THIRD ANNUAL REPORT

of the

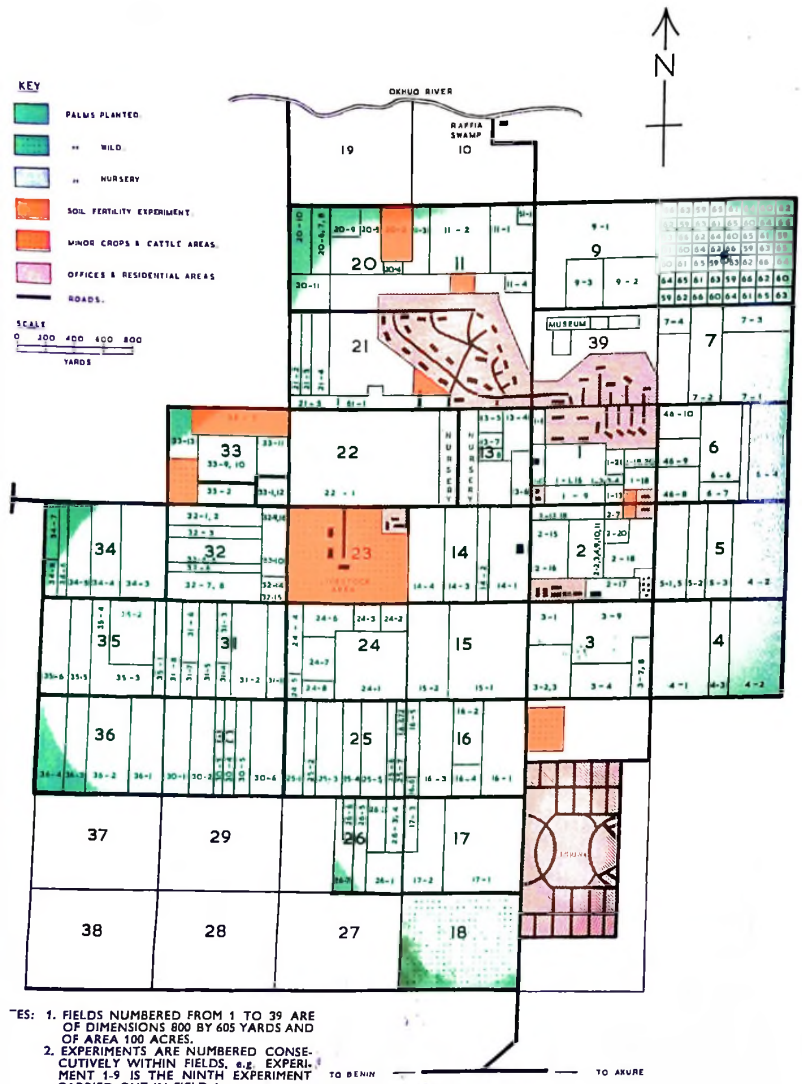
NIGERIAN INSTITUTE

FOR OIL PALM RESEARCH

(Formerly West African Institute for Oil Palm Research)

1966-67

NIGERIAN INSTITUTE FOR OIL PALM RESEARCH
MAIN STATION : 1967



NOTES: 1. FIELDS NUMBERED FROM 1 TO 39 ARE OF DIMENSIONS 800 BY 605 YARDS AND OF AREA 100 ACRES.
2. EXPERIMENTS ARE NUMBERED CONSECUTIVELY WITHIN FIELDS, e.g. EXPERIMENT 1-9 IS THE NINTH EXPERIMENT CARRIED OUT IN FIELD 1.

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NIGERIAN INSTITUTE FOR OIL PALM RESEARCH
GOVERNING COUNCIL

As at 1st June, 1966

CHAIRMAN

O. F. Obi	Permanent Secretary, Ministry of Agriculture, Enugu.

MEMBERS

G. E. O. Okiy	Director, Federal Department of Agricultural Research, Ibadan.
M. A. Akintomide	Representing Controller of Agricultural Services, Ministry of Agriculture and Natural Resources, Ibadan.
M. Liman..	Representing Chief Agricultural Officer, Ministry of Agriculture, Kaduna.
N. A. Nwosu	Chief Inspector of Agriculture, Ministry of Agriculture, Enugu.
J. D. N. Ofili	Representing Permanent Secretary, Federal Ministry of Agriculture and Natural Resources, Lagos.
Professor B. N. Okigbo	Dean, Faculty of Agriculture, University of Nigeria, Nsukka.
J. E. Iheme	Representing General Manager, Eastern Nigeria Marketing Board, Port Harcourt.
E. Ogor	Chief Agricultural Officer, Ministry of Agriculture and Natural Resources, Benin City.
S. C. Nwanze	Director of the Institute.

