ANNUAL REPORT

OF

THE PAPUA NEW GUINEA
OIL PALM RESEARCH ASSOCIATION
1983

THIRD ANNUAL REPORT

of the

PAPUA NEW GUINEA OIL PALM RESEARCH ASSOCIATION

1983

MANAGEMENT BOARD

SCIENTIFIC ADVISORY BOARD

as at 8th November, 1983

EXECUTIVE STAFF

during 1983

DIRECTOR OF RESEARCH	T. Menendez, B.Sc., DPB., M.I. Biol.,
AGRONOMIST	Ir. F.C.T. Guilking,
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
TECHNICAL ASSISTANT	J. Gorea (Higaturu)
SUPERVISOR	M. Furigi
SENIOR FIELD ASSISTANT	J. Nagi (Hargy)
FIELD ASSISTANTS	D. Tomare (to October)
	P. Engio
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)
(clerical)	B.Bubu
	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

PNG OIL PALM RESEARCH ASSOCIATION

My report last year was given against the background of depressed world prices for palm products. Whilst producers had had a reasonably satisfactory year due to peak crops obtained after the introduction of the pollinating weevil, the outlook appeared sombre. In 1983, after a poor start, the industry has experienced a phenomenal surge in prices during the second half-year due largely to a reduction in the American soya bean harvest and to the reduced availability of coconut oil from the Philippines. As a result prices paid to fruit producers have been at record levels and this has more than compensated for lower production which resulted from reaction to stress on the palms caused by the coincidence of drought with the weevil-induced peak production in 1982.

At the Annual General Meeting held in March, 1983 the Research Levy was reduced from K1 to 55 toea per tonne of FFB. This lower levy was only made possible by drawing on the reserves built up as a result of the very high crops of 1982. As a result there was a deficit of income over expenditure of K43,907 and accumulated funds were reduced to K50,086 at 31/12/83 leaving little in hand. A greater fall in reserves was averted and expenditure held within budget through a concerted effort on the part of all concerned to keep costs to a minimum level compatible with the high standards of research expected from our organisation. No expansion of the research effort was possible but previously agreed programmes of research into nutrition, replanting, pathology, entomology and agricultural uses of mill effluents were progressed or initiated.

The guiding policy of the Management Board is to direct research towards practical objectives and known needs. The expansion of the programme to include a crop physiologist and more directly smallholder-oriented research is expected to be introduced as soon as our resources permit. Regrettably we have been unsuccessful so far in obtaining meaningful aid from overseas aid programmes, though efforts to this end continue. We are however, grateful to the Government of Papua New Guinea for providing the services of a full-time entomologist on secondment to us.

Research into tree crops is of necessity a long-term business and few dramatic results can be expected such as those obtained with our successful insect introduction programme in 1982 but progress is being made in understanding nutritional needs and in controlling pests and diseases. This research is essential to the long-term health of the crop. It is particularly satisfying to your Management Board to note that our industry, one of the newest in PNG, is leading the way in industry-based research programmes in this country and I am sure that in the longer term this programme on which we have embarked will pay handsome dividends and keep our industry one of the leaders in the oil palm world.

Finally I would like to pay tribute to the Director and his staff for their work during the year, to the members of the Management and Scientific Advisory Boards for their sound advice and assistance and to the staff of the Managing Agents for the administration and accounting assistance. We note with regret the retirement of a founder member of our Advisory Board and wish Mr. Arthur Charles and his family every happiness in their retirement.

ROGER A. GILLBANKS.

RESEARCH DIRECTOR'S FOREWORD

Our research into *Ganoderma* disease was consolidated thanks to useful colaboration with the Cocoa Industry Company and their Pathologist. But it will be several years before the pathogenicity of indigenous Ganoderma spp. and their economic importance when palms are replanted can be determined.

Neither insect nor animal pests caused real alarums, indeed their low incidence prevented effective trials in the field and work was limited to aspects of biological control. The pollinating weevil continued its successful work in smallholdings and large plantations and its study in the field was intensified. The view was formed that it is desirable to introduce a supporting but unrelated pollinator and this possibility will be pursued.

Attendance at conferences and visits to Kuala Lumpur and Port Moresby provided useful new professional contacts and experience for the Agronomist. He will be investigating the effects of factory waste products on the soil and palms and has started upon an inventory of the soils where oil palms are grown in PNG.

Once again, the co-operation of everyone who has accommodated the often awkward demands of field trials on commercial plantations is gratefully acknowledged.

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

MANAGEMENT BOARD AND SCIENTIFIC ADVISORY BOARD

The Management Board met at Lae and at Higaturu Oil Palms on two occasions. The second Annual General Meeting of the Papua New Guinea Oil Palm Research Association was held in Lae on 17th March when Mr R.A. Gillbanks was re-elected as Chairman for the ensuing year.

A tour of sites of experiments and other interesting phenomena preceeded the fourth meeting of the Scientific Advisory Board on 7th November. This provided an interesting forum for technical discussions. It was agreed that it should be equally useful to visit Hargy Oil Palms in this way next year so members will have been able to appreciate conditions and work on all three oil palm developments in PNG.

FINANCE

Higher yields than anticipated for 1982 had put the Association in surplus but, rather than maintain this as a reserve, it was decided to utilise the surplus and accordingly minimise the levy. By the end of the financial year, during which production was lower than expected, the surplus funds of the Association had been largely used up.

STAFF

There was very little change in the establishment of staff during 1983. Both Dr. Jollands and Mr Prior continued to work for P.N.G.O.P.R.A. as before, Dr. Jollands being part-time from the Cocoa Industry Company and Mr Prior attached from the Department of Primary Indusry.

Mr Peter Navus was in charge of the Association's substation at Higaturu throughout the year except for spells of leave up to 17th January and from 12th December during which he was relieved by Mr Pasi Sereva and Mr F.C.T. Guiking respectively.

At the end of March the Director of Research completed 13 months acting as part-time Chief Agronomist for N.B.P.O.D., relinquishing this duty when the post was filled.

Amongst the junior staff and technicians one field assistant (entomology) resigned but was not replaced in 1983. It is planned to do this in 1984 with a more highly qualified candidate. A notable new appointment was that of a Technical Assistant who was posted to operate a new entomological unit that was established at Higaturu Oil Palms in Oro Province early in the year.

On the whole staff kept fit during the year except for Mr Sereva's absence on medical leave from October and a nasty bought of malaria suffered by a field assistant which required hospitalization before clearing up. Five birth were recorded during the year.

Mid-year salary increments were awarded to executive staff by the Management Board. Junior staff were granted appropriate increments at the same time and benefitted from a cost of living revision of wages in March.

The distribution and establishment of staff during 1983 and those recommended for 1984 were as follows:—

		Filled as at 31/12/82	Filled as at 31/12/83	Recommended 1984
Private Secretaries	Dami	1	1	1
Clerks	Dami	1	1	1
Recorders (clerical)	Dami	2	2	2
	Higaturu	0	0	1
Driver/handyman	Dami	1	1	1
Supervisors	Dami	1	1	1
Senior technical assistants	Dami	0	0	1
Technical assistants	Higaturu	0	1	1
Senior field assistants	Hargy	1	1	1
Field assistants	Dami	2	1	1
Technicians	Dami	4	4	5
	Higaturu	4	5	5
		171	181	212

In-service training was given to staff as necessary to perform their duties. The aim has been that all field staff should be able to handle all the routine procedures of field recording, however certain surveys of pests and diseases and the difficult flowering observations necessitated special selection and training of individuals for these jobs.

TOURS AND VISITS

Malaysia was visited twice by the Agronomist to prepare the way for field experiments with palm oil factory waste. For two weeks in June he saw how waste was treated and removed and the results of trials in the field. He later attended a Seminar on land application of palm oil and rubber factory effluents held in Kuala Lumpur in August.

Other visits were confined to PNG in the course of the Association's work and management. The Director of Research, Entomologist, Agronomist, Assistant Agronomist all visited Bialla and Popondetta at various times. The Supervisor also visited Bialla on relieving duty and DPI's Rural Development Officer, Mr Embupa, (who was attached to the Entomologist) also visited Popondetta. Hargy Oil Palms had ten man visits and Higaturu had thirteen. The Director of Research went to Rabaul once to see the Pathologist, Cocoa Industry Company and the printers there and to Lae twice. Port Moresby was visited twice by the Agronomist to gather information about PNG soils from the National Mapping Bureau and to attend the second part of the Fifth International Forum on Soil Taxonomy and Technology Transfer.

The Pathologist visited West New Britain from Rabaul in February, April, July and October to sample field experiments and carry out associated work in the laboratory at Dami. She also attended a meeting of the Scientific Advisory Board at Higaturu and examined the Alotau District of Milne Bay to assess the disease risk of oil palm and cocoa replanted from old plantations of coconut palms.

PUBLICATIONS AND REPORTS

The articles "Elaeidobius kamerunicus" and "The establishment and effects of the African pollinating weevil *Elaeidobius kamerunicus* on oil palm in PNG" by R.N.B. Prior were combined into one by the editors and appeared in Harvest, Volume 9, No. 2 under the title "Introducing a weevil from Africa to pollinate oil palm in Papua New Guinea.

The Second Annual Report of P.N.G.O.P.R.A. was published in November. Reporting to members was modified in November to consist of confidential monthly reports largely of an administrative nature from the Director of Research to the Managing Agents and Quarterly Progress Reports of research rather than monthly reports combining the two. The first Quarterly Report will appear in 1984, covering the last quarter of 1983 and first of 1984.

Seven progress reports were circulated to the Association members and two to the Managing Agents only. Reports of tours on duty to Popondetta and Bialla were circulated appropriately.

LIBRARY

This continued in the same location at Dami. Monthly bulletins of accessions were prepared and distributed by NBPOD's new Chief Agronomist/Plant Breeder. The library will be moved again when NBPOD's offices at Dami are re-allocated.

VISITORS

The following visitors to the Directorate were recorded:

C.J. Breure, Harrisons Fleming Advisory Services Ltd., London, England; C. Campbell, N.B.P.O.D., Mosa; R.H.V. Corley, Unifield T.C. Ltd., Unilever Plantations Group, Bedford, London, U.K.; T.Fleming, Harrisons Fleming Advisory Services Ltd., Duns, Scotland; J.P. Gascon, Institut de Recherches sur Huiles Oleagineux, Montpellier, France; P.T. Gunton, Harrisons and Crosfield PLC., London, England; A.M. Gurnah, University of P.N.G., Lae; F. Hampshire, Ciba-Geigy Aust. Ltd., Lane Cove, Australia; M. Hannah, Port Moresby; T. Hannah, High Commissioner for New Zealand, Port Moresby; P. Jollands, Cocoa Industry Company, Rabaul; A.P. Herbert, Higaturu Oil Palms Pty. Ltd., Popondetta; D. Jones, Trinity Press, Rabaul; J. Langton, Higaturu Oil Palms Pty. Ltd., Popondetta; B. Layton, Ponini Agricultural Centre, Kimbe; W. Laves, Premier's Office, West New Britain Provincial Government, Kimbe; J.R. Leach, Harrisons Fleming Advisory Services Ltd., London, England; L. Longayroux, Melbourne, Australia; J.A.K. Loudon, Commonwealth Development Corporation, London, England; J. Nightingale, New Guinea Cocoa (Export) Co. P/L., Rabaul; Ooi Cheng Hock, Kumpulan Guthrie Sendirian Berhad, Chemara, Malaysia; R.W. Orr, Analytical Services Ltd., Cambridge, New Zealand; D. Palmer, West New Britain Provincial Government, Kimbe; E.A. Rosenquist, Harrisons Fleming Advisory Services Ltd., London, England; R.A. Syed, Harrisons Fleming Advisory Services Ltd., London, England; M. Wilson, Harcros Trading Ltd., Kimbe; M.S. Wilson, Harrisons Malaysian Plantations Berhad, Kuala Lumpur, Malaysia; P. Wells, National Weather Service, Konedobu.

PHYSICAL DEVELOPMENT

BUILDINGS

At Higaturu a temporary office and an insectary were erected close to the PNGOPRA office. It was planned to put up something more permanent in due course. Additional quarters were allocated for the Association's Technical Assistant. The allocation of rented buildings and rooms occupied is represented below.

	31/12/82	31/12/83
N.B.P.O.D.		
Offices & laboratory (rooms)	7	7
Entomology buildings	1	1
Storerooms	2	2
'M' Houses	1	1
'A' Houses	2	2
'AR' Houses	1	1
'IB' Quarters	2	2
Junior Grade Quarters (1 at Bebere)	8	7
Single Men's Quarters	0	0
Single Labour Quarters	1	0
Hargy Oil Palms		
Boss boi quarters	1	1
Office	1	1
Higaturu Oil Palms		
Agronomy Building	1	1
Entomology office	0	1
Insectary	0	1
'M' Houses	1	1
Boss boi Quarters	1	1
'IM' Quarters	0	1
Labour Quarters	0	1

MAINTENANCE OF BUILDINGS

Early in the year an entrance from the road to the directorate at Dami was paved and a work area roofed over by N.B.P.O. D. Bunches were then analysed there instead of underneath the entomology building which was enclosed to protect equipment and cages installed there. General repairs were attended to as they arose. It was necessary to repanel part of the bathroom of one of the prefabricated 'A' houses because of initially poor construction. The exterior cladding of the entomology building and Director's quarters were painted by NBPOD with a mixture of creosote and linseed oil, this being a normal follow-up to their initial construction.

VEHICLES

The policy of keeping a Toyota fleet was continued. New vehicles bought were a twin-cab diesel Hilux 4-WD, a single cab petrol Hilux 2-WD and Hi-Ace long wheel base Commuter which was scheduled to run for three years instead of the two years for the Traka which it replaced.

The fleet of vehicles and its state at the year's end was as follows:

Vehicle	*Reg. No.*	*Customary user*	*Date purchased*	*km at 31/12/83*
Hilux 4 WD twincab	AEJ-558	Director	Nov. 1983	3,098
Hilux 2 WD utility	AEJ-601	Entomologist	Dec. 1983	118
Hilux 4 WD utility	ADJ-096	Agronomist	Feb. 1981	38,599
Hi-Ace Commuter	AEA-691	Driver/handyman	Mar. 1983	24,374
Hilux 2 WD utility	ADT-834	Asst/Agronomist	May 1982	50,000

An advance to buy a motorcycle for work was paid to the Supervisor at Dami and to the Technical Assistant at Higaturu for him to be able to sample and survey widely scattered blocks of the Popondetta scheme. Motorcycle allowances were paid to four junior staff (one at Hargy, one at Higaturu and two at Dami). Motor vehicle allowances were paid on three executive staff vehicles.

OFFICE AND LABORATORY EQUIPMENT

The Nashua photocopier, manual typewriters, Hewlett Packard 34C calculators and airconditioners functioned satisfactorily and were regularly serviced. A new airconditioner and refrigerator were installed to equip the laboratory. A new electronic typewriter was bought at a special price but had to be replaced because it was faulty — so was its replacement at the end of the year. Two HP15C calculators were bought and the 34C's allocated to the Records Section and Assistant Agronomist's use. A calculator with print-out was provided for the clerk.

The locally constructed drying oven was sent to Hargy for use there after a new oven was generously obtained at Dami from Analytical Services Ltd., New Zealand at no cost other than for freight.

TELEPHONE

The Association continued its exclusive use of one of the two lines serving Dami. Service provided by Post & Telecommunication Corporation was not good.

OTHER SERVICES

At Dami, electricity was generally in satisfactory supply apart from failures of equipment but piped water to some offices and quarters was sometimes inadequate.

Medical services were provided satisfactorily by N.B.P.O.D. and H.O.P.P.L. Staff requiring treatment at Kimbe hospital or clinics at Kapore, Mosa or Valoka were transported as required.

PART II, RESEARCH

AGRONOMY *(F.C.T.G.)*

WEST NEW BRITAIN PROVINCE

EXPERIMENT 101, Bebere Fertilizer Trial

Planted in August 1968 at 143 palms/ha, thinned by 1/3 in October 1976. Area 8.8ha.

Design: A ¼ replicate of a $4^2 \times 2^4$ (N,K,Mg,Mn,S,P) factorial was used in which all main effects and first order interactions were unconfounded. There were two blocks with a total of 64 plots of 16 palms each (thinned to 10 or 11 per plot). Plots were separated on all sides by trenches . The following constitutes a final report.

