and are reported below.

Effect of interpalm competition on yield sub—components: The main components of yield are single bunch weight and the number of bunches produced. Table 30 has shown how increasing density strongly affected bunch production in Expt. 102 and trends in optima for current and cumulative density are described above for that experiment. How these differences occurred is demonstrated as a direct result of the thinning treatment which is reported in the next section.

Bunch composition has been studied in data of bunch analysis obtained in Expt. 102 by New Britain Palm Oil Development's Research staff in 1973—1978 before the formation of the Papua New Guinea Oil Palm Research Association, together with the analysis completed in 1984. The latter are reported here.

The effects on bunch components of differences in competition caused by planting density are given in Table 33 and were as expected. Single bunch weight, stalk and empty spikelet weights (which together constitute the "frame"), single fruit weight, number of spikelets and flowers per spikelet declined linearly with increasing density. The magnitude of these effects was pronounced for single bunch weight, and for the frame, which was 30% less at the highest density, and its components. Single fruit weight varied only slightly (2%) and this difference was not significant. Significantly fewer flowers per spikelet and spikelets per bunch (13%) were produced at the highest density. Percentage fruitset was positively correlated with density being 16% better at the highest density and, mainly as a result of this, fruit to bunch followed the same trend. It is suggested that close planting may favour the pollinating weevil by lowering the temperature and providing a greater concentration of male inflorescences as breeding sites and sources of food thus reducing the need to wander far. It is clear this effect can be quite localised as it was detected here from plot to plot of the density trial, Expt. 102.

Inflorescence development in relation to yield sub-components: The data on flowering is shown in Figure 9 which updates Figure 9 of the Annual Report for 1983. A high level of abortion has been seen again for leaves -38 to -46, this time caused by the drought of 1982, which coincided with the cyclic trough in the sex ratio. It has been observed in this investigation and elsewhere (as in Experiments 104 and 105) that improved environmental conditions are associated with wider fluctuations because they allow the attainment of higher peaks but reach cyclical troughs similar to those before the improvement. In Figure 9 the values for sex ratio are seen to coincide for thinned palms in these troughs after a divergence (see leaves 2, -20, -42).

Lest the normal rythm of flowering differred in the populations, their pattern of flowering before the investigation started was graphed from NBPOD'S data. The two populations did not differ and changes seen since Investigation 702 comenced are therefore the consequence of the thinning treatment.

The more comprehensive data available this year also supported our previous contention that abortion does not affect developing female inflorescences rather than, or substantially more than, male ones.

Of consuming interest is the question of when the sex of an inflorescene is determined because of the strong effect of this factor on fluctuations in yield. At the end of 1983 it appeared that the sex ratio of the treatments was diverging and that the answer would become clear during 1984. That this was not entirely so is ascribed to the confusing influences of extremely high fruiting activity when the investigation started in 1981 caused by the coincidence of the onset of insect pollination and then the drought of 1982, both of which will have affected sex ratio.

A divergence between the curves for thinned and unthinned palms was observed starting at leaf -8 that persisted to leaf -18 and was statistically significant between leaves -10 to -15. This was much closer to anthesis than the developmental stage associated by earlier workers with the determination of sex. A second divergence was observed at leaf -24 which, except for a coincidence from around leaves -41 to -46, has continued. Apart from this lapse (in a trough), the difference became statistically significant at leaf -25. The divergence and convergence of the curves for sex ratio that appear to be a repeating pattern has already excited comment in this report. It is tentatively concluded that sex can be affected at more than one stage in the development of an inflorescence. Leaf -25 was harvested about 29 months after the investigation started and would have been at anthesis at about 24 months. This confirms earlier workers' results quite neatly. But it is argued that sex so established is not necessarily Irreversible. Leaf - 10 was harvested at about 21 months. Either some inflorescences escaped earlier determination or remained facultatively ambivalent.

Sex determination is reported (Corley, 1976) to coincide with the stage when the first bract is initiated. In our material this was at leaf -18, so sex determination must have occurred before and after that. However, the ordinal number of the leaf where the first bract is found can vary, as evidenced by palms outside the trial that were sampled during 1984 and which showed leaf -23 to be the one.

The practical effect on yield was that conditions favouring increased sex ratio may have raised yields after a year but the main effect was not until the passage of a little more than two years. This study continues.

In the Annual Report for 1982 preliminary results were given of the effect of thinning on bunch composition. A final summary is presented in Figure 10 in which a consistent divergence of the thinned palms from 100% indicates in which leaf axil the first affected inflorescence was situated at the outset of the experiment and therefore at which stage the inflorescence development was affected by thinning.

At first view the values for single bunch weight gave a very spikey appearance to the graph which could have resulted from palms with different bunch weight biasing the means for bunches sampled against any particular leaf number, especially when bunch numbers were low. In Figure 10 single bunch weight has been corrected by dividing observed individual values with factor "mean sbw of that palm for 3 pre-treatment years multiplied by the mean for all palms". While this improved matters this was not considered sufficient to warrant an attempt similarly to correct other bunch components with pre-treatment data available.

There was a clear effect on single bunch weight and the components of its frame around leaf 0 to +1 and to the number of spikelets at leaf -15, and flowers per spikelet at leaf -12. In the dissected material spikelet initiation was seen about leaf -4, not -15, and although the curves for spikelets per bunch also separate at this point this was no more consistant than the difference seen at leaf +9 for which no explanation occurs.

The proportion of fruit to bunch by weight was significantly better in the unthinned palms at leaf -18 and remained so with various levels of significance until recording stopped. This reflected the improved fruitset under more crowded conditions which was also encountered in Expt. 105. Fruit set itself was generally about 10% better in unthinned plots. Its effect was first seen at about leaf +19, which corresponded to anthesis of the subtended inflorescene at the beginning of the experiment. Again it was in the later, cyclic troughs of low values that the difference between treatments lessened or was temporarily reversed. From leaf -12 the improved fruitset was consistently better where there had been no thinning and the bunches were beginning to consist of comparatively fewer spikelets and flowers. These bunches would consist of proportionally less frame by weight which would weaken their correlation between fruitset and fruit to bunch. Improved yield due to variations in single bunch weight could therefore be expected after 5—6 months, when they would be due to changed conditions favouring successful pollination and, more emphatically, after about a year when the structure of the bunch would be altered.

Summarising the immediate effects of reducing competition between palms, yields were potentially improved progressively from about five months until 1 year later by improved bunch weight and from about two years onwards by a higher number of bunches.

Description of the phases of inflorescence development: In material sampled from felled palms at the start of the experiment which was studied in the laboratories of the Department of Tropical Agriculture of the University of Wageningen (who have cooperated in this venture) the initiation of certain parts of the developing female inflorescence has been determined as shown below.

PART INITIATED	SUBTENDING LEAF
First Bract	-18*
Spikelets	- 4
Bracteoles	- 2

(* -23 in a different palm sampled later)

Figure 9, *Investigation 702, Changes in sex ratio and abortion in thinned and unthinned palms*