NIGERIAN INSTITUTE FOR OIL PALM RESEARCH

SENIOR STAFF

As at 31st March, 1967

DIRECTOR	S. C. Nwanze, D.L.C.(Chem.Eng.), A.M.I.Chem.E.
DEPUTY DIRECTOR	Vacant.
SECRETARY	A. O. Osakwe, F.C.C.S.
ACCOUNTING OFFICER	A. A. Okojie
EXECUTIVE OFFICER	D. A. Onyejose.
RESEARCH OFFICERS:	
ACTING SENIOR AGRONOMIST	R. D. Sheldrick, M.A.(Cantab.), A.I.C.T.A., M.I.Biol.
AGRONOMISTS	F. O. Aya, B.Sc.(Lond.)*
	3 Vacancies.
SOIL CHEMISTS AND SOIL SCIENTISTS ..	St. C. M. Forde, M.S.A.(British Columbia).
	D. O. Ataga, B.Sc.(Lond.)*
ACTING SENIOR PLANT BREEDER	T. Menendez, B.Sc.(Reading), M.I.Biol.
PLANT BREEDERS	C. O. Obasola, B.Sc.(Lond.).
	P. O. Egwim, B.Sc.(Lond.).*
	M. O. Otedoh, B.Sc.(Ibadan).*
PLANT PATHOLOGISTS ..	K. Rajagopalan, B.A.(Madras), I.A.R.I.(Associate).
	F. O. Aderungboye, M.Sc.(Lond.), D.I.C.
PLANT PHYSIOLOGISTS ..	A. J. Odetola, B.Sc.(Lond.).*
	F. I. Opute, B.Sc.(Lond.).*
PLANT PHYSIOLOGISTS (NUTRITION) ..	H. C. Okoye, B.Sc.(Lond.), B.Sc.(Aberd.).
	O. Sowande, B.Sc.(Ibadan).*
RESEARCH ENGINEERS ..	2 Vacancies.
STATISTICIAN	B. O. Mgbolu, B.Sc.(Nsukka).
ANALYTICAL CHEMIST ..	P. I. Eapen, M.Sc.(Agra).
SENIOR LABORATORY TECHNOLOGIST	M. J-P. Leyritz.
LABORATORY TECHNOLOGIST ..	Vacant.
PLANTATIONS MANAGER ..	A. O. Egbuniwe.
MAINTENANCE ENGINEER ..	Vacant.
PLANT PRODUCTION OFFICER ..	I. Osayi.
TECHNICAL OFFICERS	A. E. Okeke.
	S. E. Nnabuchi.
	D. S. Udom.†
	E. I. Ogedegbe, B.E.M.
	E. C. Egbufor.

*Research Officers-in-Training †Sub-Station, Eastern Nigeria

NIGERIAN INSTITUTE FOR OIL PALM RESEARCH

SENIOR STAFF (*continued*)

As at 31st March, 1967

SENIOR ADVISORY OFFICER (INFORMATION)	Chief S. A. Omenai, J.P., Dip.Agric.
ADVISORY OFFICERS	Alhaj M. O. Otubu, B.Sc.(Wales), D.T.A.(West Indies). 1 Vacancy.
LIBRARIAN	I. O. N. Nwaokolo, A.L.A.
MEDICAL OFFICER	Dr. F. Ogunro.
TEMPORARY NURSING SISTER ..	E. Nwanze (Mrs.), C.M.B.(Nigeria), S.R.N.(Eng.).

INTRODUCTION

Apologies must be extended to those who take a close interest and follow the progress of the research at the Institute for the delay in publication of the Third Annual Report. The delay results from the recent disturbed conditions in the country and the serious indisposition of the Director. This report has been compiled from material partly edited by him.

The number of Agricultural Shows held in the country has decreased sharply in the last few years and it was felt that the Institute's efforts were not being brought sufficiently to the public's notice. On 17th February, 1967, the Institute held its first Field Day organized by the Advisory and Information Division, assisted by the research staff. The Field Day was held to coincide with the meeting in Benin of the Agricultural Technical Committee, so that agricultural experts from all over the country could attend. Mr. W. J. Anukpe, Permanent Secretary of the Mid-Western Ministry of Agriculture and Natural Resources, opened the proceedings and warmly welcomed the new initiative taken by the Institute. The Field Day was well attended by people from Benin, but it was disappointing that more groups of farmers did not come from elsewhere in the Mid-West. Highlight of the day for many visitors was a 40-minute colour film about the work of the Institute, prepared by members of the research staff.

In the past, the South American oil palm has been referred to loosely as both *Elaeis melanococca* and *Corozo oleifera*. Despite the common use of the name *E. melanococca* it is felt that it would be more correct to use *Corozo oleifera*. It is hoped that the change will not prove too confusing.

The Director's extensive tour of the Far East between September and November 1966 was made possible by the generosity of the Ford Foundation and proved extremely fruitful, particularly as regards gaining insight into current research on the coconut, which now forms part of the Institute's work. The internal situation in Nigeria made local prospection for coconuts difficult and only a very modest start has been made in collecting the gene pool of coconut types for planting at the Institute's Main Station. Some nuts of dwarf varieties were imported from Malaya and established in a special quarantine nursery.