Treatments: Application of fertilizer started soon after planting but stopped in 1979, when it was considered this experiment had fulfilled its initial objectives. Levels of fertilizer application increased progressively from 1969 to 1971. Treatments for mature palms were:

	Fertilizer level kg/palm.year			
	0	1	2	3
urea	0	0.75	1.50	2.25
muriate of potash	0	1.50	3.00	4.50
magnesium chloride	0	3.00	—	—
manganese chloride	0	0.20	—	—
sulphur	0	1.00	—	—
disodium phosphate	0	0.75	—	—

Yield recording was stopped in August 1981 when the intention was to abandon this experiment but resumed in April 1982 when it was considered that heavy bearing due to good pollination by *Elaeidobius kamerunicus* might deplete the soil and lead to a response to residual fertilizer. Assisted pollination stopped in October 1981.

Yield recording finally came to an end in December 1983. However, in order to study the dynamics of leaf nutrient levels, leaf samples were taken on a regular basis from six selected plots, of which three received previously a high level of fertilizers and three a low level. Yield will continue to be recorded in these selected plots, details of which were given on page 8 of the Second Annual Report. Sampling changed from monthly to bi-monthly in March 1983, and will continue thus in 1984.

Results: The results up to 1975 were described by Breure and Rosenquist (1977), and to 1980 were commented upon by Rosenquist (1980). He concluded that, except for a response to muriate of potash during the early years, none of the fertilizers had produced a yield response. It was largely this lack of response that enable New Britain Palm Oil Development to suspend the use of fertilizers.

Yield for the year is given in Table 1. After heavy bearing in the previous year and its unusual drought, production during 1983 generally slumped in WNBP. However, still no significant difference due to treatments were found for main effects or two-factor interactions. It was concluded that the weevil-induced productivity had not brought about an immediate demand for supplementary manuring. In view of the continuing lack of response the experiment was closed.

Table 1: Experiment 101, Yield per hectare, 1983

TREATMENT	*Number of bunches*	*Weight of bunches* *t*	*s.b.w.* *kg*
N0	890	22.3	25.0
N1	911	22.9	25.1
N2	897	22.2	24.8
N3	912	22.5	24.7
K0	877	21.7	24.8
K1	890	21.9	24.6
K2	944	23.7	25.1
K3	898	22.5	25.1
Mg0	890	22.1	24.8
Mg1	915	22.9	25.0
Mn0	903	22.5	24.9
Mn1	902	22.4	24.9
S0	871	21.9	25.2
S1	934	23.0	24.6
P0	898	22.3	24.8
P1	907	22.7	25.0

Leaf analysis results for 1983 are given in Table 2.

Table 2: Experiment 101, Leaf nutrients in leaf 17 during 1983 for plots previously with low or high fertilizer regimes

Element %	*Fertilizer regime*	*Jan.*	*Feb.*	*Mar.*	*May*	*Jul.*	*Sep.*	*Nov.*
N	low high	2.20 2.10	2.4 2.2	2.3 2.3	2.2 2.4	2.3 2.3	2.4 2.3	2.5 2.4
P	low high	.15 .16	.14 .14	.15 .14	.15 .14	.15 .15	.14 .14	.15 .15
K	low high	.83 .76	.71 .70	.80 .76	.80 .75	.75 .69	.83 .85	.89 .85
S	low high	.17 .17	.16 .18	.17 .18	.18 .17	.15 .15	.15 .14	.14 .14
Ca	low high	.89 1.01	.94 .95	1.01 1.03	.92 .97	1.00 1.04	1.00 1.07	.95 .97
Mg	low high	.13 .15	.14 .15	.17 .17	.18 .19	.21 .23	.21 .21	.16 .17
Na	low high	.01 .01	.01 .01	.01 .01	.00 .01	.01 .01	.01 .01	.03 .02
Cl	low high	.37 .45	.42 .51	.40 .56	.33 .48	.41 .55	.52 .66	.36 .48
ppm								
Fe	low high	72 72	69 61	63 59	59 54.	65 67	68 67	63 66
Mn	low high	77 96	73 93	78 102	72 95	76 93	70 84	76 77
Zn	low high	18 19	20 18	22 23	18 18	18 20	19 19	18 20
Cu	low high	7 7	7 7	7 7	6 5	5 6	5 6	7 7
B	low high	10 11	12 12	16 16	17 15	12 13	14 13	16 17

EXPERIMENT 103, Sources of Potash at Kumbango

Planted in September 1972 at 120 palms/ha. 2700 palms total, 1152 recorded, Area 22.5 ha.

Design: Three replicates of a 5 x 2 x 2 factorial plus 4 nil treatments per replicate; 72 plots of 36 palms of which the central 16 are recorded.

Treatments: Three different sources of potash were used: muriate of potash, sulphate of potash, and bunch ash. To allow for an effect of sulphur, a treatment of bunch ash plus sulphur was included. K was also given ½ as muriate of potash and ½ as bunch ash with sulphur added. All 5 treatment combinations were given at rates equivalent to 2 or 4 kg muriate of potash, and both rates combined with different levels of kieserite to give two K/Mg ratios.

Treatments were first applied in December 1976, and stopped in December 1982.

Results: Yield recording was concluded at the end of 1982. Yields for 1981 and 1982 were presented in the annual reports for those years (pages 11 & 12). In tables 3 & 4 results over the duration of the experiment are presented. No significant differences were seen.

A final round of leaf sampling was done in April/May. Some results are given in Table 5. The treatments with muriate of potash had higher leaf Cl and leaf Ca levels, and lower leaf K levels. The treatments with sulphur (not as sulphate) had higher Mn levels. This is ascribed to the better availability of Mn at the lower soil pH, caused by sulphur. Petiole cross section was measured in April. Results are given in Table 6. No significant differences were found.

The possible effect of K on oil content of external fruit was studied in 4 selected plots which had been treated with muriate of potash at high K and high K/Mg, muriate of potash at high K and low K/Mg, sulphate of potash at low K and low K/Mg, and nothing. Different methods of sampling fruit to determine oil were also compared using:

1. loose fruit (fruit on ground or loose in bunch)
2. fruit that could easily be picked from the bunch
3. outer fruit that had to be cut from the bunch

No difference between methods was found for oil to dry mesocarp and mesocarp to fruit (Table 7). Oil to wet mesocarp was, surprisingly, slightly higher for fruits cut from the bunch (method 3). It is presumed absorbed moisture affected the results for looser fruits. However, oil content determined in loose fruits appeared to have the lowest variation. No differences between potassium fertilizers were found for oil to dry mesocarp; for oil to wet mesocarp the treatment muriate of potash at high K and high K/Mg yielded about 5% lower than the other treatments.

Experiment 103 was concluded because no significant effect of fertilizers was found. It was, however, decided to present the results at the International Conference on Soils and Nutrition of Perennial Crops (ICOSANP), in Malaysia to be held in August 1984.

Table 3: Experiment 103, Average annual production (tons FFB/ha), March 1977—December 1982

TREATMENT[1]	high K/Mg		low K/Mg		average
	low K	high K	low K	high K	
MoP	23.2	24.3	24.2	25.2	24.2
MoP + BA + S	23.1	24.7	24.0	24.9	24.2
SoP	23.2	23.0	24.0	22.7	23.2
BA	23.3	22.6	24.1	22.0	23.0
BA + S	23.9	23.3	23.5	23.9	23.7
Nil	-	-	-	-	23.4
high K/Mg	-	-	-	-	23.5
low K/Mg	-	-	-	-	23.9
low K	-	-	-	-	23.7
high K	-	-	-	-	23.7

Table 4: Experiment 103, Yearly production (tons FFB/ha) averaged per source of potash

TREAT-MENT	Period					
	4/77-3/78	*4/78-3/79*	*4/79-3/80*	*4/80-3/81*	*1/81-12/81*	*1/82-12/82*
MoP	24.8	25.3	23.7	22.2	21.6	29.4*
MoP + BA + S	24.9	25.4	24.2	21.9	22.0	29.5*
SoP	24.7	24.1	23.0	21.4	20.1	27.7
BA	23.9	24.3	23.3	20.2	20.6	27.5
BA + S	25.1	24.4	23.1	22.0	21.3	28.0
Nil	24.5	23.8	23.9	21.6	21.1	27.6

* significantly different (P = 0.05)

Table 5: Experiment 103, Leaf nutrient levels in frond 17, April—May 1983

TREATMENT[1]	N %	P %	K %	Ca %	Mg %	Cl %	S %	Mn ppm
MoP	2.3	.14	.78	.96	.25	.57	.17	63
MoP+BA+S	2.3	.15	79	.92	.25	.53	.17	70
SoP	2.3	.14	.86	.85	.25	.36	.17	57
BA	2.3	.15	.83	.88	.25	.29	.18	58
BA+S	2.3	.15	.83	.87	.25	.38	.17	79
Nil	2.3	.14	.84	.90	.24	.32	.17	58

[1] MoP = Muriate of potash BA = bunch ash SoP = sulphate of potash S = sulphur

Table 6: Experiment 103, petiole cross section, April 1983

	TREATMENT[1]					
	MoP	MoP+BA+S	SoP	BA	BA+S	NIL
WxT, cm²	42.2	42.1	41.2	41.8	42.2	41.3

[1] for abbreviations see footnote at Table 5.

Table 7: Experiment 103, Average figures with 90% confidence limits for oil content of mesocarp and mesocarp/fruit

SAMPLING METHOD (27-31 bunches per treatment	*oil/dry mesocarp* %	*oil/wet mesocarp* %	*mesocarp/fruit* %
Loose fruit	79.9 ± 0.5	51.9 ± 1.1	81.4 ± 1.4
Easily picked fruit	80.3 ± 0.5	51.8 ± 1.4	79.8 ± 1.2
Firm fruit	80.3 ± 0.9	54.3 ± 1.3	79.4 ± 1.3

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

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

Design: Two replicates of a 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: Fertilizers were to be applied twice yearly at rates increasing with age. Details were given in the Second Annual Report (page 14). Nitrogen was given as sulphate of ammonia, phosphate as triple superphosphate, 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. Planting material was seedlings either 16 or 24 months of age.

The first fully open frond was marked every three months and — at a later date — petiole cross section measured. Petiole cross section is reported to be the parameter most conveniently correlated with future production.

Due to an atypically dry period of several months immediately after planting, the palms did not establish very well. Dead palms were replaced in January. Of the older planting material 4.0 % needed supplying, as against only 0.9% for the younger palms. The fertilizer application at 3 months (sulphate of ammonia only) was deliberately postponed until

February because of the hiatus in growth, the period of stand-still during the drought being discounted. First frond marking started in May. The 6th and 12th month's fertilizer application (N,P,Mg) were in June and December. Bunch ash was applied in September.

Results: Data for petiole cross section are given in Table 8. The better stand of the younger seedlings (code 0) was reflected in the higher values for WxT. A significant effect of nitrogen was seen in August and November. No effect was obtained by the use of phosphate. The positive, combined effect of potassium and magnesium became significant in November.

The younger seedlings produced markedly more leaves than the older ones. During the three months' period May—August the average was 2.5 leaves per month, whereas 2.0 were recorded for the older plants. For the period August—November these figures were 3.0 and 2.6 respectively.

Table 8: Experiment 106, Petiole cross section of frond 17, 1983

TREATMENT	*May*	*August*	*November*
		W x T, cm²	
N0	3.5	4.6 a	5.9 a
N1	3.6	4.8 b	6.0 b
N2	3.6	4.8 b	6.2 c
P0	3.5	4.7	6.0
P1	3.6	4.8	6.1
K, Mg0	3.6	4.7	5.9 a
K, Mg1	3.5	4.8	6.1 b
K, Mg2	3.6	4.7	6.1 b
Age0	3.7 a	5.1 a	6.4 a
Age1	3.5 b	4.4 b	5.7 b

Means with the same letter suffix do not differ significantly.

Given the atypical weather and establishment of this trial it was decided to duplicate it in 1984 but using mulch as a factor instead of age of planting material, since interest had been focussed on mulch because of its effect in Experiment 801 (q.v.).

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

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

Design: $3^2 \times 2^3$ 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: Except for nitrogen, no fertilizers will be applied during the first two years. At three months, all plots received 0.25kg sulphate of ammonia per palm. At 12 months half the plots will receive 0.6kg sulphate of ammonia per palm (treatment "establishment N"). The other treatments, to be applied 24 months after planting, will be as follows (half the amount being applied twice yearly):

	Fertilizer level kg/palm.year		
	0	1	2
sulphate of ammonia	0	1	2
triple super phosphate	0	0.5	1
bunch ash	0	3	
kieserite 0	2	-	-

Bunch ash will be applied 3 months after the other fertilizers to avoid volatilization of ammonia from sulphate of ammonia under alkaline conditons. These revised rates differ from those presented in the Second Annual Report. No differential rates of fertilizer were applied during 1983.

This trial was well planted in good weather. Although the seedlings were amongst the best available they had been deliberately held back in the nursery and it is considered that because of this it was not until May that they began to grow away satisfactorily. Much leaf yellowing and orange frond appeared after planting, but the poor appearance they gave slowly disappeared when new green leaves emerged. Leaf yellowing was surveyed in April. It was not found necessary to supply any of the palms planted originally.

The first fully open frond was marked every three months followed by measurement of its petiole cross section. First frond marking started in June.

Results: Pre-treatment petiole cross section was measured. W x T values varied between the 16 different progenies, the ranked order, however, being very inconsistent for the six blocks.

EXPERIMENT 201, Fertilizer trial on mature palms, Hargy

Planted in 1973 with IRHO DxP at 115 palms/ha; 2916 palms total, 129 recorded. Area 25.4 ha.

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

Treatments: The following treatments were applied, half the amount twice yearly.

	Fertilizer level kg/palm.year		
	0	1	2
sulphate of ammonia	0	1.0	2.0
triple super phosphate	0	0.8	1.6
bunch ash	0	1.5	3.0
kieserite	0	1.0	2.0

Treatments were first applied in June 1982. Bunch ash followed the others by 3 months because of incompatability between bunch ash and sulphate of ammonia.

Results: Production for 1983 is given in Table 9. The significant response to P, reported in the Second Annual Report (page 18), continued. The increase in yield appeared to result from improved bunch number and individual weight. Other main effects and the two factor interactions were not significantly different. Higher order interactions were considered to be absent. Petiole cross section data for June are given in Table 10. No significant differences were found due to treatments.

Table 9: Experiment 201, Yield per hectare, 1983

TREATMENT	*No. of bunches*	*Wt. of bunches* *t*	*s.b.w.* *kg*
N0	1340	24.2	18.1
N1	1312	23.8	18.1
N2	1384	24.8	17.9
P0	1304	23.3 a	17.9
P1	1344	24.2 ab	18.0
P2	1389	25.3 b	18.2
K0	1343	24.1	18.0
K1	1326	24.1	18.2
K2	1367	24.6	18.0
Mg0	1335	24.5	18.4
Mg1	1349	24.1	17.9
Mg2	1354	24.2	17.9

means with different letters differ significantly.

Table 10: Experiment 201, Petiole cross section, June 1983

TREATMENT	*W x T* *cm^2*	TREATMENT	*W x T* *cm^2*
N0	33.7	K0	33.8
N1	33.6	K1	33.7
N2	34.1	K2	33.9
P0	33.8	Mg0	33.9
P1	34.1	Mg1	33.4
P2	33.6	Mg2	34.2

ORO PROVINCE

EXPERIMENT 303, Fertilizer monitoring plots, Higaturu

This experiment is made up of the Company's monitoring plots 6—30, (described on page 15 of the First Annual Report) grouped in an attempt to provide replication of the treatments. Planted at 130 palms/ha (M6—25) or 143 palms/ha (M26—30) from February 1978 to December 1979, in plots of about 0.5—0.8 ha of which 40 central palms were recorded. Monitoring plots 1—5 were abandoned at the end of 1982. Monitoring plots 11—15 were deleted before PNGOPRA took over these trials.

Design: Four sets of 5 treatments, grouped as 4 replicates of a randomised block experiment but with planting date and site confounded with replicates.