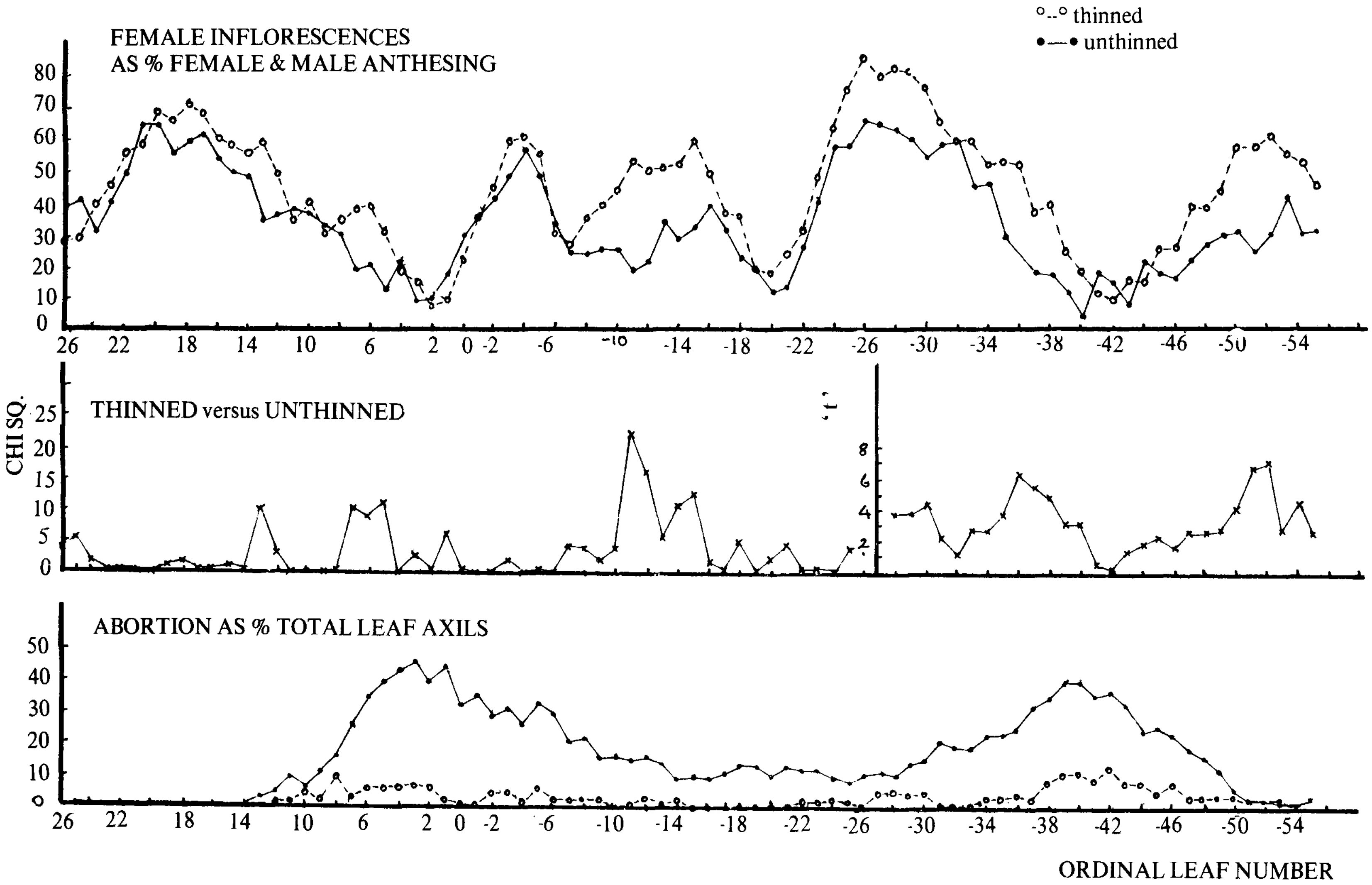


Figure 10, *Investigation 702, Bunch components for successive leaf axils of thinned palms as a proportion of unthinned palms.*

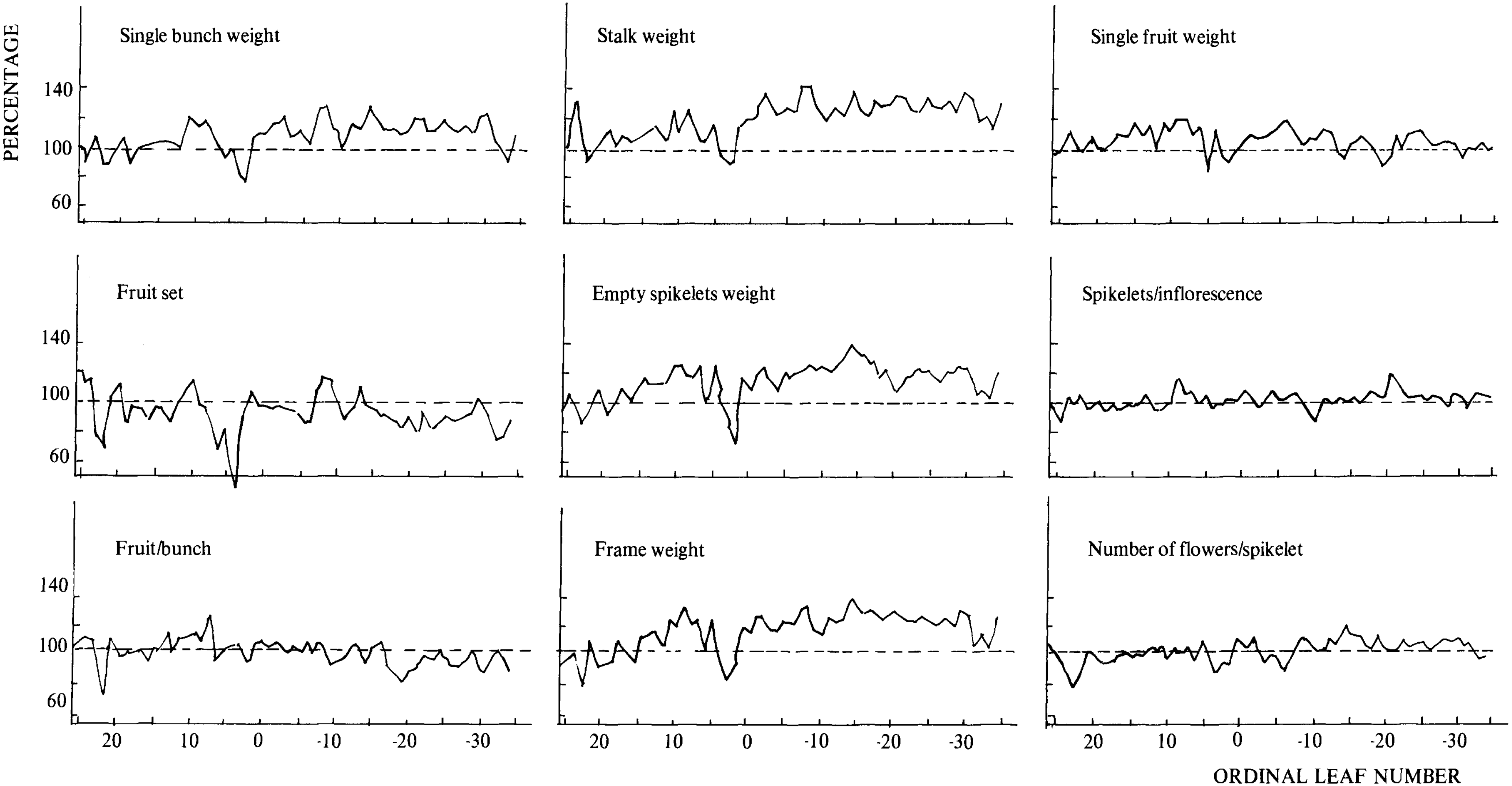


TABLE 33: *Experiment 702, Effect of density on bunch components, 1983.*

VARIABLE			PALMS / HA				r^2
			56	*110*	*148*	*186*	
II	Single bunch weight	kg	23.4 a	21.2 b	18.8 c	17.4 c	0.99
III	Stalk wt.	g	1,869 a	1,591 b	1,335 c	1,194 c	0.90
IV	No. of spikelets		212 a	208 a	194 b	185 c	0.92
V	Flowers per spikelets		15.1 a	15.0 a	13.8 b	13.1 b	0.87
VI	Fertile fruitset	%	49 b	51 ab	54 ab	57 a	0.97
VII	Fertile fruit to bunch by wt.	%	62 a	67 a	67 a	69 a	0.88
VIII	Single fruit weight	g	8.8 a	8.7 a	8.7 a	8.6 a	0.91
IX	Empty spikelet weight	g	16.3 a	14.8 b	13.7 c	12.8 c	1.00
X	Frame weight	g	5,310 a	4,644 ab	3,975 b	3,556 a	0.99
	n		321	408	328	172	

Means with the similar letter do not differ significantly.

ENTOMOLOGY

INSECT POLLINATION

INVESTIGATION 603, Elaeidobius kamerunicus Field studies (RNBP, T.M.)

Population census and fruitset: Throughout the year the population of weevils was studied at four sites in West New Britain and four in Oro Province. These sites were from both nucleus estate and smallholdings in each area and included both mature and recently planted palms.