Cooperation between the Agronomy, Plant Nutrition and Soil Chemistry Divisions over the fertilizer experiments and the associated soil and leaf analyses continued. These experiments require a great deal of careful organization and, although the results may not be spectacular unless extreme deficiencies of major elements occur, they are of great practical importance to the oil palm industry, which is now becoming aware of the need for economic programmes of fertilizer application. A new factorial fertilizer experiment was started during the year at the Eket Oil Palm Estate of the Eastern Nigeria Development Corporation.

In starting production of Extension Work Seed at the Sub-Station, Abak, a major step forward has been made with the Institute's policy on these matters. Seed production at Nkwelle Provincial Farm ceased in January 1967 and it is hoped that it can be stopped at Ogba Provincial Farm later in the year. This will mean that all Extension Work Seed will be produced on stations where senior staff can provide strict daily supervision and help to further safeguard the high quality of the seed.

R.D.S.

PART I. ADMINISTRATION, MANAGEMENT AND DEVELOPMENT

Governing Council

As mentioned in the NIFOR Second Annual Report, page 11, the Institute's Governing Council was dissolved by Decree early in 1966, together with the governing bodies of other Government-sponsored organizations. Later in the year a fresh Decree re-established the Governing Council on a rather broader basis than before. This Council held its inaugural meeting on 4th July 1966 and continued with a business meeting on 5th and 6th July.

Finance

As a result of the change in Government in the country and the suspension of the Institute's Governing Council for several months in the first part of 1966, the Institute's estimates for the financial year 1966-67 were not finally approved until March 1967. Money was spent extremely cautiously, pending official approval of the estimates, hence a surplus is shown on the accounts because certain projects were delayed or cancelled during this period of financial uncertainty.

The Nigerian Institutes Ordinance (Nigeria No. 33 of 1964) makes the auditing of the Institute's accounts the joint responsibility of the Federal Ministry of Agriculture and Natural Resources and the Federal Ministry of Finance. Up till the time of going to press (January 1968), no arrangements had been made for auditing the 1966-67 accounts and the figures shown in Appendix III are a provisional reconciliation by the Institute's Accounting Officer for the twelve months ending 31st March 1967.

Income and Expenditure 1966-67

The approved expenditure for the year was £433,800, but for the reasons explained above, final expenditure was only £406,963. The Institute's net assets at 31st March 1967 stood at £890,704. Sundry debts amounted to £51,137, which represented a big improvement over the situation a year earlier. As stated above, the accounts for the year have not been audited.

Staff

Research Staff

Mr. J. M. A. Sly, Principal Scientific Officer and formerly Acting Deputy Director retired from the service of the Institute on 13th May 1966. Messrs. R. D. Sheldrick and T. Menendez, Senior Scientific Officers, were granted acting appointments as Principal Scientific Officers (Acting Senior Agronomist and Acting Senior Plant Breeder, respectively) with effect from 1st August 1966.

Mr. B. O. Mgbolu, Statistician, attended a short course in England on computer programming in May and June 1966. Mr. H. C. Okoye, Plant Physiologist (Nutrition), attended a course in the Congo (Kinshasa) on the use of radio-isotopes in agriculture in November and December 1966.

Mr. F. O. Aderungboye, Plant Pathologist, rejoined the Institute in September 1966 after the completion of a course of post-graduate training at London University. In June 1966, Messrs. M. O. Otedoh and O. Sowande joined the staff as Research Officers-in-Training. As at 31st March 1967, the Institute had five Research Officers in training at various institutions in the United Kingdom and U.S.A. and a further two Research Officers-in-Training at the Institute.

The present distribution of research officers between the Divisions is shown below:

Division	*Establishment 1966-67*	*Posts occupied on 31st March 1966*	*31st March 1967*	*Establishment 1967-68*
Agronomy	4	2*	2*	4
Plant Breeding	4	3*	4**	4
Plant Pathology	2	2*	2	2
Plant Physiology	2	2**	2**	2
Plant Nutrition	2	1	2*	2
Research Engineering	2	Nil	Nil	2
Soil Chemistry	2	2*	2*	2
Statistics	1	1	1	1
	19	13	15	19

*Figure includes one research officer in training
**Figure includes two research officers in training

Administrative and Technical Staff

Mr. J. J. Clarke, Maintenance Engineer, retired from the service of the Institute in January 1967. Chief S. A. Omenai, Senior Advisory Officer, attended a course of training in Extension Education in the U.S.A. from April to November 1966. The course was sponsored by the United States Agency for International Development. Mr. A. O. Osakwe, Secretary, who had proceeded to the U.S.A. on a course sponsored by the Ford Foundation, returned to duty in August 1966. Mr. M. O. Otubu, Advisory Officer, returned to the Institute after completing a course of study at the University of the West Indies, Trinidad, in September 1966.