Treatments:

Replicate (plots)	*Fertilizer regime (x estate practice)*					*Soil type**	*Planted*
M 6—10	0	0.5	1.0	1.5	62.0	A	2/78
M16—20	0	0.5	1.0	1.5	2.0	A	2/79
M21—25	0	0.5	1.0	1.5	2.0	B	11/79
M26—30	0	0.5	1.0	1.5	2.0	M	12/79

* A = andesitic loam, yellow—brown B = volcanic sand soil, brown—yellow M = ash loam, yellow—grey

Treatments were applied twice yearly as a multiple of the estate rates before fertilizing was stopped as a general plantation practice, by which time palms more than three years old had received only nitrogen (as sulphate of ammonia) and potassium (as muriate of potash). Previous estate rates were 0.75kg SA and 1.75kg MoP per palm per year for A and B soils, and 1.0kg SA and 2.5kg MoP for M soils.

Recording was restricted to yield.

Results: Yield for 1983 is given in Table 11. Differences in planting date made pooling of yield data difficult. Even for equivalent periods yield differences between replicates were large.

To obtain comparable data, yield is given relative to the unfertilized control in each replicate. Relative cumulative yield data are given in Table 12. The use of fertilizer increased yield significantly (P = 0.05) compared with the control. There was no difference in yield between the different rates of fertilizer. Since fertilizer treatments consisted of a mixture of fertilizers, this experiment did not discriminate between the different fertilizers. Therefore it is impossible to say whether the yield increase was due to a single fertilizer and which, or to a combination of fertilizers. The experiment was concluded at the end of the year because it was considered that nothing more precise and worthwhile could be extracted from it.

Table 11: Experiment 303, Yield per hectare, 1983 and to date

PLOT	*Fert. regime*	*No. of bunches*	*Wt. of bunches t*	*s.b.w. kg*	*Yield to date*	
					t	*since*
M6	0	2571	34.1	13.0	80.9	Sept. '80
7	0.5	2493	33.9	13.6	84.8	"
8	0.1	2607	34.4	13.2	86.1	"
9	1.5	2577	35.1	13.6	86.1	"
10	2.0	2434	36.6	15.0	94.7	"
M20	0	2756	28.8	10.5	55.9	Sept. '81
18	0.5	2889	31.6	10.9	61.6	"
19	1.0	3068	32.0	10.4	61.4	"
16	1.5	2616	28.5	10.9	57.6	"
17	2.0	2776	30.3	10.9	62.6	"
M21	0	3101	20.6	6.6	33.9	April '82
22	0.5	3744	26.3	7.0	40.7	"
23	1.0	3686	28.5	7.7	41.2	"
24	1.5	3559	29.9	8.4	48.7	"
25	2.0	3458	27.9	8.1	44.3	"
M26	0	3586	25.3	7.0	41.7	"
27	0.5	3489	25.7	7.4	40.6	"
28	1.0	4036	31.6	7.8	48.5	"
29	1.5	3414	26.0	7.6	41.0	"
30	2.0	3554	27.6	7.8	42.8	"

Table 12: Experiment 303, Cumulative yield data as percentage of the unfertilized control

	Fertilizer regime 0	0.5	1.0	1.5	2.0
M 6—10 (Sept. '80 — Dec. '83)	100	105	106	106	117
M16—20 (Sept. '83 — Dec. '83)	100	110	110	103	112
M21—25 (April '82 — Dec. '83)	100	120	121	143	131
M26—30 (April '82 — Dec. '83)	100	97	116	98	103
overall mean*	100	108	113	113	116

* *lsd P* = 0.05) = 13

EXPERIMENT 305, Fertilizer trial on A soil, Arehe.

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

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

Treatments: Treatments were first applied in September 1981. Application rates are given below; half the amount was applied twice yearly. Rates for sulphate of ammonia were doubled from 1.0 and 2.0 kg to 2.0 and 4.0 kg, and for triple super phosphate the rate was raised from 0.5 to 2.0 kg. These changes will be effective in 1984.

	Fertilizer level kg/palm.yr 0	1	2
sulphate of ammonia	0	2.0	4.0
triple super phosphate	0	2.0	-
muriate of potash	0	2.0	4.0
kieserite	0	1.0	-

Fertilizers were applied in February and August, except for kieserite, which could only be applied in May/June and August.

Yield data for 1983 and to date are given in Table 13. For this year's yield no significant differences were found. The upward trend in yield observed in 1982 continued for N and K only. Cumulative yields still show an upward trend for all four fertilizers. These differences were not significant. Petiole cross section data for August 1983 are given in Table 14, together with previous results. Height measurements (to the base of frond 41) were done in April; data are given in Table 15. Averaged per plot height varied from 0.80 to 1.15m, with one exceptionally low plot of 0.65m. Overall average 5 years after planting was 1.00m. No significant differences were found.

Table 13: Experiment 305, Yield per hectare, 1983 and to date

TREATMENT	1983			Oct. '81 — Dec. '83
	No. of bunches	*Wt. of bunches t*	*s.b.w. kg*	*t*
N 0	3055	31.3	10.2	61.4
N 1	3135	32.1	10.3	62.6
N 3	3179	32.5	10.2	63.5
K 0	3130	31.0	9.9	61.1
K 1	3104	32.1	10.4	63.0
K 2	3136	32.7	10.4	63.4
P 0	3136	32.0	10.2	61.9
P 1	3110	31.9	10.3	63.2
Mg0	3150	32.0	10.2	62.3
Mg1	3097	31.9	10.3	62.8

Table 14: Experiment 305, Petiole cross section (WxT, cm²) at frond 17, 1980-1983

TREATMENT	PRE-TREATMENT DATA		POST-TREATMENT DATA	
	Oct. '80	*Sept. '81*	*Aug. '82*	*Aug. '83*
N 0	8.8	14.0	20.5	22.3
N 1	8.6	13.9	20.5	22.4
N 2	8.6	13.9	20.6	22.9
K 0	8.6	14.0	20.1	22.2
K 1	8.6	13.7	20.6	22.5
K 2	8.8	14.0	20.9	22.8
P 0	8.7	13.9	20.5	22.5
P 1	8.6	13.9	20.6	22.6
Mg0	8.6	13.9	20.5	22.4
Mgl	8.7	14.0	20.6	22.7
Average	8.7	13.9	20.5	22.5

Table 15: Experiment 305, Height to the base of frond 41, April 1983

TREATMENT	*Height m*	TREATMENT	*Height m*
N 0	1.00	K 0	1.00
N 1	1.00	K 1	0.98
N 2	0.99	K 2	1.01
P 0	0.99	Mg 0	1.00
P 1	1.00	Mg 1	1.00

EXPERIMENT 306, Fertilizer trial on L soil, Ambogo.

Planted in April 1980 on 'L' type (grey-yellow sand soil) soil that is similar to many neighbouring smallholdings 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 palm per plot of which the central 16 are recorded.

Treatments: The first round of treatments was applied in April except for kieserite that had to be put on in June. The level of triple super phosphate will be raised from 0.25 and 0.5 kg/palm. year to 0.5 and 1.0 kg respectively. The new rates are w.e.f. 1984:

	Fertilizer level kg/palm.yr 0	1	2
sulphate of ammonia	0	1.5	3.0
triple super phosphate	0	0.5	1.0
muriate of potash	0	2.5	5.0
kieserite	0	0.75	1.5

Yield data for the first 8 months after the first differential fertilizer application is given in Table 16. Petiole cross section (leaf 17) was measured in August, that is 4 months after the first differential fertilizer application. Data are given in Table 17. No significant differences were found.

Table 16: Experiment 306, Yield per hectare, April — December 1983

TREATMENT	*No. of Bunches*	*Wt. of bunches t*	*s.b.w. kg*
N 0	1745	9.5	5.5
N 1	1803	9.9	5.5
N 2	1816	10.3	5.7
P 0	1785	9.9	5.6
P 1	1803	10.0	5.6
P 2	1777	9.9	5.6
K 0	1724	9.3	5.4
K 1	1778	10.1	5.7
K 2	1863	10.4	5.6
Mg 0	1817	10.0	5.5
Mg 1	1773	10.1	5.7
Mg 2	1775	9.7	5.5

Table 17; Experiment 306, Petiole cross section (frond 17) August 1983

TREATMENT	*W x T, cm^2*	TREATMENT	*s.b.w. kg*
N 0	13.2	K 0	13.1
N 1	13.2	K 1	13.8
N 2	13.8	K 2	13.4
P 0	13.3	Mg 0	13.2
P 1	13.5	Mg1	13.8
P 2	13.5	Mg2	13.3

PHYSIOLOGY *(T.M.)*

EXPERIMENT 102, Density and fertilizer trial at Dami.

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

This experiment was described on page 9 of the First Annual Report. It has been extensively reviewed and results reported (Rosenquist 1980; Breure, 1977, 1981).

Interest in this trial continued because of changes in growth and production that followed in the wake of the introduction of the pollinator, *Elaeidobius kamerunicus*. These palms have also been recorded and analysed intensively by NBPOD in the course of breeding and selection of potential clones and in the course of Investigation 702.

Design: Randomised blocks in 4 replicates of 4 planting densities. At 3 spacings plots were split for 4 levels of fertilizer, and for the two higest 2 levels of fertilizer at the lowest density.

Treatments:		0	1	2	3
	Density: palms/ha	56	110	148	186
	Fertilizer: *(kg/palm)*	0	50%	100%*	150%
	Bunch ash	0	2	4	6
	Kieserite	0	0.75	1.50	2.25

* *previous estate practise*

Fertilizer was applied twice annually from September 1972 to July 1981. In 1981 half the plots at the highest density were felled to initiate Investigation 702.

Results: Breure (1981) reported for this experiment that, during the period from eight to ten years after planting at all densities, fertilizing had a marked and significant effect by increasing vegetative dry matter. This was due to differences in leaf area and production, especially at the lower densities, but there was no response in terms of yield, Bunch Index therefore being reduced. Increasing fertilizer levels reduced bunch production per palm significantly from the sixth year from planting (1979) but single bunch weight was improved significantly from the fourth year (1977). It is either the residual effect of these induced differences in vegetative vigour or residues of fertilizer in the soil that should have caused the differences and trends in bunch production and single bunch weight in 1982 (Second Annual Report, page 11). Similar responses to fertilizer were also observed in 1983 and for the cumulative, post *E.k.*, production from January 1982 to the end of 1983. Increases in single bunch weight continued to be offset by reduced bunch number to give no material benefit. This negative interaction suggests the palms were already yielding at or near their full potential irrespective of previous differences in VDM and soil nutrient levels. There appeared to be no interaction between density and fertilizer levels for yield per palm during 1982 and 1983. The results for this period and their analysis are given in Tables 18 and 19.

Statistical analysis of the data was affected because only parts of the modified whole experiment were suitable for the analysis of variance of the effects of fertilizer or density. At 56 palm/ha only the two highest levels of fertilizer were included and at 186 palm/ha half the plots had been thinned in 1981 in the course of experiment 702.

The effects of density are summarised in Tables 18 and 19 and Figures 1 and 2. Calculation of the trends in optimum density for each year (current) and overall (cumulative) are presented in Table 20 and Figures 2 and 3.

The regression of yield per palm on all four densities was highly significantly linear ($r = -0.99$) and optimum yield/ha was obtained in 1983 at 134 palms/ha. However, the curve for the variation of yield with density is relatively flat and there was not much difference (± 0.5%) between 110 and 140 palms/ha obtaining the best yields at densities on either side of the calculated optimum. In 1983, production at 110 palms/ha was as good as the latter, for example. The actual curve, drawn from only four points appeared skewed compared to the calculated one. The trend to higher optimum densities since 1981 continued. Circumstantially, the introduction of the pollinating weevil and its likely effects on leaf production and VDM at that time is implicated, though the drought of 1982 cannot be ignored.

Current optimum density has been calculated precisely by obtaining the maximum value of DY where Y is calculated from the regression of yield per palm during the year on density (D). Cumulative optimum density is estimated from $D_o = \frac{P_1 D_1 C}{2C}$, where P is cumulative production per palm at a given density D, and C is cumulative production per palm at highest density minus cumulative production per palm at lowest density divided by palms/ha at the highest density minus palms/ha at lowest density (Corley 1976, Hartley 1977).

Figure 4 shows the relationship between density and yield per palm each year since harvesting started. For the first five years, the slope of the linear relationship clearly differs markedly according to whether or not the 56 palms/ha treatment is included. Subsequently, this difference largely disappeared and 56 palms/ha has now been included to calculate current optimum yields. The lack of interaction between fertilizer and density is considered to justify this. Table 20 summarises the various results that can be obtained. If the trend to higher density continues, the spacing currently practiced by NBPOD is probably about optimum for cumulative yield in later years and is not likely to err by being too dense.

Table 18: Experiment 102, Yield per palm in 1982 and 1983

TREATMENT	1983			1982 + 1983		
Palms/ha[1]	*No. of bunches*	*s.b.w. kg*	*Wt. of bunches kg*	*No. of bunches*	*s.b.w. kg*	*Wt. of bunches kg*
56	10.9 a	22.5 a	246 a	25.8 a	23.7 a	613 a
110	9.1 b	20.8 b	187 b	21.5 b	21.8 b	468 b
148	6.4 c	19.0 c	121 c	15.8 c	20.0 c	315 c
186	4.7 d	18.2 c	85 d	11.9 d	18.3 d	218 d
linear regression	***	***	***	***	***	***
quadratic regression	NS	NS	NS	NS	NS	NS
Fertilizer[1] *% estate practice*						
0	8.3	18.6 a	154	20.5 a	19.4 a	396.7
50	7.9	19.5 a	154	19.1 ab	20.6 b	396.2
100	7.6	20.8 b	158	18.1 bc	22.0 c	397.5
150	7.1	21.1 b	150	17.1 c	21.9 c	375.6
linear regression	NS	***	NS	***	***	NS
quadratic regression	NS	NS	NS	NS	*	NS

1. Means with a similar letter do not differ significantly.
2. Calculated for densities of 110 and 148 p/ha.

The trends in yield since 1975 have been reviewed and those since 1979 are given in Figure 5 on a monthly basis. Since the weevil became active (and the peak of flowering intensity at that time) the monthly pattern of yield has been perturbed. It is therefore probably unwise to base predictions on what occurred in 1982 and 1983. If the situation is now stablising, it seems probable that yields will return to essentially the same levels as in previous years where very good artificial pollination was obtained (c.f. trends in bunch number). However, single bunch weights and, therefore, oil extraction should be better. Since 1982 the differences in single bunch weight between treatments have become less. This may be explained (as Corley has also suggested) by poorer assisted pollination at high density or by differences in relative vegetative dry matter production.

Leaf measurements (Figure 6) taken during 1983 confirmed the downward trend since 1981 seen in Experiments 104 and 105. It is only circumstantial that this follows the introduction of *E.k.*, though pollination is known to affect vegetative development, and the trend may be no more than a natural one. This trend may partly explain why the optimum density has increased. At 110 and 148 palms/ha leaf area was at a maximum in 1980—1981, that is the eleventh year from planting, which differs from the 8—10 years reported elsewhere (Corley, in Malaysia), or 8 years at Bebere plantation (Powell, NBPOD report).

Table 19: Experiment 102, Yield per hectare in 1982 and 1983

TREATMENT	1983		1982 + 1983	
Palms/ha[1]	*No. of bunches*	*Wt. of bunches t*	*No. of bunches*	*Wt. of bunches t*
56	614 a	13.8 c	1448 b	13.2 d
110	995 b	20.6 a	2366 a	51.6 a
148	939 b	17.8 b	2340 a	46.6 b
186	874 b	15.8 b	2220 a	40.5 c
linear regression	**	NS	***	*
quadratic regression	**	***	***	***
Fertilizer[1, 2, 3]				
0	1056	19.6	2589 a	49.9
50	982	19.2	2407 ab	49.7
100	943	19.6	2263 bc	49.6
150	889	18.6	2154 c	46.9
linear regression	NS	NS	***	NS
quadratic regression	NS	NS	NS	NS

1. Means with a similar letter do not differ significantly (P = 0.05).
2. Calculated for densities of 110 and 148 p/ha.
3. Interaction Ferfilizer x Density for kg/palm not significant.