The data and the relationship between weevil population, male flower counts and fruit set are set out in Figures 11 and 12. The top series of graphs combines male flower counts (dotted line) with an estimation of numbers of weevils per hectare, called the pollination force (solid line). Pollination force is calculated from weevil emergence data, number of male flowers per hectare, size of the inforescenes and planting density. There is generally a clear relationship between number of male flowers and pollination force because the fluctuation in number of male flowers effects the pollination force more than the other variables.

As might be expected with such variable data the overall picture is not clear but the extremes do indicate trends which bear closer examination as there are unexplained differences between West New Britain and Oro Province.

In West New Britain the lowest fruit set recorded in Bebere (1978 planting) of 53 percent corresponds with both a low male flower count and low weevil emergence. At other times the weevil population and male flower counts remained high enough to keep fruit set between 60 and 65 percent. At Rikau (Village Oil Palm Plot) a similar event occurred where a very low fruit set also corresponded with a previous low male flower count and weevil emergence. The fluctuations observed in the other two sites were not as great and generally a male flower count of over fifteen per hectare and a medium to high level of weevils combined to keep fruit set above 55 percent.

In Oro Province the same trends were still there but the fluctuations were more extreme in all sites observed. At Arehe, which is the oldest planting on the estate (1977), the lowest fruit set recorded of 46 percent corresponded with what we consider to be a low male flower count of ten per hectare and a low weevil emergence figure. However, subsequent low male flower counts and very low weevil emergence figures do not correspond with low fruitset, in fact quite the opposite. On Ambogo the lowest male flower counts and low weevil emergence data do not correspond directly with the very low fruit set (below 40%) but it is suggested that the continuous low male counts of below 10 per hectare seriously reduced the population of weevils over most of the estate.

It has been reported several times that during the period of high male flowers following a low male flower cycle (eg July, August, September 1984 on Ambogo) very few weevils are observed on the male flowers which appear bright yellow with pollen! If the weevil population takes such a long time to recover this development will be recorded in a different manner; either counts of weevil on spikelets and or by trapping weevils arriving on the female flowers. At Beuru a similar situation was seen where fruit set at its highest of 55 percent corresponded with the high male flower numbers and weevil emergence data. Subsequently both male flower counts and weevil emergence figures dropped and corresponded with a continuing trend of fruit set below 55 percent. At Tunana which showed the same trend where male flower counts below ten corresponded with low fruit set, the explanation for the generally better fruit set on this block is not clear. The weevil population was on average much higher, which may have cushioned the effect of lower male flower counts due to a more rapid recovery. The higher rain fall in this area compared with Beuru and Ambogo certainly favours weevil reproduction.

It is concluded that the situation in Oro Province although following general trends still requires further thorough examination to understand the limitations on fruit set.

In its turn, fruitset directly affects useful fruit to bunch and the extraction rate of oil and kernels at the factory. In the previous Annual Report of the PNGOPRA, data were presented which showed only poor correlation between fruitset and fruit to bunch. It was concluded that fruit to bunch was an unreliable guide to fruitset, probably because of variations in the amount of parthenocarpic fruit. More comprehensive new data collected by NBPOD to asses DxP progeny rows on Kumbango plantation was partitioned into seven ranges of fruit set. A much better agreement was obtained which fitted best to the logarythmic curve $y = 0.43 + 16.35 \, LNx$ (Figure 13). Parabolic curves fitted to the same data relating fruitset to oil to bunch are also given in Fig. 13. The broken line gives the curve over the whole range of values (which includes extremes averaged from less than 20 bunches) and the solid line the range from 35—85% where the number varied from 20—102. The latter indicated that between 60—40% fruitset there was a drop of 1.6% in oil/bunch and difference 60 - 35% a drop of 2%. By applying the equation for the broken line the calculated losses in oil to bunch were 2.2 and 3.2% respectively. Partial and multiple regression calculations between fruit to bunch, mesocarp to fruit and oil to bunch indicated that in this data fruitset accounted for 76% of the variation in oil to bunch and 94% of the variation in fruit to bunch.

Figure 11: *Investigation 603, Comparison between pollination force, weevil emergence and male flowering with fruit set 5 months later, West New Britain Province.*

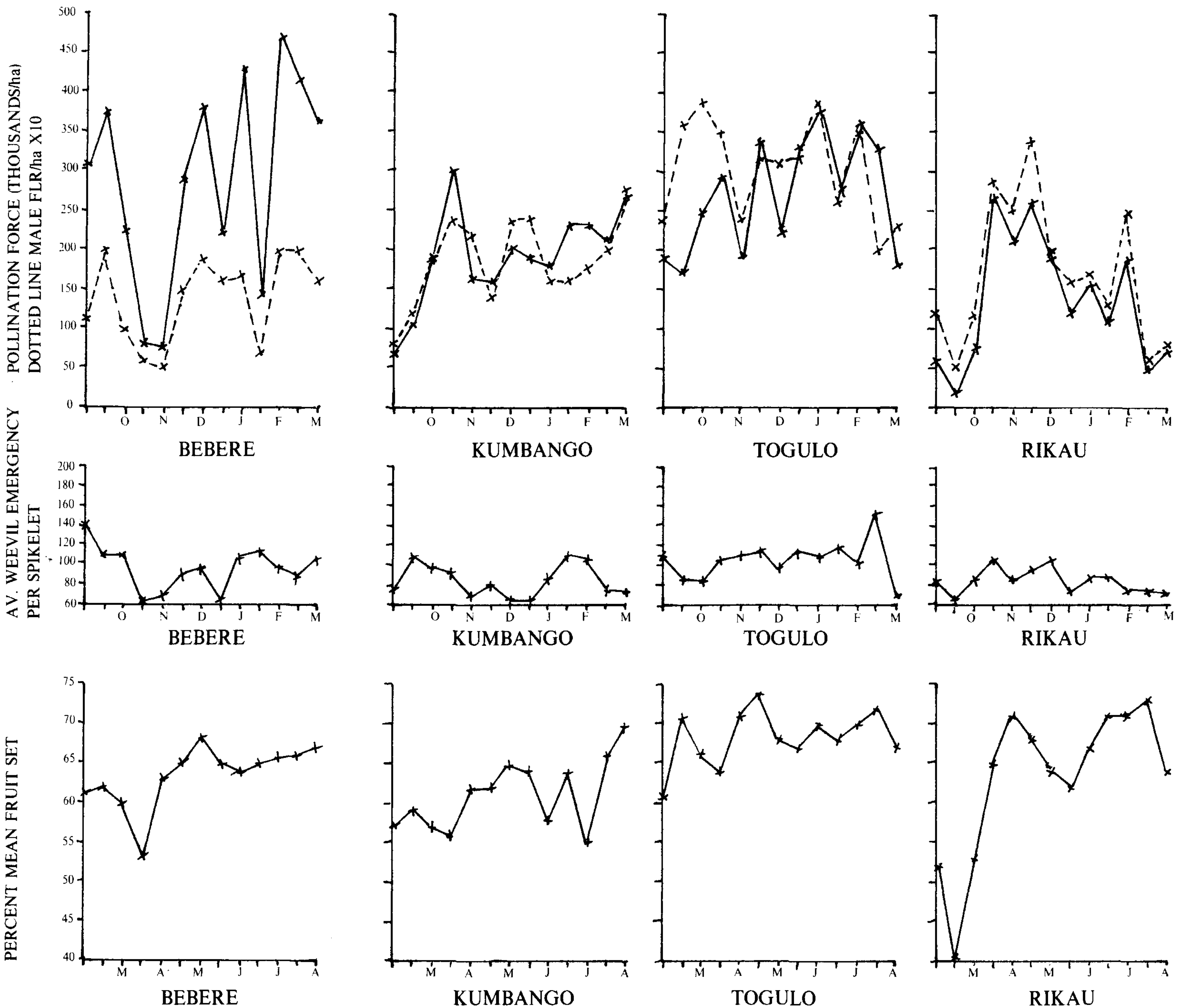


Figure 12: *Investigation 603, Comparison between pollination force, weevil emergence and male flowering with fruit set 5 months later, Oro Province.*