Messrs. A. E. Okeke, S. E. Nnabuchi and D. S. Udom, Technical Officers, were granted acting appointments as Higher Technical Officers by the Governing Council, with effect from 1st August 1966.

Junior Staff

It is recorded with regret that Mr. S. M. Kidero, Clerical Assistant, died at the Adeoyo Hospital, Ibadan on 1st July 1966.

Six members of junior staff were promoted during the year. Two of the promotions were from the Agricultural Assistant grade to Assistant Technical Officer and two from Field Overseer to Agricultural Assistant, following successful completion of a

course. Three Laboratory Assistants and one Typist resigned during the year and one staff artisan was invalided from the service of the Institute. The present strength of the junior staff is as follows:

	Strength at 31st March 1966	*Approved establishment 1966-67*	*Strength at 31st March 1967*
Assistant Technical Officers and Laboratory Assistants	17	20	17
Agricultural Assistants and Laboratory Technicians	37	37	35
Field Overseers	37	49	35
Assistant Executive Officer	1	1	1
Clerical Staff including Assistant Library Officer, Secretary/Typist, Stores Verifier and Stenographers	34	44	32
Typists	7	7	6
Senior Assistant Photographer	1	1	1
Maintenance Assistant	1	1	1
Mill Overseer	1	1	1
Artisans	26	26	26
Storekeepers, Stores Assistants and Stores Attendants	3	6	3
Drivers and Driver/Mechanics	10	10	9
Messengers	9	9	9
Telephone Attendants	3	3	3
Laboratory Attendants	4	6	4
Health Staff	5	6	5
Machine Supervisor	—	1	—
Mechanical Accounting Assistant	1	1	1
Punch Operators	6	7	6
Sub-Technical Grades	30	30	30
	233	266	225

Unestablished Staff and Labour

The unestablished staff and labour consist of the plantation labour force and maintenance engineering force of artisans, special and general labourers responsible for routine operations in the plantations and the maintenance of buildings, vehicles, tractors, etc. and for the operation of the electricity and water supplies.

Main Station: The average number of labourers employed in the plantations rose sharply over the 1965-66 figure of 709. The severe reduction of the labour force in 1965-66 had led to neglect of the maintenance in many fields. This was aggravated

in 1966 by unusually heavy rains and thus it was necessary to employ more people towards the end of the year to avoid the neglected field maintenance jeopardizing the accuracy of research results. The average daily attendance for all grades is shown in Table 1.

TABLE 1

MAIN STATION LABOUR FORCE

Average daily attendance of all grades

Month	*Artisans*			*Special Labour*			*General Labour*	*Total*
	Grade I	*Grade II*	*Grade III*	*Grade I*	*Grade II*	*Grade III*		
Plantations								
April 1966	—	4	32	80	91	102	431	740
May ,,	—	4	38	71	88	99	425	725
June ,,	—	4	38	72	89	100	451	754
July ,,	—	4	38	77	91	124	455	789
August ,,	—	4	38	79	93	135	473	822
September ,,	—	4	38	79	94	137	492	844
October ,,	—	4	38	65	104	129	481	821
November ,,	—	4	42	85	106	161	468	866
December ,,	—	4	40	82	100	154	452	832
January 1967	—	4	38	100	111	203	313	769
February ,,	—	4	41	124	132	257	320	878
March ,,	—	3	38	113	125	239	305	823
Average (Plantations)	—	4	38	86	102	153	422	805
Maintenance								
April 1966	1	11	20	21	11	3	20	87
May ,,	1	11	20	20	11	3	20	86
June ,,	1	11	20	20	11	3	20	86
July ,,	1	11	20	20	11	3	20	86
August ,,	1	10	20	18	11	3	20	83
September ,,	1	12	21	18	11	3	20	86
October ,,	1	12	22	17	11	3	19	85
November ,,	1	12	22	17	11	3	18	84
December ,,	1	12	22	17	11	3	18	84
January 1967	1	12	22	17	11	3	18	84
February ,,	1	12	22	16	11	3	18	83
March ,,	1	12	22	16	11	3	18	83
Average (Maintenance)	1	12	21	18	11	3	18	85
OVERALL AVERAGE	1	16	59	104	113	156	440	890

TABLE 2

SUB-STATION, ABAK AND OUT-STATION LABOUR FORCES

Average daily attendance of all grades

Month		*Sub-Station, Abak*			*Calaro Estate*	*Elele Estate*	*Kwa Falls Estate*	*Asutan Ekpe Survey*	*Umuabi, near Udi*	*Nkwelle Farm, Onitsha*	*Onishere Farm Settlement*	*Ogba Farm, Benin*
		Artisan	*Labour*	*Total*								
April	1966	4	74	78	1	1**	1**	9	5	4	8	10
May	,,	4	80	84	1			9	5	4	7	10
June	,,	4	80	84	1			9	5	4	7	10
July	,,	4	80	84	1			9	6	4	8	10
August	,,	4	80	84	1			9	6	4	8	10
September	,,	4	80	84	1			9	6	4	8	10
October	,,	4	80	84	1			9	9	4	8	10
November	,,	5	67	72	1			9	7	2	8	10
December	,,	5	73	78	1			8	8	3	8	10
January	1967	5	66	71	2			8	6	1	9	10
February	,,	5	66	71	1			9	6	1	9	10
March	,,	5	71	76	1			9	7	—*	9	10
Average	..	4	75	79	1			9	6	3	8	10

