ANNUAL REPORT

OF

THE PAPUA NEW GUINEA OIL PALM RESEARCH ASSOCIATION

1981

FIRST ANNUAL REPORT

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This report was presented in interim form for the convenience of the Management and Scientific Advisory Boards in November, 1981. In the present edition Part I has been up-dated to the end of the calendar year and Part II amplified.

The first Annual General Meeting of the Association took place in Lae on 30th April, 1982, and the Chairman's address is now incorporated in the introduction.

MANAGEMENT BOARD

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

Department of Primary Industry ..... J. Christensen,

Hargy Oil Palms Pty. Ltd. ..... H. Kers (until January),

N. van der Laan (from January),

Higaturu Oil Palms Pty. Ltd. ..... R. Beacham (until March),

J. Langton (from March),

Director of Research ..... T. Menendez,

Managing Agent's representative and Secretary ..... M. N. Drain

SCIENTIFIC ADVISORY BOARD

as at 6th November, 1980

R. A. GILLBANKS (Chairman) ..... Chairman, PNGOPRA,
A. CHARLES ..... Department of Primary Industry,
DR. GUHA ..... Hargy Oil Palms Pty. Ltd.,
E. A. ROSENQUIST ..... New Britain Palm Oil Development Ltd.,
C. SHEARING ..... Higaturu Oil Palms Pty. Ltd.,
T. MENENDEZ ..... Director of Research, PNGOPRA,
M. N. DRAIN (Secretary) ..... Secretary, PNGOPRA.

In Attendance

R. E. BEACHAM ..... Commonwealth Development Corporation,
J. CHRISTENSEN ..... Management Board representative,
N. HANSEN ..... Management Board representative,
C. HELLINGMAN ..... New Britain Palm Oil Development Ltd.,
J. KANDIAH ..... Management Board representative,
J. LONGAYROUX ..... Papua New Guinea Palm Oil Producers' Association,
J. A. VUGTS ..... New Britain Palm Oil Development Ltd.,
DR. P. D. TURNER ..... Harrisons Fleming Advisory Services.

SCIENTIFIC ADVISORY BOARD

as at 6th November, 1981

R. A. GILLBANKS (Chairman)	Chairman, PNGOPRA,
A. CHARLES	Department of Primary Industry,
P. GRIFFITH	Higaturu Oil Palms Pty. Ltd.,
B. JAMIESON	Hargy Oil Palms Pty. Ltd.,
E. A. ROSENQUIST	New Britain Palm Oil Development Ltd.,
T. MENENDEZ	Director of Research, PNGOPRA,
M. N. DRAIN (Secretay)	Secretary, PNGOPRA.

In Attendance

J. LANGTON	Management Board representative,
N. HANSEN	Higaturu Oil Palms Pty. Ltd.,
C. HELLINGMAN	New Britain Palm Oil Development Ltd..
F. C. T. GUIKING	Agronomist, PNGOPRA,
R. N. B. PRIOR	Entomologist, PNGOPRA.

EXECUTIVE STAFF

during 1981

DIRECTOR OF RESEARCH	T. Menendez, B. Sc., DPB., Mi. Biol.,
AGRONOMIST	Ir. F.C.T. Guiking
ASSISTANT AGRONOMIST	1. P. Navus, B. Ag. Sci. 2. Vacant
ENTOMOLOGIST	R. Prior, M. Sc.[1]
PHYSIOLOGIST	D. M. Lawton, Ph.D.[2]

JUNIOR STAFF

PRIVATE SECRETARY	P. Natnapal
SENIOR FIELD ASSISTANT	J. Nagi (Hargy)
FIELD ASSISTANTS	R. Bate D. Tomare P. Engio G. Gambrame (until February '81)
RECORDERS	B. Lukara P. Sio C. Golu J. Dapo S. Makai W. Kanama (Higaturu) P. Tarau M. Wangu (until October '81) F. Makiri (until October '81) E. Laiga (until April '81)
DRIVER/HANDYMAN	K. Duke

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1. On attachment from Department of Primary Industry.
2. On duty until November, 1981 as part of the Technical Co-operation programme of the British Overseas Development Administration.

CONTENTS

INTRODUCTION

CHAIRMAN'S STATEMENT

The period from mid 1980 to the end of 1981 has been an exciting one for the Palm Oil Industry in Papua New Guinea. It has seen the first production from the Hargy and Higaturu Oil Palm schemes in West New Britain and Oro Provinces and the commissioning of a second mill for New Britain Palm Oil Development in West New Britain. I have been privileged as Chairman to watch over the formation of the Papua New Guinea Oil Palm Research Association which now, at its first Annual General Meeting, is firmly entrenched as Papua New Guinea's first industry-based research organisation. It has been a joint effort of New Britain Palm Oil Development Ltd., Higaturu Oil Palm Pty. Ltd. and Hargy Oil Palm Pty. Ltd., their principals, Harrisons and Crosfield PLC, Commonwealth Development Corporation, S. A. Sipef N.V., and Warren Holdings Ltd. and their partners, the Government of Papua New Guinea.

Agreements have been reached with New Britain Palm Oil Development Ltd to lease housing and laboratory facilities at Dami as headquarters for the Association and with the other two producers for sub-stations. The services of Mr Tremar Menendez have been secured as Director of Research, Mr Theo Guiking as Agronomist and Mr Peter Navus as Assistant Agronomist. We are very grateful to the Department of Primary Industry for seconding to us Mr R. N. B. Prior as Entomologist. Two meetings of the Scientific Advisory Board have been held, attended by technical staff from the three participating companies and D.P.I.. The last of these was held in November, 1981. Through these meetings, a research programme has been formulated and is now being implemented. We were fortunate in being able to start with a research project which has already yielded dramatic results. I refer to the introduction of a pollinating insect which has already had the effect of increasing yields to close to the theoretical maximum, whilst decreasing the labour element involved. This programme has been of immediate value to all producers. By their very success, these insects have increased the urgency for longer-term nutritional studies which are an important part of the Association's research programme, since they have increased the stress upon the palms and the demand for nutrients from the soils. The Association is also involved in research on pests, diseases, plant densities and cultural techniques with programmes which will be of both short and long-term benefit to producers. The Management Board has held seven meetings during the pre-formation period and we are indebted to our colleagues, past and present, for their farsightedness and real contributions to the formation of the Association. In particular I would like to mention Mr Richard Beachman of Higaturu Oil Palms and his successor Mr Langton, Mr Harold Speldewinde of Hargy and his successor Mr van der Laan, and Mr Christensen and Mr Charles of the Department of Primary Industry. Harrisons and Crosfield (PNG) Ltd. have undertaken to serve as Managing Agents for the Association, having performed the secretarial and accounting functions from the outset, initially for purely nominal fees.

The Association is funded by a cess of fruit produced by all growers and the level of cess during the period from 1 June, 1980 to 31 December, 1981 was K1.00 per tonne. In addition, an advance of K15,000 was received from each of the three operating companies. During the period under review, there was a shortfall of income over expenditure of approximately K56,000; however, it is anticipated that a more favourable situation will arise in the coming year as the Hargy and Higaturu schemes move towards full production. The shortfall was financed through an overdraft and through deferred payments to companies. Efforts to obtain financial assistance in the form of low cost loans from aid sources have not so far been successful and the period when such aid would have been desirable is drawing to a close. The Association should be in a healthy financial situation by the end of 1982.

The Association is indebted to the generous help and support of NBPOD and Dami OPRS during this stage. The period covered by this first report has been one in which a nucleus of research and support staff has been established and of making do with offices and quarters as the NBPOD building programme progressed and PNGOPRA gradually moved into more ample quarters as they become available. It has been a period in which a liaison has been established with the member companies and government, which promises varied and interesting challenges for the research staff to handle during the next few years. Solomon Islands Plantations Ltd. expressed their interest in membership of the Association and it is hoped that the present logistical difficulties thwarting this plan can be solved to permit what would be a welcome expansion of our sphere of activity.

As proposals for research mature, future staffing needs have become more apparent. But what has become equally apparent is the Association's poor financial situation. This was occasioned by low production because a large proportion of the member plantations were at an early stage of development and because of poor fruit set, which diminished the value of the harvest. The industry faces continued low world prices for palm oil that may occasion a jaundiced view of the cess which provides the Association its income.

Faith in research is always necessary and the encouraging attitude of members has been much appreciated during the year. In justification of this we are able to report the imminent beneficial impact to the PNG oil palm industry of a major scientific advance that would not have been achieved without this faith.

The Association has also continued agronomic trials handed over by Dami OPRS and Higaturu Oil Palms Pty. Ltd. at the turn of the year. But the most inspiring work has been the Association's participation in the introduction, testing and release of *Elaeidobius,* the pollinating weevil. Against a history of improperly understood pollination mechanisms (how could we all have been so blind?), these weevils are playing their part in what will surely become a classic example of biological control in the context of a major agricultural industry. At the time of writing, the weevils are widespread over the localities where they have been released and preliminary data shows very good unaided fruit set indeed since their arrival.