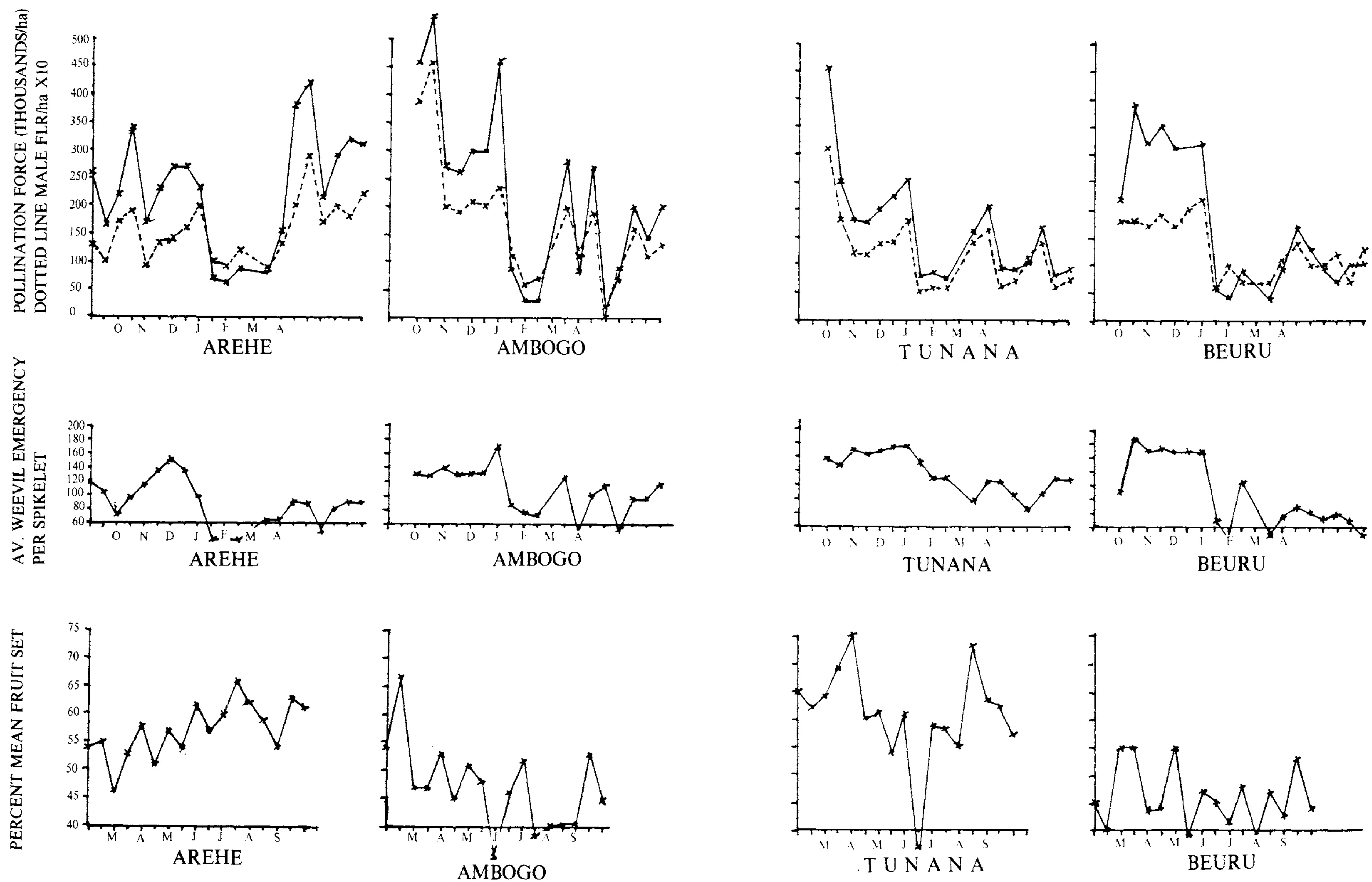
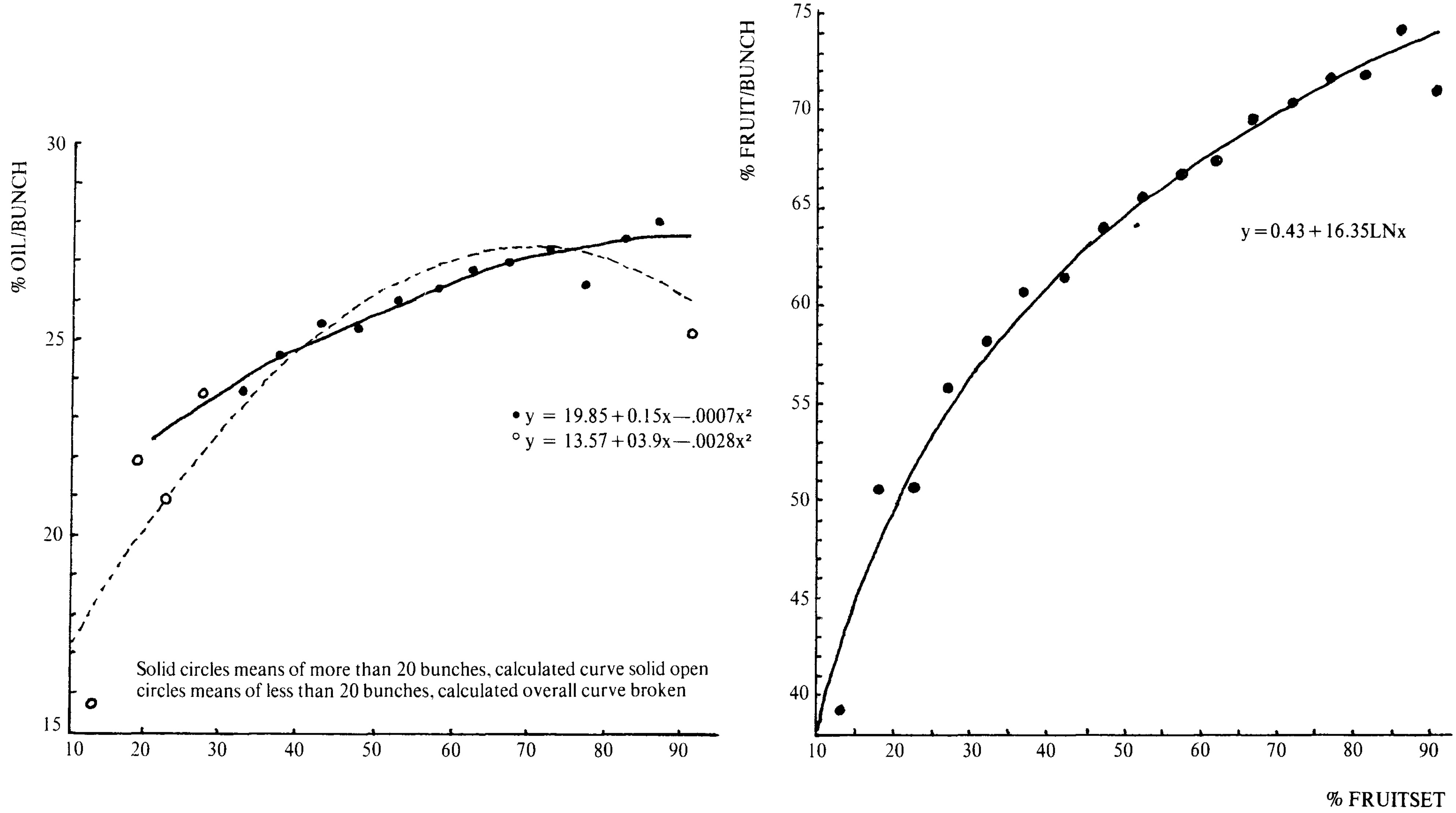