Figure 1: Experiment 102, Yield per palm in 1983

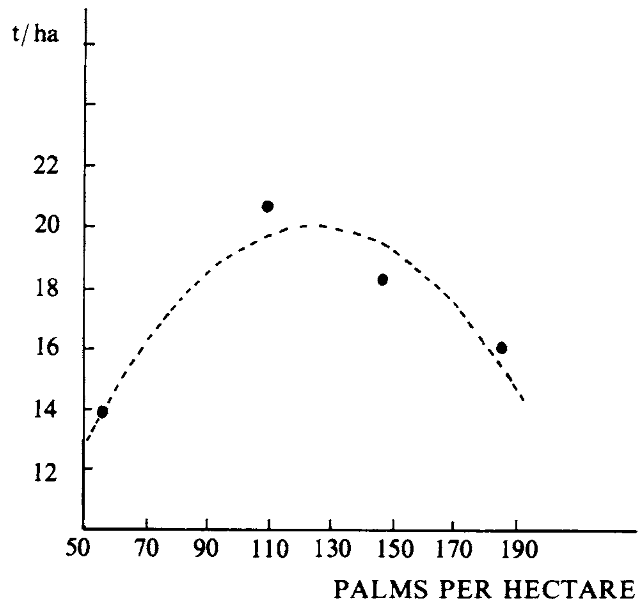


Table 20: Experiment 102, Annual and cumulative yield per palm and optimum densities for current and cumulative yield, Nov. 1973 — Dec. 1983

Year from planting		*3½*	*4½*	*5½*	*6½*	*7½*	*8½*	*9½*	*10½*	*11½*	*12½*	*13½*	
Harvest year		*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	
Period		*73/74*	*74/75*	*75/76*	*76/77*	*77/78*	*78/79*	*79/80*	*80/81*	*5/81 — 10/81*	*'82*	*'83*	
kg/palm per year	56	83	238	250	280	260	262	297	319	77	363	248	
	110	82	233	243	241	219	218	232	224	64	282	188	
	148	81	212	223	192	156	144	149	123	29	194	121	
	186	78	191	163	138	100	94	88	57	10	133	85	
													overall t/ha
Cumulative yield kg/palm.	56	83	321	571	851	1111	1373	1670	1989	2066	2429	2677	149.9
	110	82	314	557	798	1017	1235	1467	1691	1755	2037	2225	244.8
	148	81	293	516	708	864	1008	1157	1280	1309	1503	1624	240.4
	186	78	269	432	570	670	764	852	909	919	1052	1137	211.5
Optimum density 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	—	—	241	160 161	136 137	130 129	121 120	106 104	—	130 128	124 122	
	n = 3	—	266	174 180	144 145	125 124	121 118	115 113	105 102	—	126 123	122 118	
Optimum density for cumulative yield/ha.	*n* = 4	—	440	315	238	201	181	166	151	—	145	143	
	n = 3	—	321	230	192	168	155	145	136	—	132	131	

a = calculated from a linear regression

a = calculated from a linear regression

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

Figure 2: Experiment 102, Optimum density for cumulative yield per ha

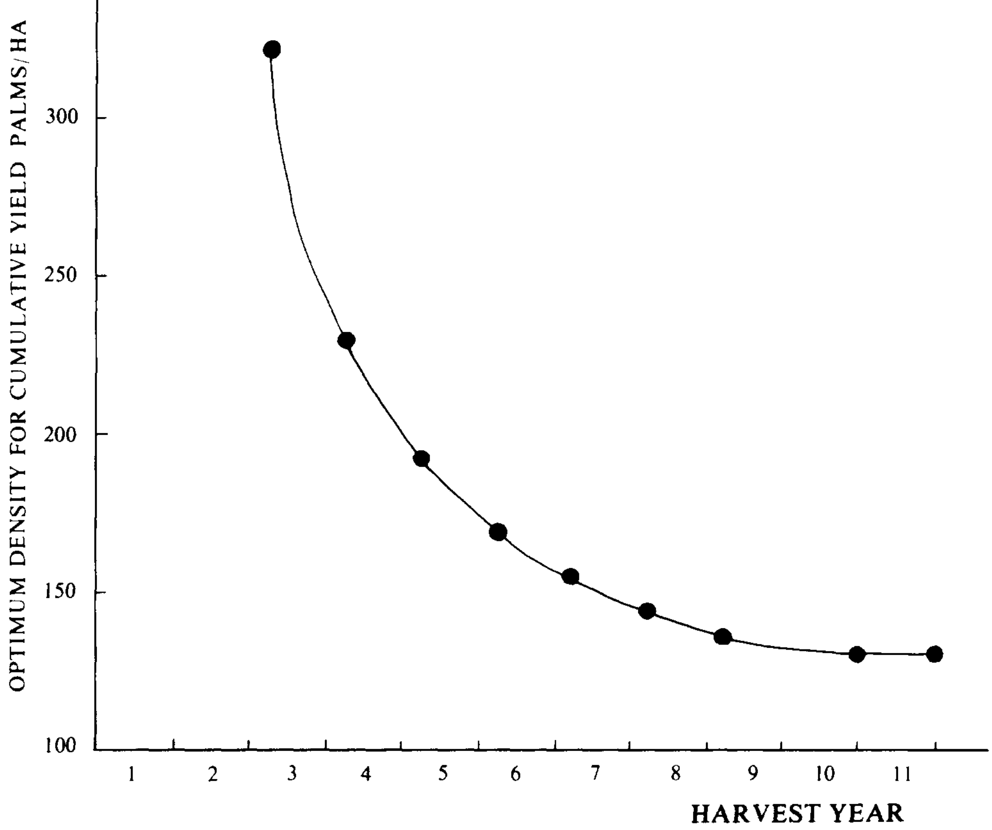


Figure 3: Experiment 102, Optimum density for current yield per palm

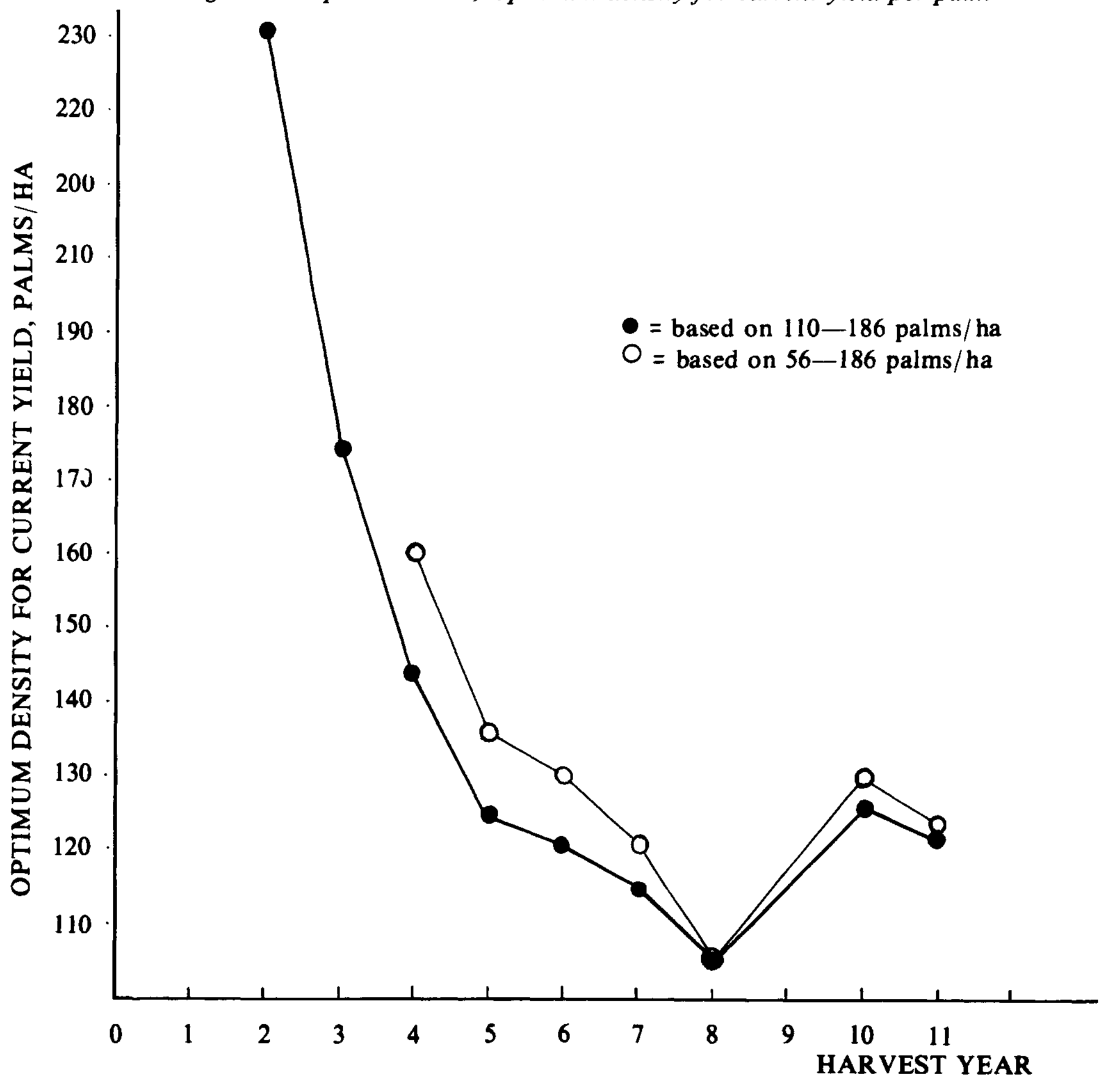


Figure 4: Experiment 102, Annual relationship between planting density and yield per palm

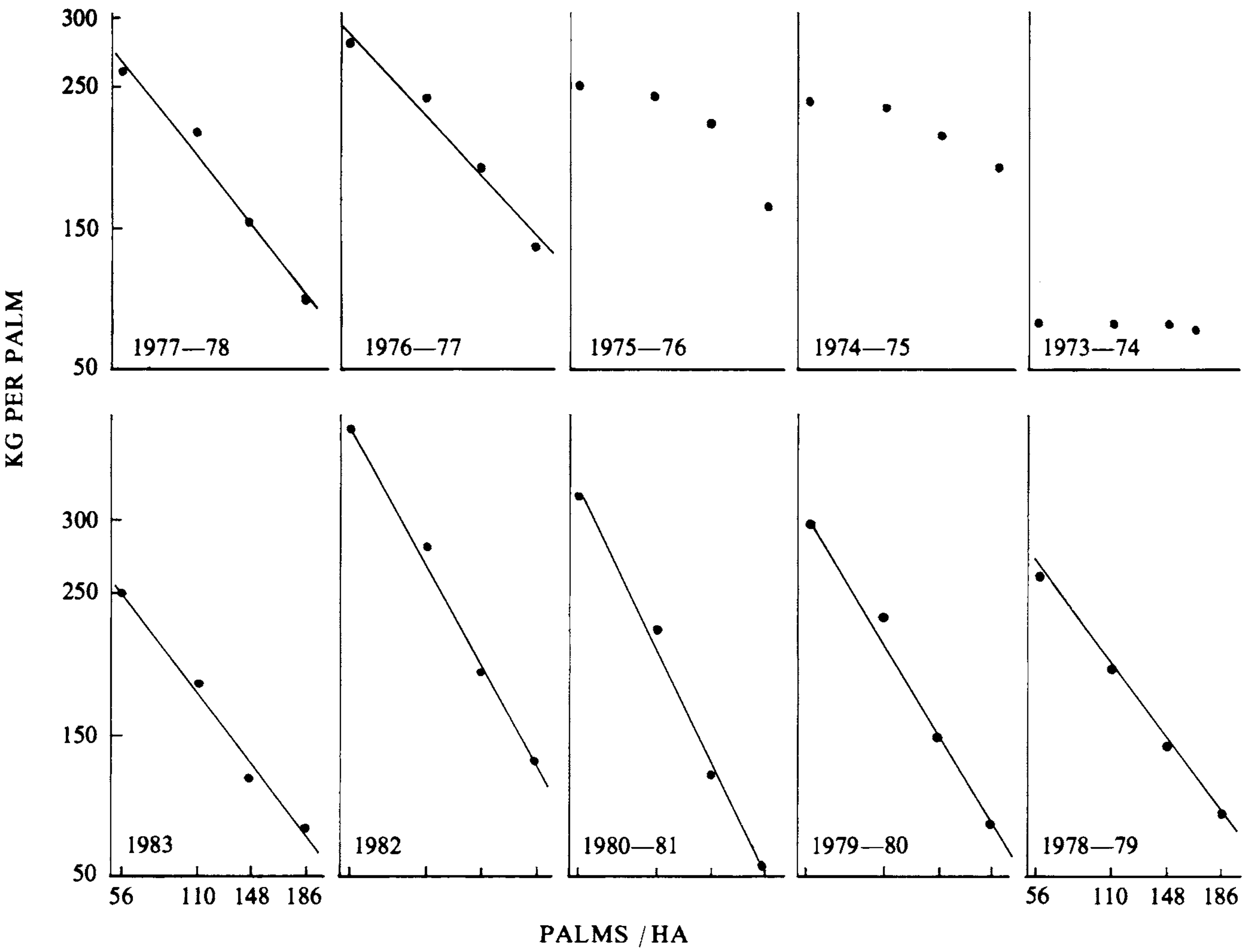


Figure 5: Experiment 102, Trends in yield: monthly values for bunches per palm, single bunch weight & t per hectare at different planting densities

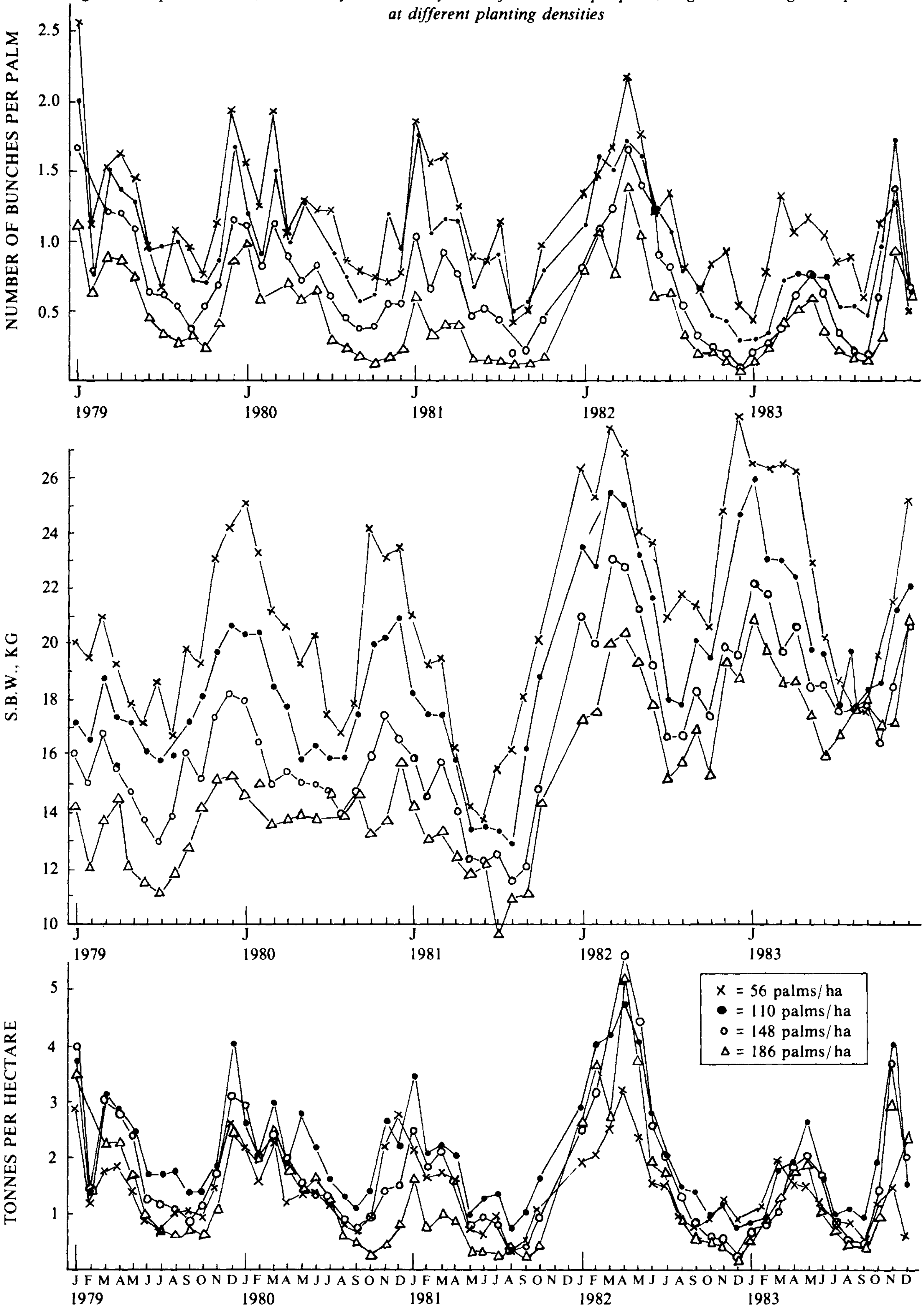
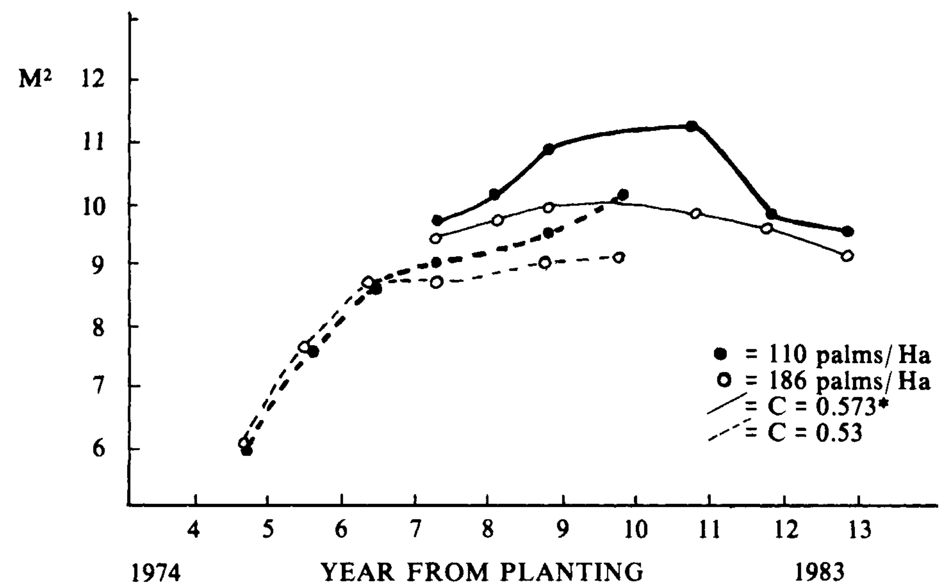