PART I. ADMINISTRATION AND DEVELOPMENT

MANAGEMENT BOARD AND SCIENTIFIC ADVISORY BOARD

The Management Board met five times during the year. The Association's registration had not been completed at the year's end.

The first meeting of the Scientific Advisory Board took place on 6th November, 1981, largely to recommend the handover of specific existing experiments to the new Association and the most urgent areas of research so that estimates of expenditure could be prepared. Its second meeting was a year later and included a tour of the sites of experiments. Unfortunately, some intended representatives were not able to attend but were substituted.

FINANCE

Income from the year came from the FFB Levy, the Solomon Islands contribution to the insect pollinater project and the sale of the Awilunga laboratory and furniture. Some working capital had been provided by the advance of K45,000 by members.

Estimates had been prepared in 1980 for three levels of operation during 1981 and the intermediate of these was adopted.

A 5-year estimate of cash flow showed a maximum deficit in 1982 but an overall surplus by 1985. Loan finance to fill the anticipated deficit had not been obtained at the time of writing.

The Association started paying its own junior staff from 1st January. Cash for this and other local operating costs was initially provided by Dami OPRS. A current account was opened at the Kimbe branch of the Papua New Guinea Banking Corporation in February and the Association has thereafter been financially independent of Dami.

Accounting was initially done by the Managing Agents, but in August it was arranged for the Dami staff to prepare monthly statements to the Managing Agents. Messrs Price Waterhouse were appointed auditors to the Association.

STAFF

Mr T. Menendez was appointed Director of Research with effect from 5th November, 1980. Mr P. Navus, Assistant Agronomist, transferred from Dami in December, 1980. He was responsible for managing field operations and his experience of local practices has been valuable during the Association's formative stages. Mr .F. C. T. Guiking, Agronomist specilising in nutrition and soil science, was appointed in February, 1981. Mr R. N. B. Prior, Senior Entomologist of the Department of Primary Industry, was assigned to the introduction of *Elaeidobius kamerunicus* since its inception and continued his brief on oil palm pests. He was attached to and under the supervisioin of PNGOPRA with effect from 11th August, 1981. Although continuing to be employed by the Public Service, he has effectively been working in the Association's interest since November, 1980.

An Assistant Agronomist, designated for Higaturu was not immediately appointed. Instead, part of the Higaturu Research and Development officer's time has been engaged to oversee experiments with the help of his senior supervisor until the Association has its own incumbent.

Dr. D. M. Lawton, Physiologist on assignment to Papua New Guinea from the Overseas Development Administration, was re-assigned from Dami OPRS to PNGOPRA where he completed his project in November, 1981 and returned to the United Kingdom.

Twelve field assistants and technicians were transferred from Dami OPRS in December, 1981. Two new assistants were appointed on trial at that time, one of whom was engaged in January. One assistant and five technicians were employed in support of the ODA project on pollen physiology. One of these left in December, another was dismissed in April and two others retrenched in October, 1981, when their services were no longer required. The assistant and remaining technician were re-assigned to the Entomologist.

It has not been found practicable to upgrade existing staff at Dami to more responsible, supervisory positions and new personnel with technical training were found necessary.

A private secretary was engaged in February and her appointment was confirmed six months later, by which time she had proved an outstandingly useful member of staff.

A driver/handyman was engaged in March, once a general purpose utility vehicle had been bought.

A senior field assistant was engaged in May and posted to Hargy Oil Palms. A junior technician was engaged locally and was on duty at Higaturu Oil Palms, working under their Research and Development Officer.

Technicians were engaged temporarily to supplement DPI staff at the Awilunga laboratory from January to June.

At Dami, a temporary technician was employed for entomological work from June until October, when a field assistant and technician were transferred from the ODA project.

All junior staff received cost of living salary revisions in March and September. Normal increments were granted on 1st July with the exception of those on probation at that time.

The distribution of staff and establishment during 1981 and recommended for 1982, is as follows:-

	Estimated	Filled as at 1/1/81	Filled as at 31/12/81	Recommended for 1982
Senior field assistants:				
Dami	0	0	0	1
Hargy	1	0	1	1
Higaturu	1	0	0	0
Field assistants:				
Dami	3	4	3	3
Hargy	0	0	0	0
Higaturu	1	0	0	3
Technicians:				
Dami	9	9	5	5
Hargy	1	0	0	0
Higaturu	1	0	1	1
Private Secretary	1	0	1	1
Accountant (part-time)	0	0	0	1
Driver/handyman	1	0	1	1
Junior recorder (clerical)	1	1	1	1
TOTAL	20	14	13	18

TRAINING

In May and June, a four-week training course for new field assistants was held. A set of 14 notes for field assistants covering the principal field activities was prepared to aid training and for future reference.

TOURS AND VISITS

The Director of Research and the ODA physiologist visited Malaysia in June to attend the Unilever Plantations Group oil palm breeders' meeting at Fraser's Hill and the international conference, "The Oil Palm in Agriculture in the Eighties", held in Kuala Lumpur.

Opportunity was taken to visit the University of Singapore, the Harrisons and Crosfield Oil Palm Research Station at Banting and the Bakasawit tissue culture laboratory and the effect of *Elaeidobius* on the oil palms at the Lake Gardens was seen. The conference and these visits proved particularly useful in establishing or renewing professional contacts relevant to the future programme of research.

The high cost of air transport has limited the amount of touring within PNG. However, five visits were made to Higaturu. Hargy was visited four times and the entomologist accompanied weevils to the Solomon Islands to help establish the insect-rearing facility there.

The Director of Research also visited Port Moresby once for a Management Board meeting and Lae twice to participate in meetings with the Chairman and DPI entomologists and to see the work at the Association's Awilunga entomological installation.

PUBLICATIONS AND REPORTS

The ODA physiologist presented a paper on pollination and fruit set in oil palm at the Malayasian conference which will be published in the proceedings. This summarised the initial phase of his investigations concerning pollination principally.

Three papers summarising the final stages of his work were written by the physiologist, one in conjunction with the entomologist. Two of these were recommended for publication.

Monthly progress reports from November, 1980 were circulated to the Associatioin members. Reports of tours to Higaturu and Hargy were sent to the respective companies.

LIBRARY

It is intended that PNGOPRA and Dami OPRS share a common library when the new Dami OPRS offices are completed. However a suitable library administration will be needed if this is to work.

Because of shortage of funds, subscriptions to Journals were not taken out during 1981, but one book on oil palm diseases was bought. Otherwise, executive officers' personal books and Dami OPRS books have been available for circulation.

VISITORS

The following visitors were recorded: C. Benjamin, Department of Primary Industry; M. Benjamin. Walindi Plantation, WNB; W. R. Black, Farmset Ltd., Goroka; C. J. Breure, H.F.A.S., London, UK; Wm. Brown, Cornell University, USA; A. Charles, Department of Primary Industry, Konedobu; J. Christensen, Department of Primary Industry, Konedobu; N. T. Dawbin, Farmset Ltd., Goroka; B. Dawson, Bowmans WNB, Kimbe; M. Drain, Harrisons & Crosfield, Lae; T. Flemming, Harrisons Fleming Advisory Services, London, UK; R.A. Gillbanks, Harrisons & Crosfield, Lae; J. H. Hanson, Higaturu Oil Palms, Popondetta; J. van Greve, Department of Primary Industry, Konedobu; P. J. Griffith, Higaturu Oil Palms, Popondetta; R. R. Harper, Roche Maag, Australia; B. L. Jamieson, Hargy Oil Palms, Bialla; H. Kers, S.I.P.E.F. Antwerp, Belgium; N. van der Laan, Hargy Oil Palms, Bialla; J. Leach, Harrisons Fleming Advisory Services, London, UK; J. Lecerq, Hargy Oil Palms, Bialla; J. Liggitt, Harrisons & Crosfield, Lae; C. M. MacQueen, I.C.I. Plant Protection Division, UK; D. S. Meredith, Coffee Industry Board, Goroka; D. O. Oiye, ICI New Guinea Pty. Ltd., Lae; J. Pippit, Department of Primary Industry, Nahavio; R. W. Orr, Analytical Services, Cambridge, New Zealand; E. A. Rosenquist, H.F.A.S., London, UK; M. L. Rosenquist, Great Missenden, UK; H. V. Speldewinde, UNDP, Port Moresby; B. E. Tull, Harrisons & Crosfield, Kimbe; M. Turner, Analytical Services Ltd., New Zealand; J. A. Vugts, New Britain Palm Oil Development, Kimbe; G. Wood, Roche Maag, Australia.

PHYSICAL DEVELOPMENT.