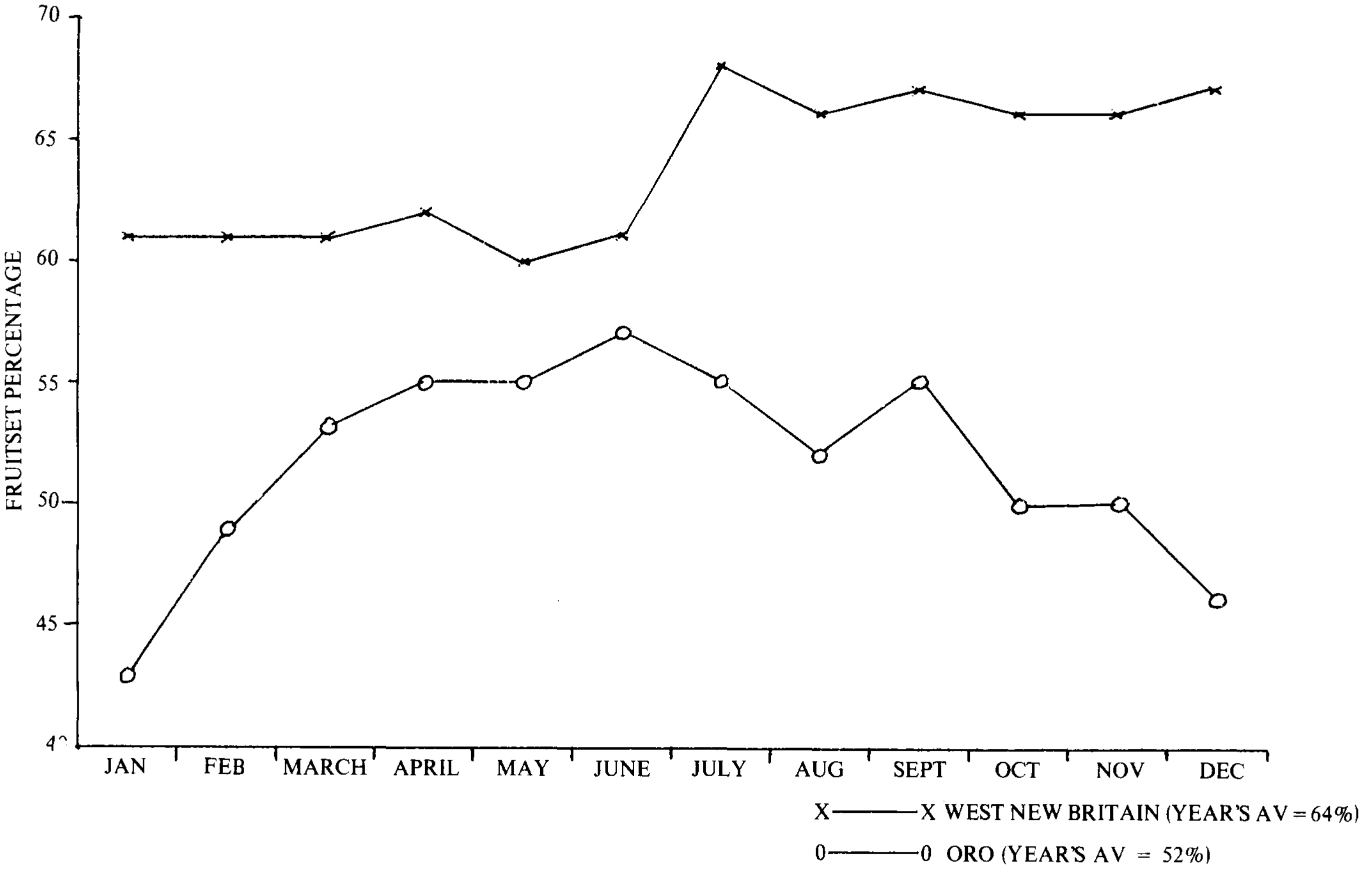
Figure 13: *Investigation 603, Relationship between fruitset, oil/bunch & fruit/bunch, Kumbango plantation 1983.*



Considering these results in conjunction with Figures 11 and 12, it was concluded that the critical level of pollination for oil yield was that which gave 50% fruitset. On this basis, at the sites monitored, pollination has only been deficient in West New Britain during the early stages of the isolated young village plots at Rikau. At Hargy Oil Palms fruit set in palms planted in 1973 remained consistently high and similar to palms at Togulo planted in 1980. Lower but still good pollination were obtained for young plantings at Kumbango (1979) and even older plantings at Bebere (1970).

Not only did fruitset continue to be more variable in Oro Province, but levels frequently fell below the critical level. This was especially true of young palms planted in 1980 on Ambogo plantation and the isolated village oil palm plots at Beuru which lie in a particularly dry area. Except at the end of the year exceptionally high fruit set was recorded in the palms planted in the high rainfall Tunana village plots in the same year. The year's average fruitset monitored at four sites in West New Britain was 64 percent compared with only 52 percent in Oro Province (Fig. 14).

Figure 14: *Investigation 603, 1984 Average Fruitset percentage from four sites in both W.N.B. and Oro Province*



Pollination problems in Oro Province: Because poor pollination was considered likely to be affecting the extraction of oil at the Higaturu factory in Oro Province a special study to elucidate the cause was started in November. Simultaneous male flower production there had frequently been less than the minimum of ten per hectare. Compaction of female inflorescences when bunches were numerous was also thought to be another factor limiting pollination. The experiment was designed to remove the limitations of compaction and pollen.

Although the poor pollination in Oro Province may have created milling problems and contributed to a lowering of oil extraction rates, production in the field was good. In the same area of Ambogo plantation where fruitset is monitored the annual yield was 35 tonnes to the hectare. Deficiencies of one aspect of production or another could be compensated for by other aspects of the pattern of growth and flowering to maintain optimal yields.

With the kind of planting material developed, which derives much of its high yielding potential from a high sex ratio, the distinct sexual cycles are very marked and synchronised during the early years. This could account for comparable fluctuations in weevil populations. If young plantings are within a kilometre of older palms, which have become less synchronised and produce fewer, heavier bunches because of their age and interpalm competition, they can benefit from pollination by weevils flying in from later source.

Plantation yields: The data collected from Walindi plantation (168 hectares) planted mainly in 1970 continued to correspond well with trends recorded in other larger plantations and much smaller blockholdings of a comparable age in West New Britain (Table 34).

This year had a different yield pattern from last year but the overall yield remained the same. Some areas on other plantations recorded extremely low yields after the normal June—July depression. These are referred to in preceding sections of this report.

Investigation 603, Production FFB/Ha. Walindi Plantation W.N.B.

	1983 t	*s.b.w.* kg	*1984* t	*s.b.w.* kg
JANUARY	1.0	22.6	2.6	24.2
FEBRUARY	0.9	21.2	2.4	24.8
MARCH	2.2	20.7	3.8	24.0
APRIL	2.7	19.8	2.8	23.3
MAY	3.2	19.3	3.2	22.1
JUNE	2.5	19.0	2.0	21.7
JULY	1.2	17.0	1.9	21.7
AUGUST	1.4	17.5	1.3	20.7
SEPTEMBER	2.0	17.0	1.0	20.0
OCTOBER	2.4	18.9	1.1	20.6
NOVEMBER	2.3	21.2	1.0	23.1
DECEMBER	2.0	23.4	0.7	23.3
TOTAL:	23.8	Av. 19.8	23.8	Av. 22.3

SEXAVA *(SEGESTIDEA spp.)* (R.N.B.P.)

INVESTIGATION 601, Sexava chemical control

In West New Britain *Segestes defoliaria* remained active in a few areas in both the Hoskins and Bialla schemes but treatment was at a low level. On Hargy nucleus estate treatment was confined to a few blocks at the end of February and no further treatment was carried out this year. In the Hoskins scheme damage was reported at both Kavugara and Buvussi in January. At Kavugara blocks were not treated and the worst affected was reserved for biological control work. The Buvussi blocks were kept under observation and treatment was carried out in August and September to about 70 blocks. Evidence of less than usual knockdown by both monocrotophos and liquid acephate in both trial and field treatments pointed to a lowering of activity by the chemicals both of which had been in store for over twelve months in P.N.G. Despite the reduced activity of the chemicals, damage was kept to less than economic levels in all affected areas. A small amount of damage to the seed production palms on Dami was treated successfully with freshly imported stocks of liquid Orthene (acephate) in November.

In the field treatments referred to above, monocrotophos was used as 10c.c. concentrate (40 percent a.i.) and acephate at 15c.c. concentrate (20 percent a.i.). Results from a comparative trail at different concentrations were inconclusive due to the weather and the unsatisfactory kill obtained by the used of stocks of both chemicals stored for over a year. Fresh stocks of both chemicals continued to be effective at the concentration used in the field applications and new trials will be set up next year.