Figure 6: Experiment 102, Trends in area of leaf 17



* Leaf area calculated from L x W x n x c

where C = 0.53 (4—8 yr old palms
or C = 0.573 (older than 8 yrs)

EXPERIMENT 104 and 105, Thinning Trials at Bebere

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

Design: Two randomised block layouts with three treatments (2 common to both experiments), 3 replicates in Expt. 104 and 4 replicates in Expt. 105. Plots of from 51 to 81 palms of which the perimeter palms form unrecorded guard rows around each plot.

Treatments:		*EXPT. 104*	*EXPT. 105*
1.	No thinning	143 p/ha	95 p/ha
2.	Every third palm removed to give hexagonal spacing	95 p/ha	95 p/ha
3.	Every third row removed	95 p/ha	—
4.	Every seventh palm removed to leave each palm next to 1 vacancy	—	122 p/ha

Results: Analysis of production during and to the end of 1983 is summarised in Tables 21 and 22.

Considering 1983 only, in both experiments thinning by a third significantly continued to increase both the number of bunches produced per palm and single bunch weight. This was strongest when thinning left a hexagonal pattern rather than two of every three rows. Thinning by a seventh, as in Expt. 105 and in the practice applied by Bebere plantation, did not give results significantly better than the unthinned treatment but yields were intermediate between these and for thinning by a third. Production per hectare increased with thinning by a third but this difference was not significant during 1983. Single bunch weights were for the first time significantly higher in both experiments after thinning by a third.

Cumulative yields from the start of these experiments had shown no significant difference in overall yield per hectare by the end of 1983 (5¾ years in Expt. 104 and 3¾ years in Expt. 105), except that significantly more bunches had been harvested from the unthinned plots of Expt. 105. Although not significantly different, cumulative yields after thinning by a third were numerically better by 17% in Expt. 104 and 3% in Expt. 105. The difference in Expt. 104 has always been exaggerated by the poor performance of one plot in the unthinned treatment but, during 1983, thinning by a third was also 17% better than the control in the younger Expt. 105, this being equivalent to 2½ tons of bunches or better than ½ ton of oil.

Table 21: Experiment 104, Yield per palm and per hectare, 1978—1983.

TREATMENT	PERIOD						
	1/83 — 12/83					*4/78 — 12/83*	
	No. of bunches per palm	*Wt. of bunches per palm kg*	*s.b.w. kg*	*No. of bunches per ha*	*Wt. of bunches per ha t*	*No. of bunches per ha*	*Wt. of bunches per ha t*
Not thinned	5.6 a**	105 a**	18.7 a*	804	15.0	5,645	93.7
1/3 thinned, hexagonal	8.4 b	182 b	21.6 b	800	17.3	5,875	110.2
1/3 rows thinned	8.1 b	166 b	20.6 ab	772	15.9	5,697	103.3

Means with different letter differ significantly: *P = 0.05
**P = 0.01

Table 22: Experiment 105, Yield per palm and per hectare, 1980 —1983

TREATMENT	PERIOD						
	1/83 — 12/83					*5/80 — 12/83*	
	No. of bunches per palm	*Wt. of bunches per palm kg*	*s.b.w. kg*	*No. of bunches per ha.*	*Wt. of bunches per ha. t*	*No. of bunches per ha.*	*Wt. of bunches per ha. t*
Not thinned	5.3 b	101 b	19.0 b	760	14.4	3,400 a*	56.9
1/3 thinned hexagonal	8.3 a***	177 a***	21.4 a***	788	16.9	3,077 b	58.8
1/7 thinned	6.0 b	115 b	19.2 b	736	14.1	3,190 b	55.3

Means with different letter differ significantly: *P = 0.05
**P = 0.01
***P = 0.001

The apparently greater improvement of fruit set in the unthinned plots since *E.k.* arrived was commented upon in the Second Annual Report (p. 13). It was subsequently seen that, where the weevil was doing the pollination, fruit set was better at the highest density of planting in Expt. 102. It was also indicated in Expt. 702 that more spikelets were found in bunches formed after removing inter palm competition. These observations prompted an examination of fruit set and bunch structure in the thinning trials between June and November 1983. It was shown that thinning by a third increased highly significantly the spikelets per female inflorescence (by 9% in Expt. 104 and 11% in Expt. 105) and thus single bunch weight. Fruit set as measured between June and November was not affected by thinning. These results are given in Table 23.

Table 23: Experiments 104 & 105, Effects of thinning on components of a sample of bunches harvested from June to November 1983.

EXPT.	TREATMENT	*No. of bunches analysed*	*Spikelets per infl.*	*Flowers per spikelet*	*Fruit set* %
104	Unthinned	51	179.5	12.9	47.7
	Thinned by 1/3	66	196.5	13.9	48.6
	difference %	—	9 **	8 NS	2 NS
105	Unthinned	76	169.4	12.5	49.8
	Thinned by 1/3	80	188.8	13.1	49.4
	difference %	—	11 ***	2 NS	1 NS

** significantly different P = 0.010
*** significantly different P = 0.001
NS Not significantly different P = 0.050

Analysis of the partial and multiple correlations between bunch components in Expts. 104 and 105 showed that spikelets per inflorescence and flowers/spikelet were correlated significantly but this was mainly due to their covarying with single bunch weight, heavier bunches consisting of more spikelets with slightly more flowers on them. 66% of the variation in single bunch was attributable to these two components. The final results are summarised in Tables 24 and 25.

Table 24: Experiments 104 & 105, Partial and multiple correlation between 18 plot means for components of bunches harvested from June to November 1983.

Comparison	*At constant*	*T*	*P*
Spikelets per inflorescence x flowers per spikelet	s.b.w.	0.03	0.05
Spikelets per inflorescence x s.b.w.	flowers per spikelet	0.59	0.05
Flowers per spikelet x s.b.w.	spikelets per inflorescence	0.57	0.05
s.b.w. x spikelets per flower and flowers per spikelet	—	0.81	0.001

Table 25: Experiments 104 & 105, Summary of components of bunches harvested from thinned and unthinned plots, 1983.

	Unthinned	*1/3 thinned hexagonal*
s.b.w. (kg)	17.2	20.2
spikelets/inflorescence	175.	193.
flowers/spikelet	12.6	13.5
flowers/bunch	2,204.	2,600.
Fruit set %	48.0	49.2
No. fruit/bunch	1,054.	1,282.

The petiole cross section of leaf 17 was 4—5% greater in the plots thinned by 1/3 in both experiments but these differences were not statistically significant (Table 26). Petiole cross section increased linearly between 1981 and 1983 overall, this trend being very highly significant in both experments but there was no interaction with thinning treatments.

Table 26: Experiments 104 and 105, Petiole measurement of leaf 17 and a year's frond production, July 1983

TREATMENT	EXPT. 104		EXPT. 105	
	W x T *cm²*	*Number of fronds*	*W x T* *cm²*	*Number of fronds*
Not thinned	38.8	20.7	37.7	19.8 a
1/3 thinned hexegonal	40.5	21.8	39.7	21.5 c
Third row thinned	38.6	22.2	—	—
1/7 thinned, systematic	—	—	37.8	20.4 b

Means with the same letter do not differ significantly at the 5% level.

INVESTIGATION 702, Effects of competition

The work reported here will be included in publications by Breure and Menendez that are being prepared. Changes in flowering and in the structure of bunches subsequent to eliminating spatial competition between palms continued to be studied throughout 1983.

In this experiment, stress caused by high density planting (186 palms/ha in Expt. 102) had been reduced in 1981 by thinning half these plots for later comparison with the remainder that continued to grow under highly competitive conditions. Details of the experimental design and methods were given on page 25 of the Second Annual Report.

The work at Dami was complemented by an anatomical study of the development of inflorescences and flower initials taken from the apical buds of those palms that were thinned in 1981. This part of the work was done with the assistance of The Department of Tropical Crop Science at Wageningen.

The drought conditons of 1982 and the high fruiting activity caused by the weevil, whose pollinating activities commenced almost at the same time as Investigation 702, caused much abortion of inflorescences and afforded a good opportunity to study further whether abortion showed sexual preference. This question was a subsidiary objective of this work and is reported here.

During 1983, growing points were dissected from a total 48 guard row palms sampled equally from all the main plots of Expt. 102 and sent to Wageningen. This was to study the stage at which flowers were initiated: it had not been possible to see this in samples taken in 1981 because they included only inflorescences that could not be sexed using a hand lens and flower initiation occurs after this stage.

The lengths of developing inflorescences in the latest samples were measured at Dami for inflorescences from two of the four replicates sampled. This dimension was taken in each spikelet from where the proximal spikelet was inserted into the stalk, to the tip.

Results: Values for bunch components were beginning to diverge towards the end of the year but confirmation of this required further recording. This aspect of the work will be reported next year when the results will have been collated, interpretated and prepared for publication.

The development of male and female inflorescences is presented in Figures 7 and 8. Both curves, especially the one for females, fitted well with the calculated exponential over the range measured. Compared to data quoted by Corley (1978) a slightly slower rate of elongation was recorded up to inflorescences subtended by the eighth leaf. Our data confirmed that abortion of both male and female inflorescences occured when the subtending leaf was the eighth to eleventh oldest, at which stage female inflorescences were usually larger than males. The leap in values for the confidence limits (bars in Figs. 7 & 8) and standard deviations of lengths (Table 27) shows this clearly and that abortion occured between leaves 8 and 9 for female inflorescences but between 10 and 11 for males.

Table 27: Investigation 702, Variation in lengths of inflorescences according to subtending leaf

LEAF	*Female inflorescences*		*Male inflorescences*	
	Mean mm	*Standard deviation*	*Mean mm*	*Standard deviation*
7	24	6	17	4
8	29	9	22	2
9	34	14	26	8
10	45	27	33	7
11	52	30	102	58

Figure 7: Investigation 702, Length of developing male inflorescences in leaf axils, Aug. 1983 with 90% confidence limits.