BUILDINGS

	1/11/80	31/12/81
Offices	3	4
Physiology building	1	0
Entomology building	0	1
Tool store	0	1
M Houses	0	1
A Houses	0	2
IB quarters	0	3
Junior grade quarters	2	5
SMQ	1	1

MAINTENANCE OF BUILDINGS AND MACHINERY

BUILDINGS

Essential repairs to the old offices and houses were requested from NBPOD so that the rentals started with the buildings in good condition. Some of this work was outstanding at the end of the year, as was making good some defects in the new constructions.

VEHICLES ETC.

Four vehicles were bought for official use by the Director of Research, Agronomist and the Entomologist and for general purposes. It was decided to buy Toyota vehicles because servicing during the warranty period and spare parts were probably better available locally than for other makes at the time. This make of vehicle has performed well elsewher overseas.

All vehicles were maintained in good condition without experiencing unwarranted problems. The useful and hard-used Traka required some repairs to damage caused by rough plantation roads. It is an inexpensive vehicle and it is planned to replace it after approximately 2 years use.

The fleet and state of vehicles during the period was as follows:

Vehicle	Reg. No.	User	Date Purchased	km at 31/12/81
Hilux 4w-d, twincab	ADA-232	Director	Nov. 1980	13,000
Hilux 4w-d, utility	ADE-160	Entomologist	Nov. 1980	36,484
Hilux 4w-d, utility	ADJ-096	Agronomist	Feb. 1981	8,856
Traka covered utility	ADH-204	Driver/handyman	Mar. 1981	20,000

An advance to purchase a motorcycle needed for work was paid to the senior field assistant at Hargy, who bought a Honda 90. Motorcycle allowances were paid to two junior staff, one of which was stopped because the machine was unserviceable.

Both grass mowers purchased have given maintenance problems, largely because spares were unavailable locally.

OFFICE AND LABORATORY EQUIPMENT

The Nashua photocopier and manual typewriters and HP34C and simple calculators have functioned satisfactorily.

The photocopier was serviced under contract from Rabaul and minor faults repaired. It is an extremely useful tool used to prepare all record sheets and forms.

A drying oven was being made by NBPOD Constructions. The equipment provided for the physiology laboratory by the Overseas Development Administration was donated to PNGOPRA for use in the new entomological laboratory at Dami.

At Hargy, a store has been allocated as temporary office space for the senior field assistant. He is adequately housed.

The field assistant at Higaturu has been satisfactorly housed and he has used office facilities available in the agronomy building. Modifications to the latter to suit Higaturu OPPL and PNGOPRA requirements have been agreed.

The entomological laboratory for handling the initial quarantine and tests on *Elaeidobius* was established in a new house at Awilunga, near Lae, in November, 1980. This site was chosen for its isolation from the main oil palm areas and the presence of a nearby oil palm block. The house and its furniture were sold in June, 1981, when the *Elaeidobius* cultures were transferred to Dami where the new entomology building was completed in late June.

TELEPHONE SERVICE

Posts & Telegraphs were unable to install a telephone line and could not promise to do so in the near future. The OPRS telephones were used, but to everyone's inconvenience especially in the rainiest season.

ELECTRICITY AND WATER SUPPLY

Electricity and water have been generally in good supply, with the exception of inadequate plumbing in the physiology laboratory, the main office and one new house. The house has recently been made good but the office installation requires work.

Although supplied satisfactorily, overloading in the main office suggested that the wiring system required overhaul by NBPOD so that the office could be taken over in good condition.

OTHER SERVICES

Medical services have been provided satisfactorily by NBPOD . Staff requiring treatment at Kimbe hospital or the clinics at Valoka and Mosa have been transported as required.

Five babies were born to junior staff during the year.

PART II. RESEARCH

INTRODUCTION

The programme of work has followed guidelines given by the Scientific Advisory Board in November, 1980. It has been recommended that specific experiments, hitherto carried out by OPRS and HOPPL, should be continued by continued by PNGOPRA and certain new ones started, giving priority to the question of response to manuring.

Of the experiments handed over from NBPOD, two of long standing were to be concluded during the year but it was decided to continue them in modified form because of the change in productivity following the spread of *Elaeidobius kamerunicus* and in order to derive fundamental knowledge on the effects of removing interplant competition. The experiments using different sources of potash and on the effect of thinning palms on Bebere Plantation continued to be recorded and results confirm previous trends.

The replanting experiment proposed for Mosa plantations had to be postponed until 1982. Two experiments recommended to start then were designed.

At Higaturu, the trials handed over included a large number of monitoring plots which had been laid down by the company each year to guide fertilizer practice. The latter had been based empirically on manuring policies developed in other parts of the tropics. The value of these plots was considered limited because the lack of replication and such simple treatments could not show interactions between the fertilizers used. The plots cover a range of soil types and, rather than abandon them, recording was reduced to a sample of palms in each plot, until such time as they are superceded by the more sophisticated experiments now underway.

New factorial fertilizer experiments for Higaturu, where the palms are mainly young, and at Hargy, on older palms, were started during the year.

Optimum planting density is still unknown at Higaturu and Hargy, though the latter may be expected to be similar to Mosa plantation. Considerable information is now available on different densities at Mosa but this relates to planting material substantially different to today's commercial *tenera* from Dami. However, new density experiments in general were postponed until a suitable range of clonal material is available. A site was set aside at Higaturu for such an experiment and was maintained under a cover of *Pueraria.*

The discovery of the importance to the oil palm of insect pollination has mitigated interest in the study of the physiological basis for poor fruit set which formed the basis of a research project carried out under the auspices of the Overseas Development Administration which was concluded in November. However, the findings of this project have been helpful in explaining why certain palms are sterile, which may affect selection criteria for oil palm breeding.

Physiological research was expanded to examine in detail the effect on growth, flowering and yield of removing competition between mature palms grown at close spacing for many years and to compare these phenomena with development of the oil palm in other parts of the world where soils and climate are different.

The introduction of the weevil *Elaeidobius kamerunicus* and its subsequent, exciting history has overshadowed other developments during the year. The work has aimed at releasing the insects as soon as possible so they could begin their work pollinating oil palms in PNG, but interesting and original observations on its behaviour under local conditions have been made and are continuing. Early results of its pollinating ability are encouraging.

The Association's work is carried out in different localities to serve the particular interests of members and is also directed at specific topics. A convenient nomenclature for identifying experimental trials and projects was instituted in December, 1980. This consists of a three figure number the first of which indicates locality or topic, while the remaining two digits give the ordinal number of the subordinate investigation, thus:

100 = New Britain Palm Oil Development Ltd.
200 = Hargy Oil Palms Pty. Ltd.
300 = Higaturu Oil Palms Pty. Ltd.
400 = Settlements — Northern Province
500 = Settlements — West New Britain Province
600 = Entomology
700 = Physiology
800 = Pathology

NEW BRITAIN PALM OIL DEVELOPMENT

EXPERIMENT 101, Bebere Fertilizer Trial

Planted in August, 1968, 143p/ha, thinned by 1/3 in October, 1976, area: 8.8 ha.

Design: ¼ replicate of a 4×4×2×2×2×2 (N, K, Mg, Mn, S, P) factorial in two blocks with a total of 64 plots of 16 palms each (thinned to 10 or 11 per plot). Each plot is separated by a perimeter trench.

Treatments: Started soon after the palms were planted in 1968.

	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		

Treatments were not applied during the year but yields and growth measurements were recorded until August, 1981 when it was planned to end the experiment. Recording will resume when production increases due to the activity of *Elaeidobius kamerunicus*. Leaf samples were taken in August.

Results: The conclusions from this experiment were summarised by Rosenquist (1980) and a paper has been published on the experiment (Breure & Rosenquist, 1977). Very few effects on yield were detected and the experiment gave the basis for reducing the commercial use of fertilizer on the plantation.

Recordings for the last full year (September 1980 — August 1981) were summarized (Table 1). The design of the experiment makes statistical analysis a delicate question; following a normal analysis of variance, significant yield differences are found for N and K (Table 1) and the interaction of K ×Mg (Table 2). (Interactions of more than two factors were not considered here). Although the figures found show differences, no obvious trend can be detected for K×Mg. For N the high yield for N-O (averaged over 16 plots) makes the other results less spectacular. The only effect that might be of value is the better result at higher K rates, with the maximum at K-2 (= 3kg muriate per palm).

Table 1: Experiment 101, Yield Per Hectare
September 1980 — August 1981.