INVESTIGATION 604, Sexava field studies

In Oro Province leaf damage was noticed in several areas of the estates and smallholdings and serious *Sexava* damage was confirmed in Waru blocks in June. The species *Segestidea novaeguineae,* (Brancsik) had been recorded in the Oro Province since 1960 and on oil palm trial blocks in 1977, so its appearance as a pest was not surprising. Specimens collected were of both green and brown colour forms with the green form predominating. In the Waru blocks a behavioural difference between this species and others was observed where large numbers of adults were found resting accessibly during the day on epiphytes on the trunks of oil palms. However, substantial numbers still remained concealed in the palm canopy. Eggs collected have evidence of parasitism but no specimens were reared from eggs kept in the laboratory. Apart from significant damage to two blocks at Waru no serious damage occurred elsewhere although *S. novaegneae* was widespread in the development. Close association with Sago swamps and several infested areas suggested a connection with this wild host plant but this was not confirmed.

INVESTIGATION 607, Sexava bio-control

Strepsiptera: *Stichotrema sp* is an internal parasite of *Sexava* which infects its host by producing thousands of free living larvae, called triungulins, which leave the female parasite via an opening in the body wall of the host. Male parasites are very rare and their possible ant host is still being sought. The parasite affects both male and female reproductive organs and is found in at least two genera of *Sexava* in P.N.G. *Stichotrema* has proved difficult to establish in the oil palm *Sexava* in W.N.B.

To refer to and update the results reported last year, out of the 82 nymphs (instars 1—6) and 54 adults of *Segestidea defoliaria* infected with triungulins of *Stichotrema* from *Segestidea decoratus* Redtb. Bubia, Morobe Province only one mature *Stichotrema* parasite was found to complete development in a sixth instar nymph and took four months to emerge. All the other specimens infected died before maturity of the parasite and in most cases when the dead insect was examined between 1—10 developing *Stichotrema* larvae were found in the body cavity. The very high mortality of *S. defoliaria* (Uvarov) when used as a host for *Stichotrema* indicates that the parasite is not well adapted to this host. In order to establish the parasite in the field a much better survival rate must be obtained. There are possible flaws in the experimental technique used and these will be investigated in future infections.

The identity of the ant, genus and species, which may be the host for the male *Stichotrema* was still unclear and work on this aspect needs to be done before further tests are carried out in the laboratory.

Evidence of significant numbers of egg parasites in all the outbreaks todate indicated that these micro hymenopterans could be important in stabilising *Sexava* populations. Collection and mass rearing of some of the seven or eight species found in P.N.G. was begun and marked a continuation of techniques which were briefly examined in 1977.

Nosema: This internal protozoan parasite of grasshoppers was imported into PNG from the U.S.A. in February 1984 at which time populations of *Sexava* were extremely low. Laboratory tests indicated that the organism was effective against *Sexava* with 50 percent mortality in the two tests carried out. Because of the low level of field populations it was decided that rather than keep this batch of *Nosema* until populations increased sufficiently to permit a proper trial, to use it on the worst affected small-holders' block at Kavugara in West New Britain and adjacent stands of *Sexava's* wild host plant *Helliconia*. Treatment was carried out in August by spraying a solution of *Nosema* into the cental row of affected oil palms on Block Number 1964 and randomly spraying several patches of *Helliconia.* The literature suggests that *Nosema* is difficult to establish in the field and one would not expect to detect or recover diseased specimens until the population of *Sexava* increases. The first sampling in November produced very few insects, all of which appeared healthy- and were kept several weeks in the laboratory where they continued to behave normally. Further checks will be made next year when it is intended to obtain fresh material of *Nosema* from the U.S.A.

BAGWORMS (PSYCHIDAE, LEPIDOPTERA) (R.N.B.P.)

INVESTIGATION 606, Bagworm (Lepidoptera: Psycididae) control

Collection of bagworms and rearing of parasites continued this year but very little material was obtained. This was primarily because populations of all three species of bagworm were very low. A new parasite was obtained from rough bagworm *Mahasena corbetti* and has yet to be identified. No damage at all by bagworms was seen in West New Britain throughout the year and only very small areas below treatable levels of damage were recorded from Popondetta.

Field trials of either Dimilin (which interferes with the moulting process) or commercial preparations of *Bacillus thuringiensis* preparations have been deferred until adequate numbersof bagworms are available for trial purposes. The interest in these two products remains because they are both safe enough to be sprayed from the air on smallholdings or estate should a bagworm outbreak develop too rapidly for the trunk injection method to be employed successfully.

OTHER PESTS (R.N.B.P.)

INVESTIGATION 605, Records and observations

Three new or unusual pests of oil palm were recorded. The first, *Rhabdoscelis obscurus* (Boisd); commonly known as sugarcane weevil, was reported by D.P.I. extension officers as damaging black (unripe) bunches at Buvussi smallholder blocks in West New Britain. *Rhabdoscelis* is a common insect in all the oil palm developments in PNG and adult weevils are usually seen feeding on sap exuding from the cut surfaces of fronds that have been pruned. Larval development is usually associated with damaged or rotten tissue. The bunches at Buvussi were rotting before they became fully ripe and there were no indications of prior damage by either cuts or disease. The exterior of the bunches was distinguished by the dull appearance of what are normally shiny black fruit and some of the outer fruits were easily detached. When the affected bunches were cut open numerous *Rhabdoscelis* larvae were found tunnelling in the developing fruit and spikelets. One bunch containing 155 spikelets had 132 spikelets with weevil damaged fruit and a total of 75 larvae and pupae were recovered from this bunch. The larvae had also tunnelled into the stalk of this and several other bunches examined, which would have assisted in the general collapse of the developing bunch. It was confirmed from other palm areas that Buvussi was not an isolated case. In the past, before the pollinating weevil was introduced, rotting bunches due to poor pollination were common-place and other causes would have been overlooked. The number of bunches affected appears to be small in the limited scope of this enquiry, nevertheless it now puts *Rhabdoscelis* as a potential pest of oil palm capable of causing primary damage to developing fruit bunches.

It is interesting to note that attention in the past twenty years on *Rhabdoscelis* was due to it being the most important beetle pest of sugarcane in PNG where it clearly causes primary damage to the crop. *Rhabdoscelis* was also a problem in Hawaii and Queensland sugarcane where a tachinid parasite (found in P.N.G.) was successfully introduced for its control. The Chief Entomologist (D.P.I.) MrT.V. Bourke in a report in 1970 on damage by *Rhabdoscelis* to coconuts on Garua island (West New Britain) considered that there may be different races of *R. obscurus* attacking palms and sugarcane. This may be followed up if *Rhabdoscelis* becomes important.

The other two insects reported on oil palm were mainly defoliators. The cockchafers, *Dermolepida proxium* and *D. noxium* were recorded as potential pests during the 1970's on the pilot oil palm plots planted in Popondetta in 1968. The adults could be found in large numbers resting during the day along the rachis of the frond among the leaflet bases. They feed at night and consume the leaf lamina causing similar damage to Sexava but smaller in area. The larvae feed on roots in the ground and have been confirmed as causing the death of a few recently planted oil palms, usually in ground which has previously been used for a garden. Although damage has only been reported in the Oro Province this insect also occurs in West New Britain. To date damage has been slight and probably remains at a non-economic level.

The longicorn *Mulciber linnaei* was first recorded in September 1982 as larval damage at Popondetta in moribund oil palms affected by lightening strike. In July 1984 damage to leaves of healthy oil palms was first observed in the same area and up to six adult beetles were found resting around the base of the oil palm spear on affected palms. *Mulciber* causes considerable damage to *Pandanus spp* and its characteristic rough edged holes, about half an inch across, often reduce *Pandanus* leaves to a 'lace curtain' effect. This damage has appeared over a wide area of the oil palm estate and smallholdings in the Popondetta area but is so far confined to very small patches of a few palms. In conjunction with Sexava damage and *Dermolepida* it adds a small amount to the general defoliation of the palms. Both *Mulciber* and *Dermolepida* will have seasonal peaks (which are not known).

PATHOLOGY

(P.J.)

EXPERIMENT 801, Incidence of Ganoderma

The design and layout of this experiment was detailed in the Annual Report for 1983. Observation of this experiment continued throughout 1984. There was no damage to the young palms caused by *Ganoderma* spp, however there was damage caused by *Scapanes* beetles. The area was surveyed for *Scapanes* damage and lindane granules were applied. Table 35 shows the amount of damage recorded in December 1983.