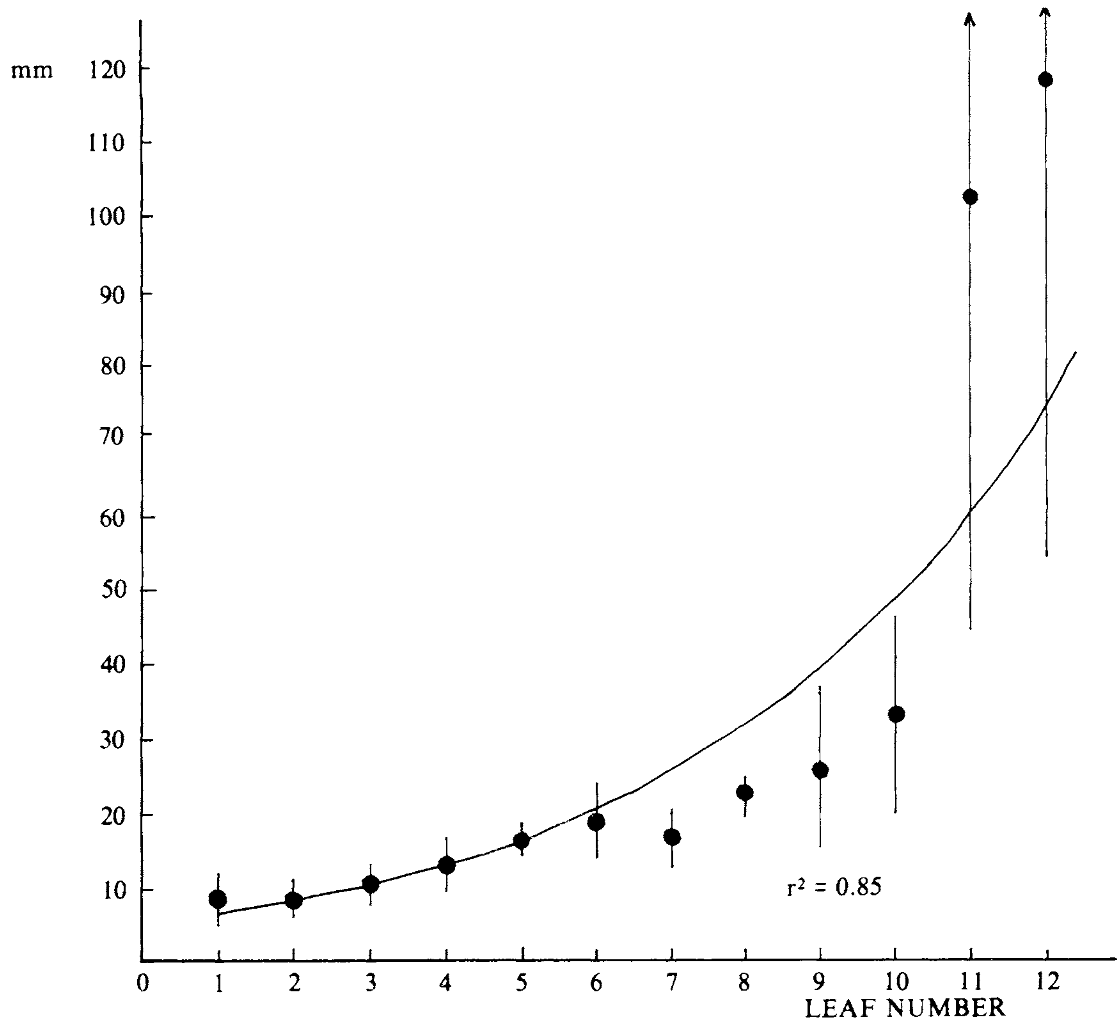
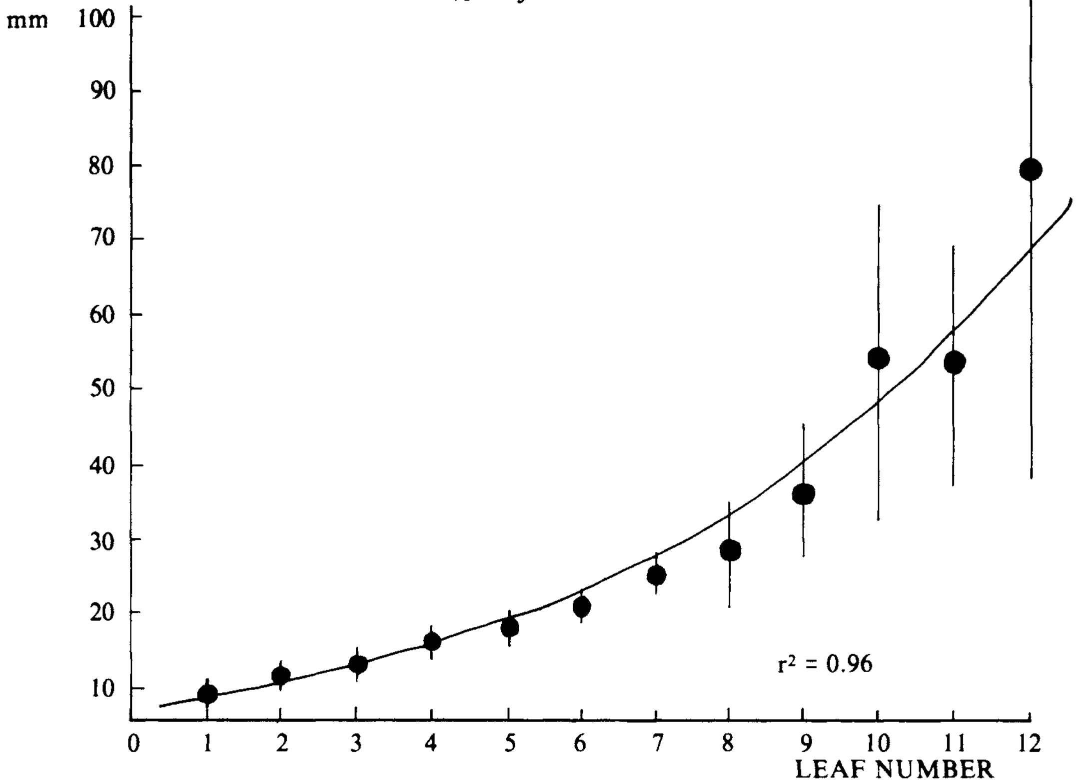
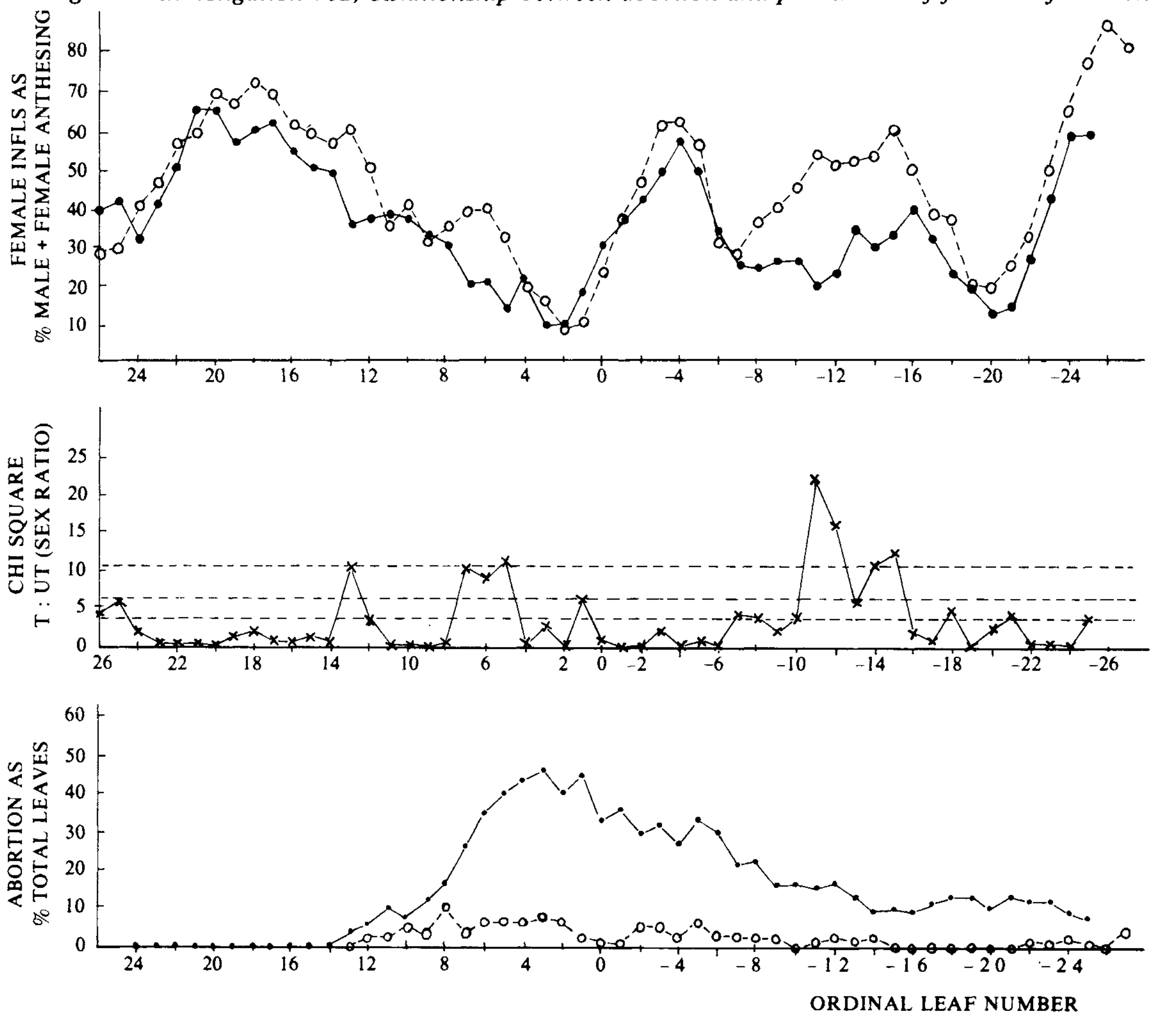


Figure 8: Investigation 702, Length of developing female inflorescences in leaf axils, Aug. 1983 with 90% confidence limits.



In the field, the unthinned plots were strongly affected by abortion, which peaked in December 1982 (> 40% as against < 10% in the thinned plots). The relationship between abortion of inflorescences of different sexes and for unthinned and thinned plots is shown in Figure 9.

Figure 9: Investigation 702, Relationship between abortion and production of female inflorescences



In this experiment bunches and inflorescences are identified by the ordinal number of the leaf by which they were subtended. Leaf O, which was the next youngest leaf to the first fully expanded frond when the experiment started on 1st November 1981 is the datum from which all leaves are counted: leaves older than this are numbered positively and those younger are numbered negatively. Over the whole range from leaves +14 to -16 significantly more female inflorescences were aborted in the unthinned plots than in those that had been thinned. However, when abortion was high inflorescences of both sexes were aborted in equal proportions, that is neither type was preferred. This suggests that female inflorescences were aborted preferentially only when the amount of abortion was comparatively low. If this difference is explained by female inflorescences being the first to go, then males must have been preferred as abortion increased to arrive at equal proportions aborted or this could also have happened if the supply of female inflorescences had first been exhausted leaving only males to be aborted.

Examining the trends more minutely, from leaves +14 to +12 the thinned plots continued to show proportionally more female inflorescences than the unthinned plots. This was probably due to random variation, rather than preferential abortion of male inflorescences, because there were more female inflorescences in the thinned plots than the sum of females and aborted ones in the plots that were not thinned.

From leaves +11 to +8 female and male flowers occurred in equal proportions but from +7 to +5 there was again a preponderance of females in the thinned plots. Abortion rates in the unthinned plots were high at this stage and the sum of female plus aborted inflorescences in these plots corresponded to or was slightly higher than the same total in the thinned plots. Either abortion was preferring female inflorescences or the random trend in sex ratio was again intruding. The former seems the more likely reason here.

From leaf +4 to -6 there was very little consistent difference between the treatments. It can be argued that the concept of preferential abortion of females is not necessarily contradicted by this data. However, the survival of some female inflorescences shows that if there was preference it was only partial.

From leaf -7 to-15 there was a decreasing proportion of female inflorescences in the unthinned plots. The sum of female plus aborted inflorescences was very much less than in thinned plots and it must be inferred that a change in sex ratio caused this. The only known difference between the two populations was the thinning treatment in 1981. For this to be the cause presumes that sex differentiation was affected around leaf -10, which disagrees with previous theories on the subject. Flower census results so far only permit comparison up to leaf -25 but it appears that the sexual change was not sustained between leaves -16 to-24. The reason for this effect is unexplained thus far.

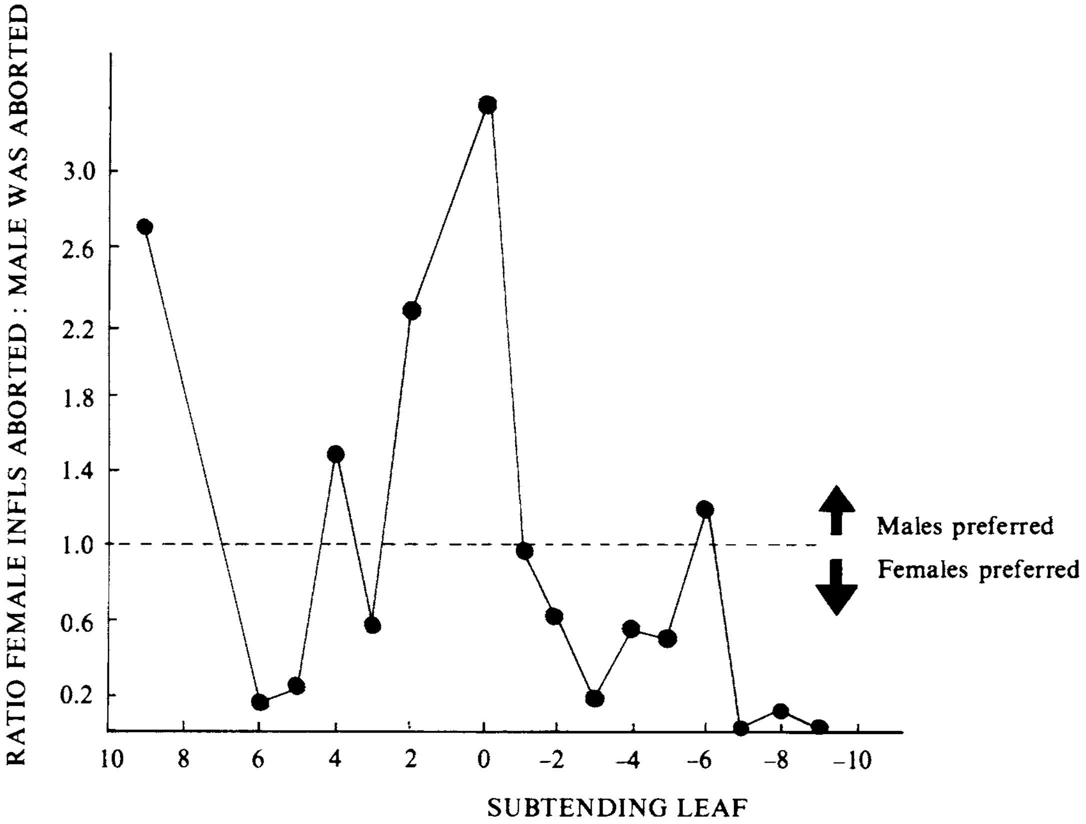
The ratio of anthesing female and male inflorescences in each leaf of the unthinned palms was compared with an estimate of the ratio before abortion occurred. This estimate was calculated from the known ratio for the same leaves in the thinned plots where abortion was negligible. Similar ratios before and after abortion would indicate that abortion showed no sexual bias.

The variability of the data made the comparison difficult to calculate but this exercise did not suggest that there was a consistent preference for either sex (Fig. 10) although one could be affected more than the other for any one leaf.

In the thinned plots, the high sex ratio between leaves -8 and +15 fell from 60% to a low of 19% by leaf -20 whereafter it peaked to 87% at leaf -26. This level was followed closely by palms in the unthinned plots up to leaf -24. The behaviour of palms at lower leaf numbers has not yet been compared.

Vegetative development of the unthinned plots was lagging behind the thinned plots. The interval between thinning and harvesting bunches from successively younger leaves is shown graphically in Fig.11, where the divergence of the linear regression lines is obvious.

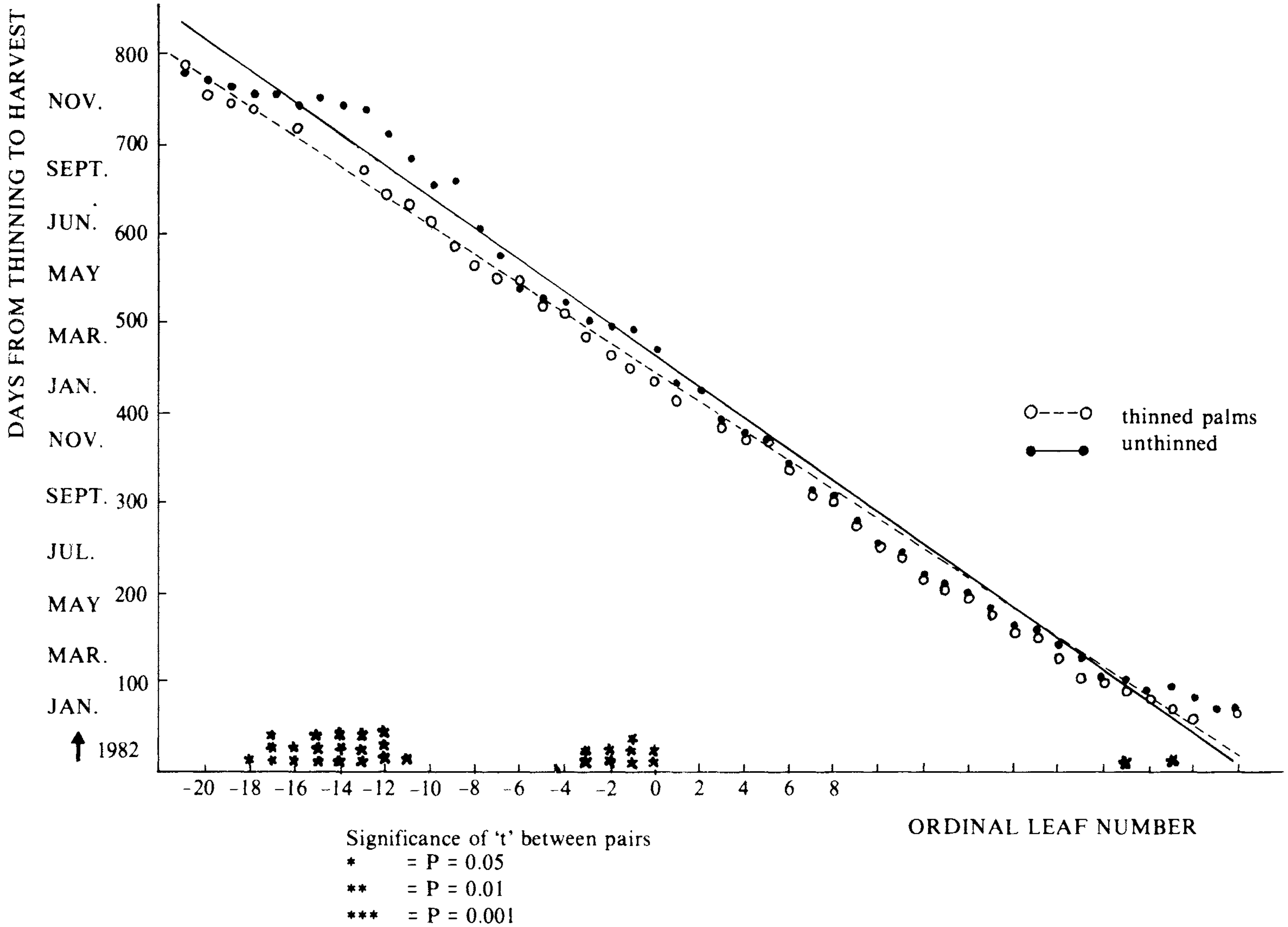
Figure 10: Investigation 702, Calculated ratio between aborted female and aborted male inflorescences for thinned and unthinned palms*



$$* \; r = \frac{F_t - F_{ut}}{F_t} \div \left(\frac{M_t - M_{ut}}{M_t}\right)$$

where F = Female, M = male
t = thinned, ut = unthinned

Figure 11: Investigation 702, Days from thinning to harvesting bunches from successive leaves



ENTOMOLOGY

INSECT POLLINATION

INVESTIGATION 603, *Elaeidobius kamerunicus* Field Studies

Population census (R.N.B.P.)