TREATMENT	Number of bunches	Weight of bunches tons	sbw kg
N 0	977	19.6	20.1
N 1	914	18.1	19.8
N 2	926	18.2	19.6
N 3	991	19.9	20.1
K 0	941	18.3	19.5
K 1	929	18.0	19.4
K 2	1000	20.1	20.1
K 3	938	19.4	20.7
Mg0	953	18.9	19.9
Mg1	951	19.0	20.0
Mn0	952	18.8	19.7
Mn1	952	19.1	20.1
S 0	957	18.9	19.8
S 1	947	19.0	20.1
P 0	972	19.2	19.8
P 1	932	18.7	20.1
AVERAGE	952	19.0	19.9
NIL	1118	23.0	20.1

Table 2: Experiment 101, Yield (tons/ha) September 1980 — August 1981

(K/Mg interaction)

	K 0	K 1	K 2	K 3
Mg0	19.6	17.0	19.4	19.7
Mg1	17.0	19.1	20.7	19.1

Leaf nutrient levels — averaged over groups — hardly seemed affected by fertilizer treatments. This is demonstrated only for the different K treatments and only for those elements that are likely to show an effect (Table 3).

Table 3: Experiment 101, leaf nutrient levels at different rates of K fertilizer (August 1981)

	% K	% Cl	% Ca	% Mg	ppm Mn
K 0	.87	.47	.80	.18	65
K 1	.83	.53	.83	.18	68
K 2	.84	.54	.87	.18	68
K 3	.85	.56	.83	.18	67

EXPERIMENT 102, Dami Density Trial

Planted in October/November, 1970; number of palms 1756 (total); 736 palms (recorded); area: 15 ha.

Design: 4 replicates of 4 spacing treatments in randomised blocks with from 49 to 169 palms per plot, split for levels of fertilizer. The central palms of each sub-plot have been recorded leaving a single guard row of unrecorded palms in each. Additional palms were planted to fill gaps between the irregular plots.

Treatments:

Density:

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

Fertilizer:

Proportion estate practice %	Density 56	111	148	185
	recorded palms/sub plot			
0	—	8	12	20
50	—	8	12	20
100	10	8	12	20
150	10	8	12	20

The experiment was recorded up to October, 1981, but it was decided to recommence recording next year, as for Experiment 101. Bunch analysis of palms in the 56, 111 and 148 p/ha treatments, valuable for the selection of ortets, continued to be done by Dami OPRS.

The densest plots were thinned to 93 p/ha in October and are being recorded as a separate experiment to study the physiological effects of removing competition.

The list of palms to be excluded from summaries because of abnormalities not associated with the treatments or proximity to vacant spaces was revised and yield data presented here takes the new list into account.

Results: This experiment was summarised by Rosenquist (1980) and in papers published by Breure (1977 and 1981). Yields for the year from April, 1980 are given in Table 4.

Yield at 110 p/ha exceeded all other densities during the year with a calculated yield of 24.5 tons FFB/ha, continuing the trend established in previous years. Palms at this density yielded 60% more bunches that at 148 p/ha which were 13% heavier. It is remarkable that, even at as low a density as 56 p/ha, yields were as good as at 148 p/ha, because of better single bunch weight.

Fertilizers continued to have no significant effect.

Table 4: Experiment 102, Yield Per Hectare 1980 — 1981

TREATMENT	PERIOD 5/80 — 4/81		
palm/ha	*Number of bunches*	*Weight of bunches tons*	*sbw kg*
56	904	18.2	20.2
110	1,390	24.5	17.6
148	1,164	18.1	15.5
186	744	10.1	13.6
Fertilizer %			
0	1,192	18.5	15.5
50	1,120	17.7	15.8
100	1,004	17.0	16.9
150	1,073	17.0	15.8

EXPERIMENT 103, Sources of Potash, Kumbango Plantation

Planted in September, 1972; 120 palms/ha; number of palms 2,700 (total); 1152 (recorded); area: 22.5 ha.

Design: Three replicates of 5×2×2 factorial plus 4 control treatments per replicate, in plots of 36 palms of which the central 16 are recorded.

Treatments: The following treatments were first applied in December, 1976.

FERTILIZER — KILOGRAM PER PALM PER YEAR

	high K/Mg		*low K/Mg*	
	low K	*high K*	*low K*	*high K*
Muriate of Potash	2.0	4.0	2.0	4.0
Kieserite	1.0	2.0	2.0	4.0
Muriate of Potash	1.25	2.5	1.25	2.5
Bunch ash	1.25	2.5	1.25	2.5
Kieserite	1.0	2.0	2.0	4.0
Sulphur	0.625	1.25	0.625	1.25
Sulphate of Potash	2.5	5.0	2.5	5.0
Kieserite	1.0	2.0	2.0	4.0
Bunch ash	3.0	6.0	3.0	6.0
Kieserite	0.5	1.0	1.0	2.0
Bunch ash	3.0	6.0	3.0	6.0
Kieserite	1.0	2.0	2.0	4.0
Sulphur	1.5	3.0	1.5	3.0
NIL	0	0	0	0

Different sources of K are given at low and high rate (equivalent to 2, respectively 4 kg muriate); both rates combined with relatively low and high levels of kieserite to give a high, respectively low K/Mg ratio.

Except frond production, no vegetative measurements were done during this year. No leaf samples were taken.

Results: Average yields ranged from 20.1 tons/ha for the sulphate of potash treatment to 22.0 tons/ha for muriate plus bunch ash plus sulphur, with the control at 21.1 tons/ha. Interaction with K rate and K/Mg ratio did occur. Therefore, results have been split out for these factors (Table 5). None of those combinations differs significantly (P = 0.05) from the control, except sulphate of potash at high K and low K/Mg. Highest yields were obtained with muriate of potash and muriate plus bunch ash plus sulphur, but only at high rates (4 kg muriate/palm); the best K/Mg ratio differs for both treatments. No beneficial effect was obtained with bunch ash plus sulphur. The trend is that bunch ash (at a moderate rate of 3 kg bunch ash/palm) raises FFB only if combined with sulphur (this might indicate a pH effect).

Table 5: Experiment 103, Yield Per Hectare, 1981

*TREATMENT**	*high K/Mg*						*low K/Mg*					
	low K			*high K*			*low K*			*high K*		
	No. of bunches	*Weight of bunches tons*	*sbw kg*	*No of bunches*	*Weight of bunches tons*	*sbw kg*	*No. of bunches*	*Weight of bunches tons*	*sbw kg*	*No. of bunches*	*Weight of bunches tons*	*sbw kg*
MoP	1120	19.2	17.2	1278	22.2	17.4	1278	21.4	16.7	1341	23.6	17.6
MoP+BA+S	1225	20.2	16.5	1345	23.5	17.5	1240	21.6	17.4	1313	22.7	17.3
SoP	1306	20.4	15.7	1206	20.3	16.9	1348	21.7	16.1	1177	17.9	15.2
BA	1270	20.9	16.4	1273	21.1	16.6	1268	21.4	16.9	1178	19.2	16.3
BA+S	1345	21.9	16.3	1209	19.6	16.2	1275	22.4	17.6	1245	21.3	17.1
CONTROL	1268	21.1	16.6									

*MoP = Muriate of Potash, BA = Bunch ash, S = Sulphur, SoP = Sulphate of Potash

lsd (5%) = 3.0 tons/ha
lsd (10%) = 2.5. tons/ha

EXPERIMENT 104, Bebere Thinning Trial

Planted in 1970; 143 p/ha; 567 palms (total); 345 palms (recorded); Area: 4.2 ha.

Design: Randomised blocks with 3 replicates of 3 treatments with 51 or 54 palms/plot, of which the perimeter palms formed un-recorded guard rows around each plot.

Treatments: The following treatments were applied in April, 1978.

1. No thinning ..... (143 p/ha)
2. Remove every third palm in each row to give hexagonal spacing. ..... (95 p/ha)
3. Remove every third row. ..... (95 p/ha)

Abnormal palms or those adjacent to accidental vacancies were re-surveyed during the year and the data presented here exclude these.

Results: The year's results (Table 6 and 7) support the trend previously reported by Rosenquist (1980). Single bunch weight was 30% greater in the thinned plots but this was not a statistically significant difference. Highly significant, more bunches were produced by palms in the thinned plots which was largely responsible for their considerably higher yield, with hexagonal thinning superior, as expected.

There were no significant differences in rachis cross-section, height or leaf production (Table 10).

Yield per hectare was very much better in the thinned plots and the hexagonal system produced half as much again as the unthinned, but with a probability of only 0.10-0.50 in the F. test (Table 6). Again the trend was as expected and concorded with differences in bunch number. This difference was perhaps exaggerated by the unexplained, consistently poor performance of one of the unthinned plots even after re-computing all the data to take into account palms that were abnormally postioned in the field and had been recorded previously.

Cumulative yield since the experiment started showed the thinned palms to have produced significantly more, with hexagonal thinning the better method. Although not statistically significant, on a per hectare basis, 18% more fruit was harvested.