*Station closed down **Recorder converted to permanent establishment

Sub-Station, Abak and Out-Stations· Table 2 gives the deployment of labour at the Sub-Station, Abak and out-stations. In the NIFOR Second Annual Report, Table 2 showed by error that the out-stations at Elele, Kwa Falls and Calaro Estates of the Eastern Nigeria Development Corporation had been closed down. This is not the case, as can be seen on page 15.

TOURING AND VISITS

The Director, Mr. S. C. Nwanze, visited organizations engaged in oil palm and coconut research in the Philippines, Malaysia, Ceylon and India, between September and November 1966. Mr. St. C. M. Forde, Soil Chemist, paid a visit to the Gambia in March 1967 to inspect palm nurseries and plantings made by their Ministry of Agriculture.

Unsettled conditions reduced the amount of touring done by officers within Nigeria. Staff of the Agronomy Division visited Ikom several times in connection with the new experiment there and also visited all the out-station fertilizer experiments to supervise application of fertilizers in February and March 1967. Staff of the Plant Breeding Division visited progeny trials in Northern Nigeria and also made prospecting visits in Western Nigeria for material for the coconut gene-pool.

AGRICULTURAL SHOWS AND FIELD DAYS

The Institute exhibited at the Agricultural Show held at Owo, Western Nigeria in January 1967.

On 17th February 1967, the Institute held its first Field Day. Each Division exhibited its work and excursions round the plantations and to the mill were arranged. The Field Day was well attended and generally regarded as most successful.

VISITORS

Many visitors were received at the Main Station during the year, amongst whom were:

Nigeria: Dr. R. Prasad, University of Ibadan; Mr. S. P. Olsen, American Embassy, Lagos; Mr. J. C. Anyansi and Mr. and Mrs. J. N. Williams, Universal Insurance Company Ltd.; Mr. A. C. Syme, University of Ife, Ibadan; Mr. K. Gopalan, F.A.O., Ibadan; Mr. W. Leigh, Deputy Superintendent of Police, Benin; Mr. J. A. Edmunds, British High Commission, Lagos; Mr. F. A. Gowan, Colorado State University, A.R.T.S., Umudike; Mr. W. C. Tappan, USAID, Benin; Mr. F. C. Jones, USAID, Lagos; Mr. W. Wood, Shell Company of Nigeria Ltd., Lagos; Mr. O. F. Obi, M.A.N.R., Enugu; Mr. M. A. Akintomide, M.A.N.R., Ibadan; Mr. E. C. Ogor, M.A.N.R., Benin City; Mr. M. Liman, M.A.N.R., Kaduna; Mr. N. A. Nwosu, M.A.N.R., Enugu; Mr. G. E. O. Okiy, F.D.A.R., Ibadan; Mr. J. D. N. Ofili, M.A.N.R., Lagos; Mr. J. E. Iheme, Eastern Nigeria Marketing Board, Port Harcourt; Professor B. N. Okigbo, University of Nigeria, Nsukka; Mr. D. N. Ajaegbu, M.A.N.R., Enugu; Messrs. A. Zuofa and C. D. Omoh, Niger Delta Development Board, Port Harcourt; Mrs. R. Le Bert, USAID, Lagos; Mr. F. C. Moore, F.A.O., Enugu; Mr. R. S. Asthana, F.A.O., Benin City; Mr. G. E. Aihie, Ministry of Economic Development and Finance, Benin