The original population studies were carried out on Bebere and Walindi plantations and data is presented for these in Table 28. The carrying capacity of individual spikelets varied with the spikelets' overall length and the longest spikelets appeared to produce a significantly higher number of adults that was more than proportional to the length.

It is possible that the longest spikelets were capable of producing more scent and for a longer period of time as anthesis progressed from the base of the spikelet to the apex. Selection of palms with this type of male inflorescence may assist in maintaining high pollination levels.

Table 28: Investigation 603, Number of weevils emerging per male spikelet (means of 100 spikelets), 1982 and 1983

	Bebere plantation		*Walindi plantation*	
	1982	*1983*	*1982*	*1983*
JANUARY	103	49	114	89
FEBRUARY	84	85	82	127
MARCH	69	—	59	—
APRIL	100	91	100	106
MAY	93	78	102	129
JUNE	95	80	110	125
JULY	142	—	114	—
AUGUST	—	112	—	178
SEPTEMBER	150	109	107	148
OCTOBER	84	140	87	123
NOVEMBER	87	109	130	60
DECEMBER	94	107	101	—

During 1983 it was realized that counts of weevils emerging from spikelets was not in itself an adequate way of measuring flying weevil populations. Emergence counts were so consistenly high that they suggested there were generally more weevils than spikelet space for them to lay eggs. The quantity of weevils per hectare available to pollinate was termed "pollination force". This was thought to vary more with the number of male inflorescences per hectare rather than emergence per se. Furthermore, mid-year fruit set was seen to vary from site to site. It was decided to increase the number of sites sampled and to include plantings of different ages and degrees of spatial isolation, and to record additional factors to permit the calculation of weevils per hectare and their relationship to fruit set. The main objectives entomologically were, as well as monitoring the well-being of the weevils themselves, to determine the reasons for poorer fruit set observed in the months June to September since the weevils' introduction and to try and determine the optimum number of male inflorescences per hectare in particular ages of palms.

A summary of results during the last quarter is presented in Table 29. The effect of the pollination force will not be seen until bunches have been analysed 5 months after those parameters were recorded.

Table 29: Investigation 603; Fruit set, rainfall and population dynamics of E.k. Sept. — Dec. 1983

SITE	SEPTEMBER						OCTOBER				
	Planted	*Fruit set %*	*Male infl. per ha*	*Weevils emerged per spikelet*	*Weevils per ha*	*Rain mm*	*Fruit set %*	*Male infl. per ha.*	*Weevils emerged per spikelet*	*Weevils per ha.*	*Rain mm*
W.N.B. PROVINCE											
Dami	1970	59				164	56				111
Bebere	1970	54	7	109			60	11	140	306,860	
Kumbango	5/79	51	5	85			61	8	75	68,040	
Togulo	12/80	50	8	89			59	24	109	197,741	
Rikau V.O.P	1980	21	8	66	35,482		28	12	82	58,680	
Hargy	1973	64		183		282	63				306
ORO PROVINCE											
Arehe	1977	58		135		106	54	13	119	263,426	262
Isavene	1977	44					50				
Isavene	1978	47					45				
Arehe	1979	49					31				
Ambogo	12/79	34					31				
Ambogo *Expt. 306*	1980	50					46				
Tunana V.O.P.	1980										
Beuru V.O.P.	1980										

SITE	NOVEMBER						DECEMBER				
W.N.B. PROVINCE											
Dami		63				400	67				304
Bebere		61	20	109	377,541		63	10	107	227,407	
Kumbango		45	12	108	106,288		55	19	97	193,328	
Togulo		61	36	83	175,470		54	39	82	252,067	
Rikau V.O.P.		44	5	64	18,125		37	12	84	75,600	
Hargy		66				402	60				642
ORO PROVINCE											
Arehe		47	10	108	165,875	253	47	17	74	223,857	358
Isavene		52					49				
Isavene		48					44				
Arehe		28					42				
Ambogo		38					29				
Ambogo (306)		43					40	39	133	467,297	
Tunana V.O.P.							46	31	159	454,958	
[illegible]u V.O.P.		[illegible]					44	18	110	221,760	

Pollination and fruit set (T.M., R.N.B.P.)

Fruit set was monitored at all the oil palm developments in PNG, the number of sites being increased later in the year for the reasons explained above. The following lists all sites sampled routinely at the end of the year.

		Site	Planted
	West New Britain Province		
Hoskins Oil Palm Scheme:	N.B.P.O.D.	Bebere	1970
		Dami	1970
		Kumbango	1979
		Togulo	1980
	Smallholdings:	Rikau V.O.P.	1980
Bialla Oil Palm Scheme:	H.O.P.P.L.	Hargy	1973
	Oro Province		
Popondetta Oil Palm Scheme:	Higaturu:	Arehe 1	1977
		OPA 7	1977
		OPA 11	1977
		M21—25	1979
		Isavene M06—10	1978
		Ambogo	1979
		Ambogo	1980
	Smallholdings:	Tunana V.O.P.	1980
		Beuru V.O.P.	1980

There is very scant data on fruit set in the weevil's homeland. If percentage fruit to bunch could be used as a reliable indicator of fruit set, then the wealth of data of bunch analyses from Africa and elsewhere could be used to estimate fruit set.

Grouping the data into populations, each consisting of a range of fruit set by averaging the values for leaves of each ordinal number from +26 to -13, gave a weakly correlated ($r = 0.7$) relationship suggesting a critical value for fruit set of between 40—50%. In Figure 12 the data was sorted into thirteen categories of fruit set from 10 to 80%, each category including a range of 5%. It was not possible to fit a calculated curve to this data but it appeared that fruit to bunch was likely to suffer when fruit set falls below 30%.

In this study fruit to bunch of individual bunches could not be used to indicate fruit set. It gave only a poor estimate for the average of larger populations of bunches and it was concluded that, in general, fruit to bunch is an unreliable guide to fruit set.

The variation in entomophilous fruit set at the sites that have been monitored since before *E.k.* was liberated are shown in Fig. 13. In West New Britain the monthly values were similar at Dami and Bebere (N.B.P.O.D.) and the same trends were recorded at Hargy. On the whole fruit set was good (above 50%) but higher values (above 60%) were recorded at Hargy. Apart from differences in day to day weather between the Hoskins and Bialla Schemes, the most likely difference between the two that might affect the effectiveness of *E.k.* in this way is that the planting material at Hargy originated from I.R.H.O. and might be more readily pollinated by the weevil. In Oro Province, the plantings sampled at Higaturu yielded generally poorer fruit set and although the same general trends appeared to be establishing, the West New Britain pattern was followed but weakly. In the latter area, a pronounced mid-year fall in fruit set was reflected also for a short while by poorer bunches at the roadside, especially in some younger plantings. Although fruit set had been monitored for barely two years since the weevil took effect, a pattern of mid-year dip for fruit set and single bunch weight seemed to be forming. This would continue the same trend in single bunch weight that occurred before *E.k.* was introduced and is probably an intrinsic part of the pattern of yielding in this region. Future research should elucidate this.

Figure 12: Investigation 603, Relationship between Fruit set and fruit to bunch ratio, 1983, with 90% confidence limits

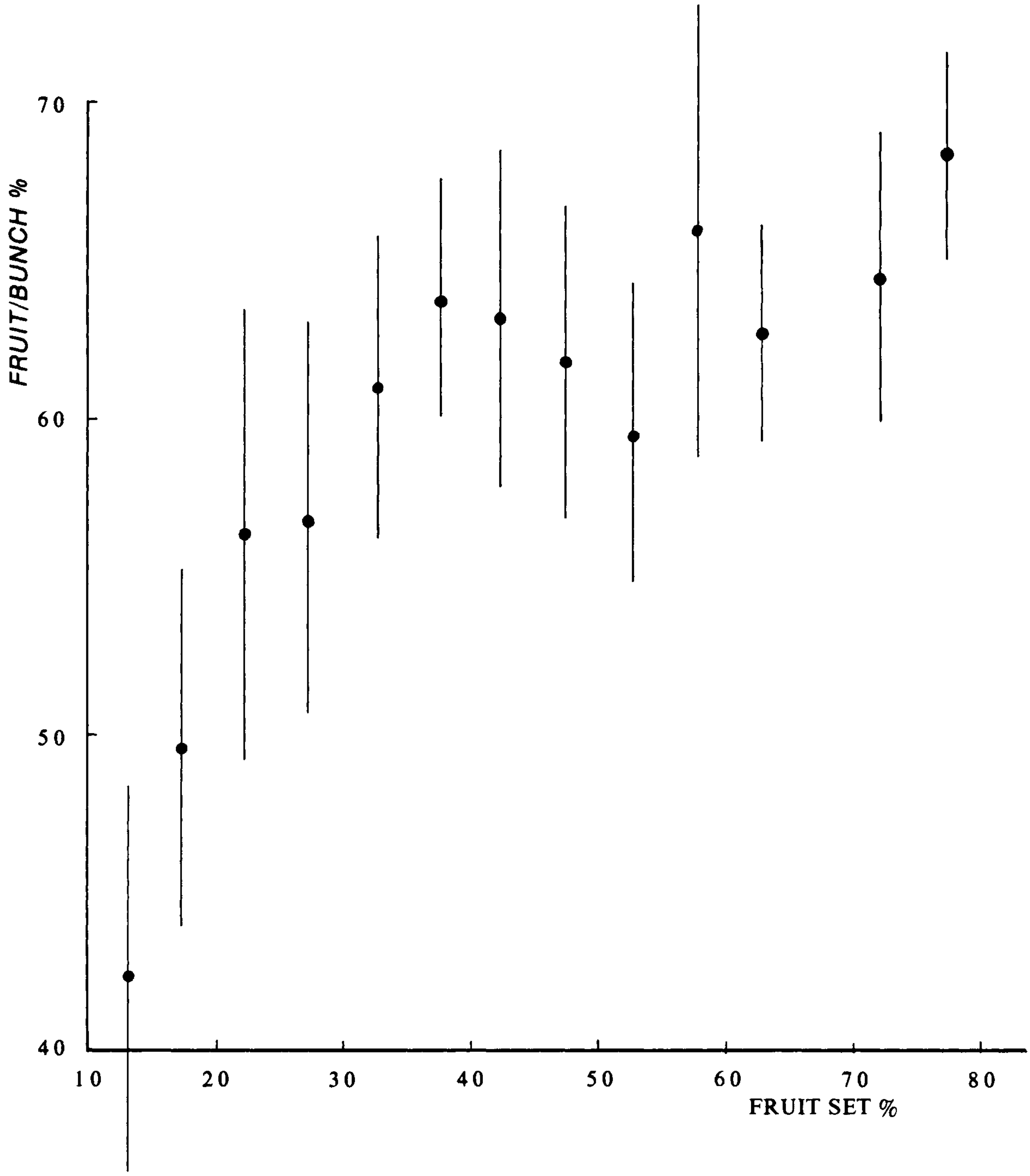
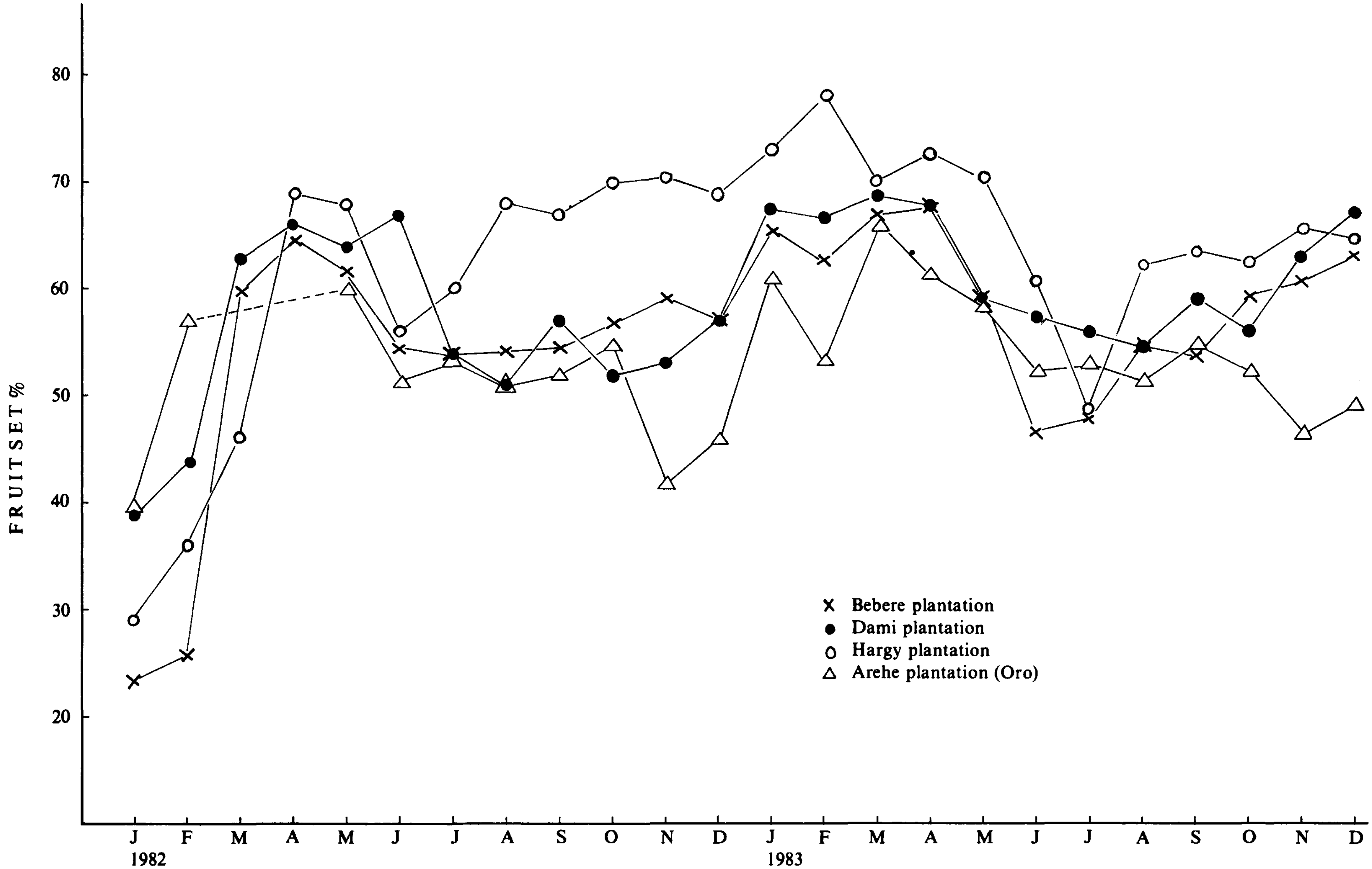


Figure 13: Investigation 603, Fruit set in West New Britain and Oro Provinces, 1982 & 1983



Fruit set of *Elaeis oleifera* recently bearing bunches at Dami appeared good. Recorded fruit set in two bunches sampled in June was 29% and 39%. Very large numbers of parthenocarpic fruit were counted, many of which though infertile contained shell reminiscent of unpollinated hormone-induced *dura* fruit. This data is recorded here for general interest.

2 bunches		*No.*	*Percent*
	Total flowers	6,251	100
	Shell-less infertile fruit	694	11
	Infertile fruit with shell	3,505	56
	Fertile fruit	2,062	33
	Fruit set %	33	—

E.k. was seen visiting both male and female inflorescences in the field. One male inflorescence in about half full anthesis was bagged and found to contain 4,406 weevils, that is 113 weevils per spikelet. Adults emerged from samples incubated in the laboratory but fewer than would be expected from the number of eggs laid. There is no evidence that these palms are other than genetically pure *E. oleifera* and it is inferred that *E.k.* pollinates this species of palm in PNG.

A continuously recording, tipping-bucket rain gauge measuring units of 0.1mm of rain was set up on January 1st. When the trace showed continuous rain (defined as no rainless periods longer than half an hour between 6am and 5pm) female inflorescences then at full anthesis in the field were tagged. This state of affairs was rare and on only 3 occasions was the tagging of inflorescences warranted. Once developed as bunches these were analysed for fruit set together with their adjacent bunches in the same fruiting cycle. The data presented in Table 30 clearly demonstrates that continuous, heavy rain will prevent pollination.