The fact that yields have not been reduced, rather increased, by thinning demonstrates the marked effect of reducing competition in a plantation that is now known to have been planted too densely for local conditions. It will be interesting to examine the effect of insect pollination. The economic advantage of thinning has yet to be studied.

Table 6: Experiment 104, yield per hectare 1978-1981

TREATMENT	PERIOD			
	1/81 — 12/81		4/78 — 12/81	
	No. of bunches	*Wt. of bunches tons*	*No. of bunches*	*Wt. of bunches tons*
Not thinned	889	10.5	3,726	56.9
1/3 thinned, hexagonal	1,118	17.4	3,921	67.0
Third row thinned	984	15.3	4,484	63.0

Table 7: Experiment 104, Yield per palm 1978—1981

TREATMENT	PERIOD					
	1/81—12/81			4/78—12/81		
	No. of bunches	*Wt. of bunches kg*	*sbw kg*	*No. of bunches*	*Wt. of bunches kg*	*sbw kg*
Not thinned	6.3	73	11.9	26.1	398	15.0
1/3 thinned, hexagonal	11.7	182	15.6	41.1	703	17.1
Third row thinned	10.3	160	15.5	40.1	661	16.4

EXPERIMENT 105, Thinning Trial, Bebere Plantation

Planted in 1970; 143 p/ha; 816 palms (total); 496 (recorded); area: 6.8 ha.

Design: Randomised blocks with 3 replicates of 3 treatments and plots of 54, 69 and 81 palms of which the perimeter palms form unrecorded guard rows around each plot.

Treatments: The following treatments were applied in April, 1980.

1. Unthinned (143 p/ha)
2. Every third palm in each row thinned to give hexagonal spacing. (95 p/ha)
3. Every seventh palm in each row thinned to place each palm next to 1 vacancy. (122 p/ha)

Abnormal palms or those adjacent to accidental vacancies were re-surveyed during the year and the data presented here exclude these. Recording started in April, 1980.

Result: This is a younger trial than Expt. 104 but the results already show the same trends (Table 8 and 9).

Since the experiment started, 15% more bunches were harvested from palms in the thinned plots, but this difference was not significant. However, during 1981 highly significant differences showed thinning by a third superior to a seventh ($P = 0.05$) and unthinned ($P = 0.01$). Thinning by a seventh was better than no thinning at all ($P = 0.05$). Yield of FFB per palm showed similar differences: all treatments were significantly different from each other.

Yield per hectare did not differ significantly (Table 8), the increased yield from the thinned plots already having compensated for the loss of palms.

Differences in single bunch weight, leaf area and rachis cross-section were not significant. Frond production in 1981 was significantly better in the thinned palms, again with $1/3 > 1/7 > 0$, which contributed to the variation in bunch number reported. Increased leaf production is an expected consequence of reducing competition but was not evidenced in Experiment 104. The observation is therefore to be repeated in both trials in 1982.

In practice, Bebere Plantation had been thinned by a seventh but it has now been shown that one third would have been safe and better. The economics of the operation have yet to be established however.

Table 8: Experiment 105, Yield per hectare 1980 — 1981

TREATMENT	PERIOD			
	1/81 — 12/81		5/80 — 12/81	
	No. of bunches	*Wt. of bunches tons*	*No. of bunches*	*Wt. of bunches tons*
Not thinned	1083	15.3	1540	22.1
1/3 thinned hexagonal	1007	15.5	1340	20.6
1/7 palm thinned	1013	15.1	1428	21.2

Table 9: Experiment 105, Yield per palm, 1980 — 1981

TREATMENT	PERIOD					
	1/81 — 12/81			5/80 — 1981		
	No. of bunches	*Wt. of bunches kg*	*sbw kg*	*No. of bunches*	*Wt. of bunches kg*	*sbw kg*
Not thinned	7.6	107	14.1	10.8	154	14.3
1/3 thinned hexagonal	10.6	162	15.4	14.1	216	15.4
1/7 palm thinned	8.3	124	14.9	11.6	173	14.9

Table 10: Experiments 104 & 105 growth characteristics, July 1981.

TREATMENT	*Height* cm	*Rachis W x T* cm^2	*Leaf area* m^2	*Annual Frond Production*
Experiment 104				
Not thinned	709	35.8	12.1	22.6
1/3 thinned, hexagonal	694	35.8	12.4	23.0
1/7 palms thinned	687	33.9	12.6	23.7
Experiment 105				
Not thinned	—	34.1	11.7	22.9
1/3 thinned, hexagonal	—	35.3	12.1	24.2
1/7 palms thinned	—	35.1	11.7	23.4

HARGY OIL PALMS PTY. LTD.

A suitable site for a fertilizer experiment was selected and surveyed during July and the following experiment laid down.

EXPERIMENT 201, Fertilizer trial on mature palms a Hargy

Planted in 1973; IRHO DxP; density 115 p/ha; number of palms 2,916 (total); 1,296 (recorded); area: 28 ha.

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

Treatments: The following treatments are applied twice yearly in April and October.

	Level, kg/palm yr.		
	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

First treatment application was postponed until 1982.

Pre-treatment leaf samples were taken in September. The results show that the area is fairly uniform. No severe deficiencies occur, although Mg is low and Cl very low.

The following experiments were handed over from the Company and routine recording of yield and vegetative growth continued during the year. The types of soil mentioned below are:

A yellow-brown, andesitic loam
B brown-yellow, volcanic sandsoil
M yellow-grey, ash loam

EXPERIMENT 301, Monitoring Plots 1—3

These are unreplicated plots of 0.5, 1.0, and 2.0 times normal estate fertilizer practice, planted in April, 1977 on "A" type soil. First differential fertilizer application was in November, 1977. Harvesting started in May, 1980. Till November, 1981 the number of recorded palms was 77 (treatment 0.5) or 76 (treatments 1.0 and 2.0). Since then only 40 palms per plot have been recorded.

Results: The cumulative yield for the first 8 months (May — December, 1980) did not differ much between treatments (Table 11); for treatment 0.5 it was about 13.5 tons/ha, for treatments 1.0 and 2.0 it was 14 tons/ha (see Agronomy Annual Report 1981, Higaturu Oil Palms).

For 1981 there was hardly any difference in yield between treatments 0.5 and 2.0 (Table 11); neither in total number of bunches per hectare nor average bunch weight. The yield for treatment 1.0 was slightly lower due to a lower number of bunches.

The conclusion from these data is that higher rates of fertilizer did not improve yield.

Table 11: Experiment 301, Yield per hectare 1980 and 1981

TREATMENT	PERIOD			
	5/80 — 12/80	1/81 — 12/81		
	Weight of bunches tons	*Number of bunches*	*Weight of bunches tons*	*sbw kg*
0.5 × estate practice	13.5	2117	23.6	11.1
1.0 × estate practice	14.0	1985	21.4	10.8
2.0 × estate practice	14.0	2132	23.1	10.8

EXPERIMENT 302, Monitoring plots 4 — 5

These comprise two unreplicated plots 0 and 1.0 times normal estate fertilizer practice, each plot divided into ridge, side and gulley. Planted in April, 1977, on "A" type soil. First fertilizer application in November, 1977. Harvesting started in May, 1980, but reliable data are available only from November, 1981. The number of recorded palms was reduced to 40 (ridge), respectively 20 (side, gulley) effective November, 1981.

EXPERIMENT 303, Monitoring plots 6 — 10, 16 — 20, 21 — 25, 26 — 30.

Taken as a group, these provide four replicates of five treatments (0; 0.5; 1.0; 1.5; and 2.0 times normal estate fertilizer practice) but the replicates are confounded with planting data and soil type, thus:—

	Soil type	Planted
M6 — 10	"A"	Feb. 1978
M 16 — 20	"A"	Feb. 1979
M 21 — 25	"B"	Nov. 1979
M 26 — 30	"M"	Dec. 1979

Note: M 11 — 15, planted in January, 1979 on "A" type soil, were abandoned before PNGOPRA took over these experiments. M 11 — 15 were felt to be a duplicate of M 16 — 20.

Monitoring plots 6 — 10

Planted in March, 1978. First fertilizer application in November, 1978. Harvested since September 1980. Up to November, 1981 the plot size varied between treatments (64 — 103 recorded palms per plot); since then the number of recorded palms per plot has been reduced to 40.

Results: The trend is that higher fertilizer rates increase yield (Table 12), mainly because single bunch weight was higher. For the highest rate (treatment 2.0) the number of bunches was considerably higher. Treatment 1.5 had a comparatively low yield; single bunch weight and number of bunches were low.

Table 12: Experiment 303, Monitoring plots 6 — 10, Yield per hectare 1980 and 1981.