Table 35: *Experiment 801, Incidence of Scapanes on young palms.*

	Newly Damaged	Old damaged recovering	Dead
	%	%	%
Section 9	3	3	1
Section 20	1	6	0.2

Some more of the experiment was mulched with empty bunches; 150kg (2 wheelbarrows full) per palm. One half of Section 9 and one half of Section 20 are now mulched. This has resulted in a marked improvement in growth of the young palms with the result that more roots will be in contact with the decaying stumps which are the possible source of infection.

In July the treatments "old poisoned palms felled 1m from ground, live palms felled 1m from the ground and poisoned palms excavated" (2,4 & 6) in replicate 1 from Section 9 and 20 were surveyed for the presence of *Ganoderma* spp as indicated by sporophores and examination of the state of the stumps. This was a subjective assessment divided into: stump disintegrated, disintegration just started, frond bases removed, fond bases intact. The results are shown in Table 36.

Table 36: *Experiment 801, State of palm stumps.*

Section and Treatment	*Stump Disintegrated*	*Disintegration Just started*	*Frond Bases Removed*	*Frond Bases Intact*
SECT 20, 2	1	3	18	3
SECT 20, 4	0	2	13	10
SECT 20, 6	2	23	0	0
SECT 9, 2	10	13	2	0
SECT 9, 4	1	3	0	18
SECT 9, 6	20	5	0	0

The presence of *Ganoderma* spp in the treatments is shown in Table 37.

Table 37: *Experiment 801, Presence of Ganoderma* spp on *palm stumps*

Section and Treatments	*Ganoderma Present*	*Ganoderma Absent*
SECT 20, 2	13	12
SECT 20, 4	6	19
SECT 20, 6	5	20
SECT 9, 2	5	20
SECT 9, 4	5	20
SECT 9, 6	5	20

In September the area was surveyed again and this time there appeared to be more *Ganoderma* spp in the non-poisoned palms (treatment 4) and further disintegration in treatment 2. In the earlier survey (Annual Report 1983) there were no sporophores on the non-poisoned palms for *Ganoderma* spp to colonise the stumps and to produce sporophores. In poisoned stumps the process was much quicker but disintegration of the stump did not take place until approximately 3 years after felling: this means there is approximately a 2 year period in which *Ganoderma* spp are actively growing in the stump before the food base has been exhausted.

Sporophores of *Ganoderma* were collected whenever the area was visited for use in pathogenicity tests.

AMS has failed as a poison for oil palm, but it may be possible to use it as an accelerator of stump decomposition.

The trial was surveyed to assess the state of the stumps and also the presence of *Ganoderma* sporophores. The results are shown in Table 38.

The stumps were also sampled for the presence of Basidiomycetes including *Ganoderma* spp. Two slices were cut from the top of each stump and isolations made from colonised areas. The first two stumps of treatments 1 to 8 were sampled in replicate 1. Many Basidiomycete fungi were isolated including *Ganoderma* spp. However isolations of *Ganoderma* were not made from the holes where *Ganoderma* sawdust cultures had been inoculated into the palm. This method of inoculations into palm stumps was therefore not successful and any *Ganoderma* present in the tissues had probably colonised from the frond bases. Sporophores of *Ganoderma* in several cases were still attached to the stump slices. slices.

Table 38: *State of Stumps in Experiment 802 (total of 4 replicates - 20 stumps)*

Treatment	*Frond Bases Intact*	*Frond Bases Removed*	*Ganoderma Present*	*Ganoderma Absent*
1	11	6	1	19
2	12	8	1	19
3	12	8	7	12
4	11	9	5	15
5	9	11	10	10
6	9	11	8	12
7	16	4	1	19
8	16	4	4	16
9	12	8	7	13
10	14	4	7	13
11	17	3	1	19
12	17	3	1	19

EXPERIMENT 802, Treatment of oil palm stumps with Ammonium sulphamate.

The objective of the experiment was to attempt to accelerate the decomposition of palms using ammonium sulphamate (AMS). The trial was set up by February 1983.

Design: Randomised complete blocks, with 5 replicates of 12 treatments, 5 treated palms per plot.

Treatments:

1. Stumps cut at a height of 1 metre, non-poisoned. AMS applied to the cut surface.
2. As 1, with sawdust impregnated with *Ganoderma* spp inserted into the stump.
3. Stumps cut at a height of 1 metre, poisoned, AMS applied to the cut surface
4. As 3 with sawdust impregnated with *Ganoderma* spp inserted into the stump.
5. Stumps cut a height of 1 metre, poisoned.
6. As 5 with sawdust impregnated with *Ganoderma* spp inserted into the stump.
7. Stumps cut at a height of 1 metre, non-poisoned.
8. As 7 with sawdust impregnated with *Ganoderma* spp inserted into the stump.
9. Trees left standing, poisoned with sodium arsenite.
10. As 9 with sawdust impregnated with *Ganoderma* spp inserted into the trunk.

11. As 3, but after injected AMS. Failed to kill standing palms.

12. Trees left standing, injected with AMS.

The type of rot caused by *Ganoderma* in these tissues could be seen, which was a yellow, soft dry rot. However, often *Ganoderma* was not isolated from these tissues; it is very slow growing so presumably other faster growing fungi had grown from the tissue first. This factor is worth noting as it explains occasions where *Ganoderma* is thought to be present but is not isolated. The rot caused by *Ganoderma* was generally on the outside of the slice further emphasising that it had colonised from the frond base, though on occasions it occupied almost all of the stump tissue. In some cases *Ganoderma* occupied part of the stump and was separated from other Basidiomycetes occupying other areas of the stump by zone lines.

EXPERIMENT 803, Pathogenicity tests

Since very little is known and little success has been achieved with pathogenicity testing of *Ganoderma* spp, it was decided that a range of methods should be used. Samples of *Ganoderma* found on Bebere and sent to Kew for identification showed that pathogenic species have been found here *(G. boninense* and *G. miniatocinctum).* The most common species found, *G. tornatum,* is thought to be non-pathogenic.

Treatments: The following methods are being examined:

1. Root inoculation
2. Stem inoculation
3. Seedling inoculation
4. Placing inoculum at the base of a live palm.

Root inoculation: Ganoderma spp were grown on sawdust in McCartney bottles until the mycelium had fully permeated the sawdust. The roots of living palms were exposed and cut to about 60cm from the base. The outer cortex was removed and sterilised in alcohol and the end inserted into the McCartney bottle through a hole made in the rubber top. The root was re-covered with soil and the position marked.

Stem inoculation: 'Dowels' of 5cm long and 1cm diameter were prepared from *Leucaena* sticks and autoclaved. These were placed on *Ganoderma* spp cultures in petri-dishes and left for 3 weeks. The frond bases from live palms were removed from 4 opposite positions about 1.5m above ground level. Holes of 5cm were drilled into the palm with an electric drill and a dowel inserted into the hole. This was covered with a piece of plastic and watered for 7 days. The plastic was then removed. Indications of infection should start to appear after about 6 months. Palms at both L.A.E.S. and Dami have been studied in this way.

Seedling inoculations: Blocks of palm wood 15cm x 8cm x 8cm had a hole drilled in one end and a 'dowel' colonised by *Ganoderma* spp inserted in it. This block was wrapped in foil and stored in plastic bags. This was replicated 10 times with four different *Ganodermas.* These were kept for 2 months. Oil palm planting bags had a covering of soil put in the base, the blocks were unwrapped and placed on the soil and then a young 4-5 leaf seedling planted on top. This was repeated with all the blocks and 10 bags were left without a block as control. These will be left until there is any indication of infection.

Placing inoculum at the base of live palm: A poisoned palm was cut up into 30cm lengths. Each length was divided into 6. A hole 3cm long was drilled into each end and a 'dowel' colonised by *Ganoderma* spp inserted into it. The pieces were stored for 2 months in a pit to maintain moisture. Holes of 50cm were dug adjacent to young field palms as close to the bolus as possible. A block of the stored palm wood was placed in the hole so that its top was a few centimetres below the soil surface. The hole was refilled and firmed down and the palm marked. These will be left and observed for any signs of *Ganoderma* infection. This has been repeated 2 times with different isolates of *Ganoderma* spp.

All the experiments were checked regularly on each visit to Dami for any signs of *Ganoderma* infection So far there has been none. The experiments will be further examined in 1985.