City; Mr. E. U. Edem, F.D.A.R., Umudike; Mr. M. J. Newington, Deputy British High Commissioner, Benin City; Mr. Felix Pardo, Ministry of Industries, Lagos; Lt.-Col. R. F. Trimmell, Benin City; Mr. F. C. Halim, Benin City; Mr. K. T. Pike and Mr. E. C. Holmes, I.C.I. (Nigeria) Ltd., Ibadan; Mr. Curtis Trent and Mr. Joseph B. Igunnu, Institute for Agricultural Research, Samaru, Zaria; Mr. J. Owen, I.C.T. Ltd., Lagos; Mr. R. Postel, Sick-Hagemeyer (Nig.) Ltd., Lagos; Mr. G. C. Gleadle, I.C.I. (Nigeria) Ltd., Lagos; Mr. R. C. Lang, UNESCO, Benin; Mr. W. Walter, Crown Agents Representative in Nigeria, Lagos; Captain M. O. Edionseri, Benin City; Mr. J. B. Quinn, Institute for Agricultural Research, Samaru, Zaria; Mr. N. R. Lancaster and Mr. F. B. Feldbrugge, Pamol (Nigeria) Ltd., Sapele; Dr. J. C. Edozien, Ibadan University, Ibadan; Professor J. Bowden and Dr. T. Ajibola Taylor, University of Ibadan, Ibadan; Mr. E. G. H. Williamson, Produce Division, Ministry of Trade and Industry, Benin; Mr. K. Gbegbeje, Trade Division, Ministry of Trade and Industry, Benin; Mr. W. O. Enaboifo, M.N.D.C., Benin City; Mr. M. A. O. Omiyi, Marketing Board, Benin City; Mr. M. A. Oshomegie, Marketing Board, Benin City; Mr. S. I. Igiehim, Ministry of Information, Benin City; Mr. G. B. A. Egbe, Agricultural Credit Corporation, Benin City; Mr. J. Ilo Okudiafor, Marketing Board, Benin City; Mr. C. M. Kubeyinje, Registrar of Co-operatives, Benin City; Mr. J. Adeola, Commissioner of Police, Benin City; Mr. J. E. Imoukhuede, Military Governor's Office, Benin City; Mr. W. Gascorpe, Survey Department, Ibadan; Mr. R. O. Coker and Mr. Olumuyiwa Adebeken, Federal Surveys, Lagos; Mr. Olalunde Oluwole, School of Surveying, Oyo; Mr. S. J. Ojekire, Midwest Survey, Benin City; Mr. W. H. Young, Ministry of Lands and Housing, Benin City; Mr. C. T. Horsfall, Federal Surveys, Lagos; Mr. G. C. Odumode, Survey Dept., Enugu; Messrs. J. P. W. Ward, J. Ashton and C. K. Durojaiye, Survey Department, Kaduna; Mr. K. G. Windsor, M.A.N.R., Lokoja; Mr. R. E. M. Silberrad, M.A.N.R., Idah; Dr. Martin, UNESCO, Lagos; Mr. W. V. Rose, British High Commission, Lagos; Mr. I. Katsina, M.A.N.R., Zaria; Mr. R. J. Lewis, M.A.N.R., Ibadan; Mr. M. Wessel, C.R.I.N., Ibadan; Dr. S. A. Apeji, C.R.I.N., Ibadan; Mr. B. A. Shitta-Bay, Ministry of Justice, Lagos; Dr. Pandey and Mr. Fadayomi, F.D.A.R., Ibadan; Mr. Yuno Adeniji, C.R.I.N., Ibadan; Messrs. J. Buchanan, D. J. Hartman and H. T. Stimble, Peace Corps, Benin City; Mr. C. Heath, Barclays Bank D.C.O., Lagos; Mr. G. Westeijn, C.R.I.N., Ibadan.

Cameroons: Mr. G. Blaak, Pamol Ltd., Lobe.

France: M. de Padirac, Institut de Recherches sur le Caouchouc en Afrique.

Italy: Mr. G. Chiesa, Montecatini-Edison Ltd., Milan; Messrs. Swamy and Dobes, F.A.O., Rome; Dr. R. H. Stoughton, F.A.O., Rome.

The Netherlands: Messrs. J. S. de Vries and J. A. Hoekendijk, State Agricultural College, Deventer.

United Kingdom: Dr. D. J. Morgan, School of Agriculture, Cambridge; Mr. Anthony Greenwood, British Minister for Overseas Development; Messrs. G. Thorn, G. Crossby, A. J. Peckham and R. Dean, Ministry for Overseas Development; Mr. P. G. W. Purves, Northrop Tractors Ltd.; Mr. D. B. Saunders, Marshall Fowler Group; Mr. G. A. Hannah, Pegson Ltd.; Mr. J. Nicholson, Howard Rotavation Co. Ltd.; Mr. P. E.

Haycroft, Cooper Pegler & Co. Ltd.; Mr. P. Galbraith, British National Export Council; Mr. J. J. Foster, Commonwealth Development Corporation; Jean G. N. Ritchie and Fellows from the London/Ibadan Nutrition course, London School of Hygiene and Tropical Medicine; Mr. I. Hill, Directorate of Overseas Surveys; Mr. D. A. Hole, Hurley, Maidenhead; Mr. D. E. Warren, Directorate of Overseas Surveys; Mr. J. Coulter, Rothamsted Experiment Station; Mr. S. de Blank, Unilever Plantations Group, London.

United States of America: Mr. J. S. Long, University of Wisconsin; Mr. W. H. Pine, Kansas State University; Mr. L. H. Watts, Colorado State University.

PHYSICAL DEVELOPMENT

Building Construction—Main Station

Two type T.63 Senior Staff Quarters were constructed by the Institute's contractor during the year. Seven type "C" quarters for Junior Staff are now under construction and are expected to be completed before the end of next year.