TREATMENT	PERIOD					
	9/80—12/80			1/81—12/81		
	No. of bunches	*Wt. of bunches tons*	*sbw kg*	*No. of bunches*	*Wt. of bunches tons*	*sbw kg*
0	639	3.4	5.3	1847	13.6	7.4
0.5	668	3.4	5.0	1847	15.9	7.6
1.0	860	4.3	5.0	2100	16.1	7.7
1.5	598	3.1	5.2	1998	14.8	7.4
2.0	823	4.5	5.5	2657	20.5	7.7

Monitoring plots 16 — 20

Planted in February, 1979. First fertilizer application in September, 1979. Harvested since the end of August, 1981, so only 4 months harvest data are presented here. In November, 1981 the number of recorded palms per plot was reduced to 40.

Results: Differences in yield are mainly due to differences in number of bunches per hectare, which seems to be influenced by the rate of fertilizer (Table 13).

Table 13: Experiment 303, Monitoring plots 16 — 20, Yield per hectare September — December, 1981.

TREATMENT	PERIOD		
	No. of bunches	*Weight of bunches tons*	*sbw kg*
0 x estate practice	316	1.9	5.9
0.5 x estate practice	444	2.7	6.1
1.0 x estate practice	450	3.1	7.0
1.5 x estate practice	734	4.9	6.7
2.0 x estate practice	694	4.5	6.5

Experiment 303, monitoring plots 21—25 and 26—30, planted end 1979, were not yet harvested.

Other investigations in Expts. 301 —303

Vegetative measurements were done about every six months in all monitoring plots. Most of the results were published in the Agronomy Annual Reports 1980 and 1981 of Higaturu Oil Palms. During 1981 vegetative measurements were discontinued, because the laborious task of collecting and processing those data was considered to be a luxury for these so-called "practical" experiments.

Leaf samples were taken twice a year in all monitoring plots. Analysis results for N, P, and K were reported in the Agronomy Annual Reports 1980 and 1981 of Higaturu Oil Palms. The correlation between treatments and leaf nutrient status is — taken for all monitoring plots (Experiments 301, 302, 303) — not consistent. No further comments on leaf analysis results will be given at this stage.

Experiment 304, Sources of Potash and Nitrogen

Planted in January, 1979 on "A" type soil at 130 palms per hectare, number of palms 864 (total), 384 (recorded), area 7 ha.

Design: Three replicates of randomised blocks of 8 treatments each, with approximately 36 palms/plots of which the central 16 are recorded.

Treatments: Three sources of potash are compared: muriate of potash (MoP), sulphate of potash (SoP) and bunch ash (BA) — the latter with and without sulphur (S). Each of those four with urea or sulphate of ammonia (SA), to give a total of 8 treatments.

The quantities of fertilizer applied are equivelent to the normal practice of the estate and triple super phosphate has also been applied throughout.

Treatments were first applied in July, 1979, when the palms were six months old. Yield recording started in May, 1981 and vegetative measurements were done from July, 1981 (twice yearly). In future the only vegetative measurement will be rachis cross-section. Leaf samples were taken in July, 1981.

*Results:*The first months the trial suffered from very variable pollination (Agronomy Annual Report 1981, Higaturu Oil Palms). The number of bunches harvested in the first eight months varied from more than 1100 per hectare in replicate I to about 740 per hectare in replicates II and III.

The treatments BA and MoP yielded higher than BA+S and SoP (Table 14). For BA this is due to a higher number of bunches only, for MoP this is partly caused by a higher number of bunches and partly by a higher single bunch weight. Note that the difference between BA and MoP vs. BA+S and SoP is the difference between low (or no) Sulphur vs. high Sulphur.

The overall yield for urea treated plots is not significantly higher than for plots fertilized with sulphate of ammonia.

Table 14: Experiment. 304, Yield per hectare, May — December, 1981 (8 months)

TREATMENT	*No. of bunches*	*Wt. of bunches tons*	*sbw kg*
BA + SA	926	6.1	6.5
MoP + SA	878	6.2	7.1
SoP + SA	780	4.9	6.4
BA + S + SA	775	5.0	6.5
BA + urea	1064	6.8	6.4
MoP + urea	872	5.8	6.7
SoP + urea	815	5.2	6.5
BA+S + urea	813	5.2	6.4
SA (average)	840	5.5	6.6
urea (average)	891	5.7	6.5
low Sulphur (average)	935	6.2	6.7
high Sulphur (average)	796	5.1	6.4

Table 15: Experiment 304, Rachis cross-section (W x T) at 24, 30, and 36 months

TREATMENT	RACHIS CROSS-SECTION, W x T (cm^2)		
	1/81	*7/81*	*12/81*
BA + SA	8.33	12.27	14.77
MoP + SA	8.22	12.60	15.07
SoP + SA	7.99	11.04	14.28
BA+S + SA	8.18	12.44	14.63
BA + urea	8.09	11.51	14.01
MoP + urea	8.40	12.21	15.27
SoP + urea	7.83	11.18	14.59
BA+S + urea	7.91	11.76	13.82
SA (average)	8.18	12.09	14.69
urea (average)	8.06	11.66	14.42
low S (average)	8.26	12.15	14.78
high S (average)	7.98	11.60	14.33

No significant difference in rachis cross-section occurred. However, rachis cross-section has been consistently high for treatment muriate of potash and low for sulphate of potash (Table 15). Accordingly. "low sulphur" was higher in W x T than "high sulphur". Further, urea gave higher values than sulphate of ammonia.

Except for Cl, leaf analysis results did not differ much between treatments; for treatment muriate of potash, Cl levels were about 0.49% where the other treatments showed an average of 0.25% Cl. The leaf K levels were slightly lower (1.0 instead of 1. 1% K) for muriate of potash and Mn levels higher (99 vs. 78 ppm Mn). No differences in N level due to N sources were found. The level of sulphur fertilizer had no influence on leaf S.

One new experiment was started as follows:—

EXPERIMENT 305, Fertilizer Trial on Higaturu 'A' type soil

Planted in 1978, 130 p/ha, 2,587 palms (total), 1,152 palms (recorded), area: 25.4 ha.

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

Treatments: First application of treatments was made in September, 1981.

	Level, kg/palm/yr		
	0	1	2
Sulphate of ammonia	0	1.0	2.0
Triple super phosphate	0	0.5	—
Muriate of potash	0	2.0	4.0
Kieserite	0	1.0	—

Half the amount of each treatment is applied twice a year in March and September.

Yield and growth recording started in April and pre-treatment soil samples were taken in March and leaf samples in August.

INVESTIGATION, 701, Flower Fertility

This project encompassed three phases during the year. The first was a study of the effect of climate on availability of pollen and bunch survival. Secondly, the germination of pollen and the relationship between presence of pollen tubes and success of fertilization as measured by the fertile fruits sets was examined. The third involved the study of the histological basis for sterility.

Results related to bunch survival, pollen availability and survival and female inflorescence morphology were presented at the 1981 conference "Oil Palm in Agriculture in the Eighties" and two other papers were prepared for publication entitled "Anatomical observations on the embryo sac, its fertilization and evidence of sterility in oil palms and "Raphides do not deter the weevil (*Elaeidobius kamerunicus*) from feeding on the pollen of the oil palm".

Bunch Survival

The availability of pollen markedly affected bunch survival. Climatic effects, especially of rain on pollen distribution, indirectly influenced survival. A formula was derived from data of 312 *tenera* palms at Dami during two periods of two years each, expressing the following relationship.

$$S_1 = \frac{K_1 \quad M}{\log_{10} \quad R_1} \text{ and } S_2 = \frac{K_2 \quad M}{R_2}$$

Where S is survival ratio
K_1 and K_2 are constants

M = male inflorescences/ha/month
R_1 = depth of rain per month

R_2 = days of rain per month

The formula which emphasises days of rain is preferred as giving less variable results.

Seed set was related to scarcity of wind-borne pollen during wet weather but this situation will doubtless be modified by the occurrence of an insect pollinator such as *Elaeidobius kamerunicus.*

Pollen Yield

Pollen yield from ten inflorescences from different mature palms are given in Table 17. A good correlation is found ($r = 0.75$, $P = 0.001$) between the weight of dry pollen and weight of the dried, empty inflorescences. Pollen yield is conveniently expressed in g/m spikelet length.

Table 16: Experiment 701, Numbers of pollen tubes developing per flower at three temperatures.

TIME FROM POLLINATION HR	*POLLINATED*															*UNPOLLINATED*				
	27° C					*31° C*					*38° C*					*31° C*				
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	0	1	0	0	0	0	0	2	0	0	2	2	1	2	1	0	0	0	0	0
4	0	0	1	0	0	0	3	0	9	1	0	0	1	0	0	0	0	0	0	0
5	0	0	1	0	0	1	1	4	1	8	1	0	3	1	2	0	0	0	0	0
6	3	1	1	3	1	4	1	8	5	2	5	4	7	3	5	0	0	0	0	0
7	1	4	0	4	2	7	3	14	2	7	15	8	1	0	5	0	0	0	0	0
8	0	5	0	0	3	5	7	0	1	5	5	5	3	5	7	0	0	0	0	0
9	9	0	7	1	1	8	4	4	10	5	13	5	4	10	7	0	0	0	0	0
10	10	4	7	2	6	10	6	66	1	9	10	7	11	7	13	0	0	0	0	0

Table 17: Experiment 701, Pollen yield of 10 inflorescences from mature oil palms.