Observations in the field at the time of continuous rain showed that *E.k.* did not leave the shelter of the palm canopy. Hunderds of weevils could be seen settled on the underside of the fronds adjacent to a heavily populated male inflorescence, waiting for the rain to stop before flying further.

Table 30: Investigation 603, Fruit set of inflorescences recepetive during rain at Dami 1983

	Experimental bunch	next youngest	next oldest	next youngest & oldest
No. of bunches	8	7	6	13
Fruit set	10.9	19.6	34.2	31.7
s	11.4	21.5	6.2	15.9

Predation by Rattus exulans (R.N.B.P.)

No further studies were considered necessary since those reported in the Second Annual Report (page 32) at Dami. At Bialla the opinion was held locally that damage there justified control measures because damage by rats to loose fruit might represent a loss recoverable by rat-baiting. The situation elsewhere remained as before with little or no evidence of economic damage to fruit or serious reduction in the pollination force.

SEXAVA *(Segestidea defoliaria)* *(R.N.B.P.)*

INVESTIGATION 601, Chemical Control.

No significant damage to oil palm occurred in the Hoskins area throughout 1983. Small areas of Sexava damage continued throughout 1983 at Bialla on the nucleus estate. Trunk injection of monocrotophos stopped in November and in December the estate was recorded as free from Sexava damage. Field trials using liquid Orthene were again abandoned for lack of insects to run a satisfactory trial.

INVESTIGATION 607, Biological Control.

Up to the end of 1983 all *S. defoliaria* infected with the internal parasite *Stichotrema* from *S. decoratus* collected at Bubia, Morobe Province, died before the parasite reached maturity in its host. Infection rates were 90—100% and all dead Sexava above 4th instar examined which had been exposed to triangulins had one or more immature *Stichotrema* in the body cavity. Mortality in first second and third instar nymphs of *S. defoliaria* was 100%. Fourth, fifth instars and adults survived longer but the end result was death before maturity of the parasite. The results are summarised in Table 31. Production of mature *Stichotrema* in *S. defoliaria* has been claimed by Perry (pers comm) at L.A.E.S. Keravat. However, it would appear from the tests at Dami that the parasite does not adapt well to *S. defoliaria* and obviously without a proportion of parasites reaching maturity the parasite will not maintain itself in the field.

Table 31: Investigation 607, Survival of Stichotrema infected S. defoliaria and development of parasite in host.

Instar	*No. specimens infected*	*No. of specimens dead and days to die*	*Triangulins in host*	*Larval development*
First	22	21 in 18	frequent	none
Third	34	22 in 25 13 within 65	present	*Stichotrema* larvae in 10 host specimens (2—4 larvae per host)
Fourth	9	all in 15	?	(specimen lost)
Fifth	10	4 in 26 6 in 57	present present	1—2 *Stichotrema* larvae in 3 host specimens
Sixth	7	4 in 25 3 in 38	present	4 hosts specimens had 2,4,6 & 10 *Stichotrema* larvae
Adults	54	16 in 25 38 in 64	few	Only 5 host with specimens *Stichotrema* larvae

Putative specimens of the ant *Camponatus papuana* were collected from Bubia in Morobe Province and colonies raised in the insectary at Dami. This species is reported to be the alternate host of *Stichotrema* and specimens at Dami were infected with this parasite. Other than observing triangulins in the bodies of both larvae and adult ants no evidence was obtained over nearly three months observation that any development had occurred within the host ant.

The importation of *Nosema locustae* from the U.S.A. moved ahead slowly. The first batches of *Nosema* were expected to arrive early in 1984.

BAGWORMS *(Psychidae Lepidoptera)*

INVESTIGATION 606, Chemical and biological control.

No economic damage by bagworms occurred in any of the oil palm developments during 1983. Collection of parasites continued but material was generally scarce.

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

INVESTIGATION 605, Records and Observations.

No new insects damaging oil palm were recorded in 1983.

PATHOLOGY *(P.J., T.M.)*

EXPERIMENT 801, Incidence of *Ganoderma*.

This experiment seeks to estimate the probability of *Ganoderma* disease affecting replanted palms and therefore the practices necessary to minimize the risk. Current replanting assumes such a risk exists and the old stand is both poisoned and excavated before replanting dead palms. The experimental treatments also provide material for studying *Ganoderma* and fungi causing rots and their interactions.

Design: Details of this experiment were given on page 40 of the Second Annual Report. Briefly, it consists of treatments to twelve year old palms to kill them and surrounding their remains with three normal field plantable seedlings to attract possible *Ganoderma* disease. Six treatments were laid out at 2 sites in randomised blocks replicated four times at each site.

Treatments: 1 Old palms poisoned and left standing.
2 Old palms poisoned and felled at 1m from ground level.
3 Old palms poisoned and felled a 30cm from ground level.
4 Live palms felled at 1m
5 Live palms felled at 30cm.
6 Poisoned palms excavated.

Palms were poisoned in 1980 (Site 1) and 1981 (Site 2). Felling and excavating were completed in 1982.

Results: During 1983, samples were taken from treatments 2 and 4 for isolation of Basidiomycete fungi by cutting two slices approximately 10cm thick from the top of the stump. Two replicates from one site and two from the other were sampled. A total of 140 Basidiomycetes (82 from treatment 2 and 58 from treatment 4) were isolated, many being different isolates of the same fungus. In addition *Ganoderma* spp have been isolated from stumps of forest trees in the plantings. A survey was made of the whole trial to assess the number of stumps which bore sporophores of *Ganoderma* spp., with the results shown in Table 32.

Table 32: Experiment 801, Number of sporophores of Ganoderma spp.

SITE AND REPLICATE		TREATMENT											
		1		2		3		4		5		6	
		+	−	+	−	+	−	+	−	+	−	+	−
Site 1	I	21	4	16	9	16	9	0	23	0	25	1	23
	II	19	5	16	8	16	8	0	25	0	25	10	23
	III	19	6	20	5	20	5	0	25	0	25	12	13
	IV	18	7	17	7	14	10	0	25	0	25	0	12
Site 2	I	17	8	20	5	15	10	0	25	0	25	7	18
	II	17	7	20	5	12	8	0	25	0	25	11	13
	III	9	9	24	4	16	3	0	23	0	24	7	17
	IV	20	5	21	4	16	10	0	25	0	23	6	19
Present		73	27	79	21	66	34	0	100	0	100	33	67

\+ = *Ganoderma* sporophores
− = no sporophores

The treatments which were not poisoned and had been felled only in 1982 had no sporophores of the fungus. Thei tissues were still extremely hard and few fungi had colonised the cut surfaces. Their frond bases were still intact. Th poisoned palms had lost their frond bases and were extremely rotten, especially those poisoned in 1980. Many poisoned palms that were left standing had crumbled to the ground.

There was no evidence of any *Ganoderma* infection in the young palms, this would not be surprising even if pathogenic strains were present as the experiment was as yet young. Sporophores of *Ganoderma* spp. collected from the area were sent to the Royal Botanic Gardens, Kew for identification. The most common species found was *G. tornatum*. This is regarded by Steyaert as a saprophyte. However two other species found, *G. boninense* and *G. minatocinctum*, were thought to be parasitic on oil palm. Whether these latter two species and other possibly parasitic species occur frequently enough to cause a disease hazard is as yet unknown.

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 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.

Inoculum was prepared by obtaining a plate culture of *Ganoderma* spp. from a fresh sporophore and growing this on sterilised sawdust + 3% malt extract broth. The fungus was then inserted into the stump by drilling holes down through the cut surface and filling each hole from the sawdust cultures. The end was sealed with a wooden plug. This should indicate how *Ganoderma* growth is affected by the various treatments.

Results: Ammonium sulphamate was applied to the cut surface and sides of the stump at a rate of 200g per stump, and to holes drilled in standing trees at the same rate. In May it was observed that AMS applied to the standing palms (treatments 11 and 12) had not killed the trees. It was therefore decided that the trees should be felled and AMS applied to the cut surface in treatment 11 but treatment 12 left untreated.

AMS is not successful as a palm killer and is also much more expensive than sodium arsenite. It remains to be seen whether it encourages the degradation of palm tissue compared with sodium arsenite.

EXPERIMENT 303, Pathogenicity studies on oil palm.

According to Steyaert (1967), species found on oil palm that were apparently parasitic were *G. zonatum, G. miniatocinctum, G. bonienense* and the latter two have been found on Bebere. Those which are apparantly saprophytic are *G. chalceum, G. tornatum* and *G. xylonoides*.

G. chalceum has been found in Milne Bay and *G. tornatum* is very common on poisoned palms and stumps in Bebere: however other authors have records of *G. tornatum* in association with basal stem rot (Turner 1981). It is therefore necessary to test the pathogenicity of a repesentative sample of *Ganoderma* spp. found in PNG.

Methods: A really satisfactory and convenient way of inoculating Ganoderma into live palms has not been developed.

The following methods will be tried in the course of this investigation:

1. Holes 6cm x 1cm will be drilled into blocks of freshly cut palm wood of different sizes. A dowel impregnated with *Ganoderma* spp. will be inserted into the holes which will then be plugged. Once the fungus has permeated the wood block these will be placed at the base of young field palms. The amount of inoculum needed to infect palms is unknown. Elsewhere it has been possible to infect field palms by placing blocks of diseased tissue 0.3m from affected palms just below the soil surface close to the palm base (Turner 1981).

2. Trunks of live palms will be inoculated with dowels impregnated with *Ganoderma* spp.

3. Roots of live palms will be inserted into bottles containing an inoculum of *Ganoderma* spp.

4. Blocks of wood colonised by *Ganoderma* spp. will be placed at the base of planting bags and young oil palm seedlings planted on top.

APPENDIX I

METOROLOGICAL DATA

The data presented below was made available by the courtesy of N.B.P.O.D., Hargy Oil Palms Pty. Ltd., and Higaturu Oil Palms Pty. Ltd. The equipment at Hargy was damaged on New Year's eve and recording of rainfall only was resumed in March. Nationally accredited meteorological Stations are sited near PNGOPRA's offices at Dami and Higaturu. PNGOPRA personnel took over recording at Higaturu during the year, the other stations are recorded by staff of the plantation companies.

Table 33 : Rainfall (mm): HARGY, 1983.

	Jan	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Total*
1982	796	745	800	275	166	272	25	103	153	9	18	160	3522
1983	—	—	653	554	179	278	566	596	282	306	402	642	—
Mean 1982-83	710	753	640	377	148	218	314	303	211	165	191	380	4410

Table 34: Meterological data: HIGATURU, 1983.

	Rainfall mm			*Sunshine hrs*			*Rainy days*		
	1983	1982	Mean 1981-83	1983	1982	Mean 1981-83	1983	1982	Mean 1981-83
January	457	222	294	206	136	160	19	17	17
February	521	356	322	154	125	116	27	19	20
March	504	503	417	178	141	174	24	20	19
April	178	169	223	186	167	162	18	18	18
May	193	178	197	219	152	162	15	13	14
June	211	133	169	166	135	150	19	12	15
July	27	22	69	173	166	151	4	6	9
August	90	114	100	169	168	174	13	18	13
September	106	32	122	185	203	158	15	8	12
October	262	63	190	170	168	161	21	15	18
November	253	348	307	182	200	184	15	20	17
December	358	348	343	118	200	146	17	20	18
TOTAL	3166	2188	—	2105	1961	—	207	186	—

Table 35: Meteorological date: DAMI 1983

	Rainfall mm			*Sunshine hrs*			*Temprature °C*		*Rainy days*	*Sunny days*
	1982	1983	Mean 1970-83	1982	1983	Mean 1970-83	max.	min.		
January	758	750	688	37	96	114	30.4	23.1	31	28
February	665	797	80	693	81	113	29.9	23.2	28	19
March	378	808	531	99	71	122	30.3	23.1	26	22
April	356	388	360	117	130	149	30.7	23.0	23	27
May	139	285	240	130	143	175	31.3	22.5	27	30
June	57	287	153	87	93	163	31.5	23.6	21	26
July	51	249	189	146	68	164	29.9	21.8	21	20
August	60	226	164	189	56	177	30.5	23.1	20	9
September	64	164	173	192	160	184	31.6	22.2	18	29
October	31	111	159	183	157	187	31.5	23.0	18	30
November	30	400	249	214	142	183	31.9	23.0	20	26
December	364	304	359	176	86	139	31.0	23.9	24	20
TOTAL	2953	4769	3958	1623	1310	1867	—	—	277	286

APPENDIX II

THE ASSOCIATION'S ACCOUNTS FOR 1983

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 1983 and of its income and expenditure for the period ended on that date.

Price Waterhouse
Chartered Accounts
Lae, March 1984.

Balance Sheet as at 31st December, 1983.

	KINA
Accumulated funds	50,084
Represented by:	
FIXED ASSETS	43,309
CURRENT ASSETS:	
Cash at bank and on hand	19,650
Debtors	29,223
	48,873
CURRENT LIABILITIES:	
Trade Creditors	25,848
Other Creditors and Accruals	16,250
	42,098
Net Current Assets	6,775
	50,084

Statement of Income and Expenditure for the year ended 31st December 1983.

INCOME:

	KINA
FFB Levy	225,813
Profit on Disposal of Fixed Assets	1,894
Bank Interest	2,612
	260,319

EXPENDITURE:

	KINA
Agency, Audit, Legal and Professional fees	24,132
Bank Charges	475
Depreciation	8,521
Direct experiment costs	34,218
Electricity, water and gas	334
Insurance	2,735
Laboratory	1,873
Loss on disposal of fixed assets	799
Medical	158
Motor vehicle	9,903
Office expenses	7,120
Rentals and other accommodation costs	58,484
Repair and maintenance — buildings	14,368
Salaries, Wages and allowances	125,410
Staff recruitment	115
Staff training	259
Travel and entertainment	15,322
DEFICIT FOR THE YEAR	304,226
EXCESS OF INCOME OVER EXPENDITURE FOR THE PERIOD	(43,907)
ACCUMULATED FUNDS BROUGHT FORWARD	93,991
ACCUMULATED FUNDS 31 DECEMBER	50,084

Statement of Accounting Policies

Basis of Accounting: the accounts have been prepared on the basis of historical costs and do not take into account changing money values or current valuations of non-current assets.

Fixed assets and depreciation: Fixed assets are recorded at cost. Depreciation is calculated by the straight line method at rates considered adequate to write off the assets over their estimated economic lives.

Current rates of depreciation are as follows:

Furniture 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	22,630
Less accumulated depreciation	4,847
	17,783
Motor vehicles at cost	35,870
Less accumulated depreciation	10,344
	25,526
Total Fixed Assets	43,309

Management Board's Statement

We, R.A. Gillbanks and J. Langton, 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, 1983 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, 1983 and of the results for the period ended on that date.

Lae,
March 1984.

APPENDIX III

List of experiments and investigations in progress and concluded as at 31 December 1983

No.	*Title*	*Initiated*	*Concluded*
101(a)	Bebere fertilizer factorial experiment	1968	1983
101(b)	Bebere leaf nutrient monitoring plots on part of concluded experiment 101a)	1982	
102	Dami density trial	1970	
103	Kumbango sources of potash trial	1976	1983
104	Bebere thinning trial	1978	
105	Bebere thinning trial	1979	
106	Bebere replanting establishment trial	1982	
107	Bebere replanting fertilizer trial	1982	
201	Hargy fertilizer trial	1981	
301	Higaturu monitoring plots	1977	1982
302	Higaturu monitoring plots	1977	1982
303	Higaturu monitoring plots	1978-79	1983
304	Higaturu sources of potash and nitrogen	1979	1982
305	Higaturu fertilizer factorial expt. on "A" soil	1981	
306	Higaturu fertilizer factorial expt. on "L" soil	1982	
601	Sexava: chemical control	1981	
602	Pollinators: introductions	1980	
603	*Elaeidobius kamerunicus* field studies	1981	
604	Sexava: field studies	1981	
605	Other pests: general studies	1981	
606	Bagworms: general studies	1982	
607	Sexava: biological control	1983	
701	Flower fertility investigation	1979	1981
702	Efects of competition	1981	
801	Incidence of Ganoderma disease	1982	
802	Treatment of oil palm stumps with AMS	1983	
803	*Ganoderma* spp. tests of pathogenicity	1983	

APPENDIX IV

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