MAINTENANCE OF BUILDINGS AND MACHINERY

Staff

Mr. J. J. Clarke, Maintenance Engineer, left the Institute on retirement leave in September 1966 since when Mr. A. O. Egbuniwe, Plantations Manager, has been in control of the Division.

Buildings

Re-decoration was carried out in nine Senior Staff Quarters, the Rest House chalets, the Senior Staff Club, two "A" type quarters, fourteen "B" type quarters, and thirty-eight "C" type quarters, thirty "D" type quarters, the Maternity Home, the Isiuwa Recreation Hall, the Postal Agency and two offices.

Motor Vehicles and Tractors

All vehicles and tractors were satisfactorily maintained, except for the County Crawler CD 50 tractor, which was awaiting spare parts from the agents from December 1966 onwards. Vehicles had no difficulty in passing their roadworthiness tests. The bus was in continuous operation throughout the year.

Water Supply

There was one interruption in the supply of water during the year. There were a few breakdowns in the pump engines which were quickly repaired. Some burst water pipes were replaced. The overhead reservoir tank was washed and maintenance was carried out on defective taps and valves on the Station. The pump engines worked 5,250 hours, an average of 14.3 hours per day, consuming a total of 12,846 gallons of diesel oil, an hourly consumption of 2.4 gallons.

Electricity Supply

Re-wiring of certain Senior Staff Quarters was undertaken. Electricity was in continuous supply throughout the year. The engines ran for 14,974 hours, consuming 68,023 gallons of diesel oil, an hourly consumption of 4.5 gallons as against 4.7 gallons for the previous year. The total output in units for the year was 907,930 as against 860,530 in 1965-66.

PLANTATIONS MANAGEMENT

Staff and Labour

The Plantations Manager, Mr. A. O. Egbuniwe was on leave in December and January 1967. Mr. E. I. Ogedegbe, Station Superintendent, was on leave in August and September 1966. Dr. F. Ogunro, Medical Officer, was on leave in September 1966, while the Nursing Sister was on leave in October and November 1966.

The strength of the labour force at the Main Station on 31st March 1967 was 913, composed as follows:

Bini, Ishan, Afenmai and Igbanke	405
Ibo (Mid-Western)	142
Ibo (Eastern)	219
Ibibio	119
Urhobo	19
Others	9

Sixty labourers were re-engaged during the year, while one hundred and twenty-five labourers laid off in the previous year were recalled. Nineteen labourers were laid off as delinquents. The average daily attendance at the Dispensary was 2.5% as against 2.8% in the previous year. Rather more than half the cases were placed on "Medicine and Duty", while the remainder were placed on the sick list. Twenty-four members of the labour force applied for *ex-gratia* gratuity due to old age or other causes.

The following table shows the employment of labour, the acreage of palms and the yield of bunches at the Main Station each year since 1952.

Year	*Average daily attendance*	*Total acreage of palm fields*	*Tons of bunches harvested*
1952-53	758	968	1,409
1953-54	694	1,052	1,944
1954-55	783	1,126	1,920
1955-56	729	1,153	2,600
1956-57	745	1,272	2,673
1957-58	829	1,345	3,401
1958-59	753	1,438	2,807
1959-60	743	1,523	3,986
1960-61	747	1,633	3,335
1961-62	774	1,795	3,767
1962-63	939	1,976	3,635
1963-64	981	2,286	4,613
1964-65	1,014	2,457	5,740
1965-66	709	2,544	5,674
1966-67	805	2,840	5,208

TABLE 3

NIFOR STORK MILL

Milling Results during 1966

Month	*No. of working days*	*No. of hours*	*Weight of bunches milled*	*Weight of oil produced*	*Oil extraction efficiency*	*Weight of kernels produced*	*Kernel extraction efficiency*
			tons	*tons*	*%*	*tons*	*%*
January	17	209	290.37	35.92	91.29	13.20	—
February	17	240	368.12	46.00	93.48	23.73	84.03
March	15	221	356.27	48.18	94.02	21.67	85.06
April	21	190	313.10	44.36	89.73	17.10	76.47
May	22	195	298.84	50.69	94.64	16.29	78.59
June	21	190	291.24	51.26	93.47	13.36	75.25
July	24	222	322.65	53.12	92.52	16.13	73.74
August	23	261	374.15	56.76	92.52	20.78	74.41
September	19	223	342.97	59.34	93.40	19.22	78.79
October	20	271	376.12	64.24	92.57	21.02	77.21
November	19	216	328.80	55.53	92.64	16.86	78.81
December	15	144	217.95	37.28	91.94	11.65	78.81
Total	233	2,582	3880.58	602.68		211.01	
Average	19	215			92.68		71.70