Palm No.	*Pollen Yield*		*Total Length of Flower Bearing Parts of Spikelets m*	*Pollen Yield Per Unit Length of Spikelets g/m*		*No. of spikelets*	*Fresh Weight of Extracted Inflorescence g/m*
	fresh	*dry*		*fresh*	*dry*		
C_2 819	139	115	21.0	6.6	5.5	243	4,210
C_1 602	108	99	26.2	4.1	3.8	221	5,496
C_2 207	224	169	32.1	7.0	5.3	243	4,195
C_2 401	106	81	24.5	4.3	3.3	197	2,800
C_1 207	191	130	47.9	4.0	2.7	262	5,165
C_1 601	161	119	30.8	5.2	3.9	213	3,411
C_1 315	149	82	24.4	6.1	3.3	223	4,220
C_1 707	192	128	31.8	6.2	4.1	189	3,645
C_2 207	245	—	—	—	—	—	4,347
48	281	—	—	—	—	—	4,375

The rate of decline of viability of oil palm pollen exposed to atmospheric humidity was similar in the dry and wet seasons at Dami and was related linearly to humidity. Viability fell from 89% to 16% in 20 days in the dry season (RH67%) and from 92% to only 54% in 11 days in the wet season, despite a light fungal infestation of the inflorescence. However, it is concluded that the viability of pollen in the air is reduced in the wet season. This is supported by germination tests of trapped pollen.

Effect of quantity of pollen

Many attempts were made to improve seed set by using more pollen during artificial pollination. It was repeatedly found that a palm with constistently good fruit set will set even if very dilute pollen/ talc mixtures are used but that a palm with a poor reputation will not, even if large quantities of a pollen rich mixture are used. As a demonstration of this, each of two twin inflorescences produced in the axil of one leaf of a particularly sterile palm were bagged separately. One was pollinated with pure pollen and gave 17% fruit set, the other yielded 20% fruit set when a pollen/ talc mixture containing only 0.05% pollen was used. Clearly, pollen was not the limiting factor. The most sterile palm handled has not yielded more than 5% seed set after artificial pollination.

Dysfunctional anthesis

This term refers to abnormal development of stigmas, reduced splaying of the spikelets and exposure of receptive stigmas and an extended period during which successive flowers are at anthesis. Dysfunctional anthesis is a factor affecting fruit set but must be assumed a minor one. For example, a particularly sterile palm in the population of *tenera* examined did not manifest any of these irregularities.

Pollen tube growth

Vitro studies using stigmas kept fresh in the laboratory confirmed the stimulation of pollen tube growth with increasing temperature. The results are given in Table 16.

The number of intrastylar pollen tubes was slightly increased by mixing the pollen with borax-enriched talc, 100 ppm being optimal.

The literature reports a week's delay between pollination and fertilization and this phenomenum appears to be confirmed at Dami.

Anatomical studies

Fertile *tenera* examined microscopically have shown normal embryo-sacs. A low yielding *tenera* was often found to be incompletely developed, lacking the normal egg apparatus of the embryo-sac. In a sterile *pisifera* very little differentiation was apparent in the ovule and there was no trace of an embryo-sac. Thus, the sterility of these palms is inherent and no amount of inducement will enable fertile fruit to be set in such flowers.

ENTOMOLOGY

INSECT POLLINATION

INVESTIGATION 602, Introduction and establishment in the laboratory

PNGOPRA has stimulated and supported the bold scheme to introduce pollinating insects to Papua New Guinea. As a result of research carried out in Cameroun, one thousand pupae of *Elaeidobius kamerunicus,* a species of weevil implicated in the pollination of oil palm, arrived at a laboratory specially established at Awilunga, via Malaysia, on 10th November, 1980. Because of possible contamination with exotic nematodes from both Africa and Malaysia, particular attention was given to this during the quarantine period. Subsequently no nematodes were observed in culture or in the field.

No serious problems occurred during the laboratory rearing phase of the insect's establishment in PNG. The life cycle followed closely the pattern for West Africa and Malaysia.

Three indigenous plants of economic importance in PNG were tested against the weevil while under quarantine. These were betel nut (*Areca catechu*), sago palm (*Metroxylon sagu*) and Dutchman's pipe (*Aristolochia tagala*). Very slight feeding damage was observed in some cases but no evidence of breeding or harm to the normal functioning of these plants.

The laboratory rearing and plant testing under quarantine conditions ended on 2nd April, 1981 when the cultures were transferred to the laboratory at Dami, where they were maintained until it was no longer convenient to keep them pure because all male spikelets brought in for food were contaminated by wild weevils, following their general release.

Field Release

Bubia, near Lae, Morobe Province: The first area chosen was a 4 ha isolated block of oil palm on the DPI Agricultural Station at Bubia. Approxmately 4,000 insects were released as adults on 15—16th April into this block over a period of 12 days. Saturation of all available male flowers occurred 47 days after release, which corresponded to approximately four generations of the weevils.

The weevil was observed behaving normally except on one female flower where large numbers had congregated. No obvious feeding damage was observed.

New Britain Palm Oil Development: The first field release in West New Britain was on 6th June and the rate of spread and establishment followed the pattern at Bubia. Over 100 ha became saturated in 80 days.

Distribution of infested inflorescences from the core of the primary release site began 69 days from release date. Both nucleus estate and smallholders were covered by the 5th September at approximately one inflorescence (24,000 insects) per 20 ha. It was estimated that assisted pollination could be stopped by the end of October, but by the second week in October it was becoming very difficult to collect pollen on the nucleus estate because of the weevils activity. Natural pollination became effective over the whole scheme from the end of October.

Hargy Oil Palms Pty. Ltd: Field release at Bialla began on 22nd July and several consignments of both laboratory-reared insects and whole inflorescences from Bebere were sent to Bialla. Distribution to smallholdings was completed on the 31st September, at a density of one infested inflorecence for every 12 hectare. Examination of these blocks indicated that effective insect pollination should be achieved by the end of November.

Due to the difficult terrain on the Hargy nucleus estate, the management decided to distribute the inflorescences in a different manner. Several inflorescences were placed in one block of 40-100 hectares and saturation was achieved rapidly in three to four weeks. Assisted pollination in these areas could be stopped at the end of October and further distribution of inflorescences was carried out in the remaining areas. The area was completely savoured by the end of November.

Higaturu Oil Palms Pty. Ltd: The first release was carried out on 24th June. However, several factors made establishment difficult. The most serious problem was a shortage of male flowers in the release site, which had been planted in 1977. This age of planting has been the most difficult in which to obtain satisfactory insect establishment because a very high proportion of female flowers is produced.

As a direct result of the frequency of male inflorescences, once the insects were established it was dificult to find sufficient inflorescences to distribute. The insects were established, but the insufficiency of inflorescences made it necessary to airlift 270 infested inflorescences from West New Britain. This was not done until 3rd November, pending the result of observations on the effect of damage caused by the weevils to the stigmas in West New Britain.

Effect on Pollination:

On 27th September, large numbers of weevils were found congregating on female inflorescences in West New Britain and causing feeding damage to stigmas. There is no satisfactory explanation of this behaviour, which differs from recorded observations of this insect in other parts of the world, but it has been established that the damage is not affecting pollination.

Fruit set was recorded in oil palm plots with and without assisted pollination in West New Britain, Northern and Morobe Provinces before and after the weevils were released.

At Bialla it was expected that improved fruit set would be demonstrable in bunches harvested in December, although the full influence would not yet be apparent. This was indeed the case in a small sample of bunches analysed with the result shown below.

Period	Number of	Fruit set			
	bunches	*Mean*	*Minimum*	*Maximum*	*c.v.%*
Jan-April	43	26	4	92	78
December	11	55	38	71	6

Before the weevil came, occasional bunches were being well pollinated by the wind, other insects or natural selfing, but there was great variation in fruit set. By December more uniform set was apparent, as evidenced by the much lower coefficient of variation.

Nine bunches pollinated by *Elaeidobius* at Walindi plantation where the aggregation of the insect was first observed showed 54-98% fruit set with a mean of 86%. Eight bunches from the Bebere release site, where similar but lesser damage occurred, gave 68-96% fruit set with a mean value of 83%.

Since aggregation and feeding was first noticed, slight fluctuations in numbers of insects on the female flowers have been observed. However, this behaviour is continuing and is now seen at several localities. It has been postulated that if fruit set remains at above 80%, mesocarp development should be affected adversely because of compression within the spikelets. Bunches were being analysed in order to test this.