EXPERIMENT 804, Interaction experiments.

Interactions between *Ganoderma* spp and basidiomycete fungi isolated from oil palm wood were set up in blocks (15x8x8cm) of oil palm wood. These were examined by splitting the blocks and isolating onto agar.

Several problems were encountered using this method, the main one being that some blocks had fly larvae in them. These destroyed the block and the inoculated fungi so were useless for examination. Despite this some colonisation occurred in some of the blocks and interactions were observed between *Ganoderma* spp and the inoculated fungi. Because of the problems with fly larvae the next batch that are set up will be autoclaved before they are inoculated. The technique used is very time consuming: growing fungi in agar, putting 'dowel' on the fungi, cutting up palm wood and drilling blocks, inoculating the fungi, spraying, wrapping and labelling. They are then left for 1 to 2 months before sampling and recording the results.

APPENDIX I

METEOROLOGICAL DATA

The data presented below was made available by courtesy of NBPOD, Hargy Oil Palm 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 39: *Rainfall (mm): HARGY, 1984*

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1984	215	229	687	164	169	240	443	143	375	567	190	1325	4747
1983	—	—	653	554	179	278	566	596	282	306	402	642	—
Mean 1981-84	545	578	652	324	153	224	346	263	252	277	191	617	4422

Table 40: *Meteorological data: HIGATURU, 1984*

	Rainfall mm			*Sunshine hrs*			*Rainy days*		
	1983	1984	1981-84	1983	1984	1981-84	1983	1984	1981-84
January	457	55	234	206	210	173	19	10	15
February	521	176	286	154	168	129	27	20	10
March	504	289	385	178	132	164	24	23	20
April	178	204	218	186	174	165	18	20	19
May	193	229	205	219	143	157	15	19	15
June	211	180	172	166	130	145	19	18	16
July	27	88	74	173	137	148	4	11	10
August	90	164	116	169	140	166	13	18	14
September	106	144	128	185	219	173	15	12	12
October	262	362	233	170	167	163	21	19	18
November	253	239	225	182	226	195	15	17	14
December	358	291	330	118	141	145	17	21	19
TOTAL	3160	2421	2605	2105	1987	1923	207	208	192

Table 41: *Meteorological data: DAMI 1984*

	Rainfall mm			*Sunshine hrs*			*Temperature °C*		*Rainy days*	*Sunny days*
	1983	1984	Mean 1970-84	1983	1984	Mean 1970-84	max	min		
January	750	194	655	96	209	120	31.7	22.7	17	30
February	797	241	663	81	177	117	31.5	22.5	19	27
March	808	565	533	99	136	123	31.8	22.8	26	29
April	388	373	361	130	132	148	31.2	22.8	23	26
May	285	126	232	143	145	173	31,2	22.6	21	29
June	287	219	157	93	139	161	31.2	22.6	20	27
July	249	185	189	68	122	161	30.0	22.5	19	23
August	226	104	160	56	188	178	31.4	22.6	14	29
September	164	180	173	160	164	183	31.8	22.3	18	27
October	111	197	162	157	185	187	31.6	22.7	17	29
November	400	233	248	142	191	184	32.3	22.6	14	26
December	304	572	373	86	57	134	30.6	23.0	28	18
TOTAL	4769	3189	3906	1311	1845	1869	—	—	236	320

APPENDIX II

THE ASSOCIATION'S ACCOUNTS FOR 1984

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 accompanying notes thereon as set out are drawn up so as to give a true and fair view of the state of affairs of the Association as at 31st December 1984 and of its income and expenditure for the period ended on that date.

Price Waterhouse
Chartered Accountants
Lae, March 1984

Balance Sheet as at 31st December, 1984.

	KINA
Accumulated funds	50,084
Represented by:	
FIXED ASSETS	44,480
CURRENT ASSETS:	
Cash at bank and on hand	11,279
Debtors	34,896
	46,175
CURRENT LIABILITIES:	
Trade Creditors	31,300
Other Creditors and Accruals	25,112
	56,412
Net Current Assets/Liabilities	(10,237)
	34,243

Statement of Income and Expenditure for the year ended 31st December 1984.

INCOME:

	KINA
FFB Levy	349,906
Profit on Disposal of Fixed Assets	1,748
	351,654

EXPENDITURE:

	KINA
Agency, Audit, Legal and Professional Fees	16,085
Bank Charges	363
Depreciation	15,388
Direct experiment costs	56,624
Electricity, water and gas	12,851
Insurance	2,212
Laboratory	1,060
Medical	1,931
Motor vehicles	14,002
Office expenses	5,287
Rentals and other accommodation costs	55,974
Repair and maintenance — buildings	9,786
Salaries, Wages and allowances	141,203
Staff recruitment	60
Staff training	352
Travel and entertainment	14,700
TOTAL	347,878
SURPLUS FOR THE YEAR	3,776
ACCUMULATED FUNDS 1 JANUARY	30,467
ACCUMULATED FUNDS 31 DECEMBER	34,243

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 $33^1/_3$% per annum

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

FIXED ASSETS

	KINA
Household and office furniture at cost	30,465
Less accumulated depreciation	7,592
	22,873
Motor vehicles at cost	39,273
Less accumulated depreciation	17,666
	21,607
Total Fixed Assets	**44,480**

MANAGEMENT BOARD'S STATEMENT

We, R.A. Gillbanks and N. van der Laan, being two of the 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 31 December, 1984 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 so as to exhibit a true and fair view of the state of affairs of the Association as at 31 December, 1984 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
101b	Bebere leaf nutrient monitoring plots (previously Expt. 101)	1982	1984
102	Dami density trial	1970	
103	Kumbango sources of potash trial	1976	1982
103b	Kumbango vegetative growth monitoring plots (previously Ext. 103)	1980	1984
104	Bebere thinning trial	1978	1984
105	Bebere thinning trial	1979	1984
106	Bebere replanting establishment trial	1982	
107	Bebere replanting fertilizer trial	1982	
108	Kumbango mature palm nitrogen/anion systematic fertilizer trial	1985	
109	Bebere factory-waste manurial trial	1984	
110	Bebere nitrogen/anion trial on young replanted palms	1984/85[1]	
111	Malilimi phosphate fertilizer trial	1985	
112	Buvussi, phosphate fertilizer trial	1985	
113	Smallholders' nitrogen fertilizer trial on replanted palms with food crops, W.N.B.P.	1985	
201	Hargy fertilizer trial	1982	
202	Hargy refuse manurial trial	1984	
305	Arehe fertilizer factorial expt. on "A" soil	1981	
306	Ambogo fertilizer factorial expt. on "L" soil	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	E.k.: 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 study	1979	1981
702	Effects of competition	1981	
703	Study of female inflorescence characteristics in relation to pollination and fruitset	1985	
801	Incidence of Ganoderma disease	1982	
802	Treatment of oil palm stumps with AMS	1983	
803	Ganoderma spp: tests of pathogenicity	1983	

1. modified 1985 from establishment trial

APPENDIX IV

LITERATURE CITED

1. ROSENQUIST, E.A. (1980). Harrisons Fleming Advisory Services Report.

2. BREURE, C.J. (1977). Preliminary results from an oil palm density and fertilizer experiment on young volcanic soils in West New Britain. *In Proc. Int. Agricultural Oil Palm Conference,* 192-207, Incorporated Society of Planters, Kuala Lumpur.

3. (1982). Factors affecting yield and growth of oil palm teneras in West New Britain. *In Proc. Int. Conference "Oil Palm in Agriculture in the Eithties",* 109-130 Incorporated Society of Planters and Oleagineux, 37, 5, 213-224.

4. (1985). Relevant factors associated with crown expansion in oil palm (Elaeis guineensis Jacq). *Euphytica,* 34.

5. BREURE, C.J. and CORLEY, R.H.V. (1983). Selection of palms for high density planting. *Euphytica, 32, 177-186.*

6. CORLEY R.H.V., (1976). Inflorescence abortion and sex differentiation. *In Developments in Crop Science 1, Oil Palm Research,* Elsevier Scientific Publishing Company, 37-54

7. First, Second and Third Annual Reports of the Papua New Guinea Oil Palm Research Association, Lae, 1981, 1982, 1983.

Printed by Hebamo Press
P.O. Box 6033,
Boroko
Papua New Guinea