It is interesting to note that similar behaviour and fruit set have not yet been reported in Malaysia, where the insect was released in February, 1981. The prognosis for the success of natural, entomophilous pollination in PNG was very good at the year's end.

INVESTIGATION 601, Sexava Control.

Chemical Control.

Sexava damage was mainly confined to the smallholder blocks and village oil palm areas. Only very slight damage had been reported from the NBPOD nucleus estate and chemical treatment was done only on the site of Experiment 102 at Dami. From November, 1980 to June, 1981 the area was surveyed regularly and the operating efficiency of the injection team checked. The annual costs of treatment dropped from K100,000 previously K34,000 during the period. It has been recommended that when damage causes more than 60% defoliation, retreatment after 10 weeks have elapsed is essential to prevent resurgence of the pest from the many eggs laid in the soil, palm frond bases and palm crowns. The second treatment will kill the majority of *Sexava* hatched before they become adult. When the first treatment is carried out when the infestation is slight (10%-20% defoliation) no treatment has been found to be necessary.

The chemical used for trunk injection is Monocrotophos (trade names Azodrin 40, Nuvacron and Monocron though the effectiveness of the latter brand has not been yet assessed nor data on its performance received). Monocrotophos is effective against *Sexava* with a single injection of 10 ml of the concentrate containing 40 percent active ingredient. The injection hole must be freshly drilled and the chemical immediately injected into the hole, which should be one centimetre wide and not less than 13 centimetres deep.

Orthene 75 wettable power is effective injected as 10 ml solution of one gramme of concentrate containing 75% active ingredient dissolved in one gramme of water.

Trials testing the effectiveness of Acephate against Monocrotophos were attemped twice, in November, 1980 and March, 1981, but in the first case wet weather caused the trials to be abandoned and subsequently the level of *Sexava* infestation has been too low for effective experimentation. Acephate is a safer chemical than Monocrotophos but both its high cost and the difficulty of handling the wettable powder make it unattractive. If a safer way to dispense Monocrotophos can be found it will probably remain the best choice for trunk injection.

Life history and ecology of oil palm Sexava

Field studies were commenced at Bialla. Aerial inspection of the heavily-infested part of the nucleus estate and the ground mapping clearly indicated that nearly all infestations had established in blocks adjacent to a natural forest boundry. Preliminary findings indicate the main wild host plant of this *Sexava* to be a *Helliconia* sp. with Rattans and other wild Palmae also capable of supporting *Sexava*. Further investigations in smallholder blocks of the Hoskins development may lead to cultural practices aimed at preventing easy ingress of the *Sexava* from the forest.

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ABBREVIATIONS USED IN THIS REPORT

FFB	Fresh Fruit Bunches
ha	hectare
ton	metric tonne
swb	single bunch weight
No.	number
Expt.	experiment
Wt.	weight
g	gramme
kg	kilogramme
lsd	least significant difference
P	probability
$<$	less than
$>$	greater than
c.v.	coefficient of variation
OPRS	Oil Palm Research Station
PNGOPRA	Papua New Guine Oil Palm Research Association
DPI	Department of Primary Industry

APPENDIX I

METEOROLOGICAL DATA

A second-order meteorological station is maintained at Dami by West New Britain Palm Oil Development's research station. At Hargy and Higaturu rainfall and sunshine is recorded informally. The installation by PNGOPRA of recording eqiuipment at other sites is under consideration.

The data collected by these organisation has been made freely available to the Association and is presented in the tables that follow.

Table 18: Meteorological data: HARGY, 1981

1981	*Rainfall mm*	*Sunshine hrs*	*Rainy days*	*Sunny days*
January	623	126	23	29
February	760	67	26	19
March	467	199	18	27
April	302	132	21	24
May	99	237	8	31
June	105	187	18	30
July	351	157	22	28
August	210	196	18	28
September	198	177	16	29
October	180	159	17	31
November	152	144	16	28
December	339	100	25	28
TOTAL	3786	1880	228	332

Table 19: Meteorological data: HIGATURU, 1981

1981	*Rainfall mm*	*Sunshine hrs*	*Rainy days*	*Sunny days*
January	203	139	15	31
February	88	69	15	20
March	245	204	13	31
April	321	134	18	30
May	220	114	14	28
June	163	148	14	28
July	159	113	18	21
August	97	186	9	25
September	229	87	13	17
October	244	144	18	24
November	321	171	15	29
Decembr	323	119	18	22
TOTAL	2613	1627	180	306

Table 20: Meteorological data: DAMI, 1981

1981	*Rain-fall mm*	*Sun-shine hrs*	*Temperature °C*		*Dewpoint*			*% Relative humidity*			*Rainy*	*Sunny*
			max	*min*	*0900 hrs*	*1200 hrs*	*1500 hrs*	*0900 hrs*	*1200 hrs*	*1500 hrs*	*days*	*days*
January	501	108.4	31.4	22.7	21-28	22-29	24-29	74-97	79-97	83-100	20	26
February	808	50.9	29.7	22.9	23-29	24-29	23-30	85-100	89-100	97-100	24	18
March	372	199.2	31.2	22.7	23-29	24-30	23-31	85-100	89-100	79-100	12	26
April	379	132.5	30.6	23.3	23-26	23-26	22-26	70-100	64- 89	60- 97	22	25
May	138	197.9	32.2	23.5	22-26	23-27	23-26	69- 89	62- 89	64- 97	13	30
June	318	151.1	31.2	22.7	22-25	22-26	23-26	70- 92	63-100	64- 98	19	30
July	298	130.2	30.4	22.8	22-25	22-24	22-24	69- 97	63-100	55- 98	20	26
August	97	203.6	30.9	22.6	20-25	—	16-24	64- 94	—	49- 83	12	27
September	152	166.9	31.9	23.8	21-25	20-25	21-25	63- 88	51- 91	55- 95	13	27
October	241	182.1	31.6	23.0	21-25	23-26	21-26	64- 90	61- 87	62- 98	15	30
November	259	181.8	31.6	22.6	23-26	21-26	22-26	66- 97	62- 90	60- 95	12	28
December	414	81.9	30.8	22.9	22-27	23-26	22-26	68- 97	64- 92	53-100	25	28
TOTAL	3977	1787									207	321

APPENDIX II

THE ASSOCIATION'S ACCOUNTS FOR 1981

Auditors' Report to the Members of the Papua New Guinea Oil Palm Research Association.

In our opinion the attached balance sheet, income and expenditure account and accompanying notes thereon as set out on schedules 1 to 3 are drawn up so as to give a true and fair view of the state of affairs of the Association as at 31st December, 1981 and of its income and expenditure for the period ended on that date.

Balance Sheet as at 31st December, 1981

	1981
Accumulated Funds — Deficit	(56,318)
Advances from members	45,000
	K(11,318)
Represented by:	
Fixed Assets (Note 4)	31,965
CURRENT ASSETS:	
Cash on Hand and Bank	22,367
Debtors	34,382
	56,749
CURRENT LIABILITIES:	
Trade Creditors	80,032
Other Creditors and Accruals	20,000
	100,032
Net Current Liabilities	(43,283)
	K(11,318)

Statement of Income and Expenditure for the eighteen months ended 31st December, 1981.

	1/7/80 to 31/12/81
INCOME:	
FFB Levy	294,874
Profit on Disposal of Fixed Assets	302
	295,176
EXPENDITURE:	
Agency, Audit, Legal and Professional fees	4,209
Bank Charges	300
Depreciation	6,240
Direct experiment costs	92,303
Electricity, water and gas	4,401
Insurance	1,800
Interest	4,764
Laboratory	425
Medical	590
Motor vehicle	11,301
Office expenses	5,086
Rentals and other accommodation costs	54,294
Repair and maintenance — buildings	9,104
Salaries, wages and allowances	127,382
Staff recruitment	18,773
Staff training	2,242
Travel and entertainment	8,280
	351,494
EXCESS OF EXPENDITURE OVER INCOME FOR THE PERIOD	K(56,318)

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.

Incorporation

The Association was not incorporated during the period covered by the financial statements.
Incorporation was granted under Associations Incorporation Act on 4 February, 1982.

Comparative figures

The Association commenced operations on 1st July, 1980 therefore there are no comparative figures for the previous period.

Fixed Assets:

Household and office furniture at cost	17,159
Less accumulated depreciation	818
	16,341
Motor vehicle at cost	20,940
Less accumulated depreciation	5,316
	15,624
Total Fixed Assets	K31,965

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 at 31 December, 1981 and the statement of income and expenditure is drawn up so as to give a true and fair view of the resuls of the business of the Association for the period ended on that date.

Secretary's Statement

I, Gordon C. Langlands, 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, 1981 and of the results for the period ended on that date.

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