TABLE 4

NIFOR STORK MILL

Analytical Control of Milling during 1966

Determinations	*Av. 1965*	*Jan.*	*Feb.*	*Mar.*	*April*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*	*Av. 1966*
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Sterilized fruit analysis														
Proportion of pulp ..	50.8	50.5	48.9	48.9	52.5	55.2	57.2	56.5	53.6	55.2	55.4	54.2	56.2	53.7
Proportion of nuts ..	48.2	47.9	49.6	46.7	46.4	43.6	41.9	42.2	45.4	43.2	43.4	44.0	42.4	45.6
Water	13.5	16.6	16.0	14.7	15.1	14.8	15.0	15.0	14.8	14.2	13.4	12.9	14.2	14.7
Dry fibre	11.4	12.4	11.5	12.2	11.6	11.3	13.1	11.8	12.2	12.2	12.2	12.2	12.3	12.1
Oil	25.9	21.6	21.3	23.0	25.2	28.6	30.1	28.4	26.2	29.6	29.5	29.1	29.7	26.9
Oil to mesocarp ..	50.2	42.7	43.9	46.0	49.0	51.8	53.0	52.4	49.4	52.1	53.9	54.8	52.9	50.2
Press fibre analysis														
Oil to dry fibre ..	9.6	9.2	8.0	11.0	9.3	7.9	6.8	8.6	9.5	9.5	9.4	9.0	9.7	9.0
Oil analysis														
F.F.A. in clean oil ..	2.6	2.7	2.4	3.1	2.3	1.7	1.8	1.8	2.0	2.5	2.4	2.1	2.4	2.3
Moisture in clean oil ..	0.6	0.7	0.5	0.7	0.7	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.2	0.6
Dirt in clean oil ..	0.03	0.02	0.03	0.02	0.01	0.04	0.03	0.03	0.02	0.01	0.01	0.01	0.02	0.02
Analysis of dry kernels (as bagged)														
Moisture	7.2	6.0	5.3	7.1	7.5	7.5	6.7	8.0	7.4	7.4	5.6	5.5	6.2	6.7
Dirt	1.4	1.2	1.0	1.2	1.4	2.3	2.0	1.6	1.4	1.7	2.3	1.7	1.8	1.7
Milling efficiency														
Percentage oil to bunch (extracted)	14.8	12.4	12.6	13.5	14.2	17.0	17.6	16.6	15.2	17.3	17.1	16.9	16.9	15.6
Fruit to bunch ratio (from test) ..	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6	62.6
Percentage oil in fruit	25.9	21.6	21.3	23.0	25.2	28.6	30.1	28.4	26.2	29.5	29.5	29.1	29.1	26.9
Oil extraction efficiency	91.6	91.6	93.5	94.0	89.7	94.6	93.5	92.5	92.5	90.6	90.6	92.7	91.9	92.6

Development and Maintenance of Residential Areas

Maintenance of residential areas was carried out satisfactorily. The sanitary condition of Isiuwa village was very much improved by the introduction of monthly inspection of compounds. Eroded compounds were filled with earth and levelled up. The line of mango trees on the western side of the major road entering the Station was thinned and inter-planted with seedlings of royal palms. These will eventually replace the Mango trees when the remainder are felled.

Health and Sanitation

The Institute's Medical Officer, Dr. F. Ogunro maintained his usual thrice weekly visits. A total of 21,987 cases were treated at NIFOR Dispensary of which 260 were referred to the General Hospital, Benin. Five cases of chicken pox were sent to the Infectious Diseases Hospital, Benin. A total of 1,475 persons were vaccinated against Small-Pox. At the Maternity Centre 165 births were recorded.

THE MAIN STATION PLANTATION

New Plantings

Clearing operations for 1966 plantings started in December 1965. An area of 97 acres was planted in 1966, comprised of:

Agronomy Division	42 acres
Plant Breeding Division	32 acres
Statistics Division	23 acres

Re-planting accounted for 61 acres, the remainder being cleared from high forest. The cost of establishment in 1966 was higher than in 1965, an average of 50.2 man/days per acre being used for the whole operation from underbrushing, to the fixing of wire-collars.

Maintenance of Planted Areas

An area of 2,598 acres of palm fields was maintained during the year. Regular field spraying and routine hand removal of Siam weed were carried out. The average cost in man/days for field maintenance per round during the year is shown below:

Old Areas: 1939-1953 plantings	1966-67 *Dry Season*	1966-67 *Wet Season*	*Average*
Cutlassing	1.70	2.83	2.27
Ring cutlassing	0.95	—	0.47
Opening rides	0.74	1.43	1.09
Pruning..	5.0	—	2.50
TOTAL	8.39	4.26	6.33

Intermediate Areas: 1954-1959	1966-67 *Dry Season*	*Wet Season*	*Average*
Cutlassing	1.42	2.41	1.92
Ring cutlassing	0.77	0.66	0.71
Opening rides	1.12	1.03	1.08
Pruning..	—	—	—
TOTAL	3.31	4.10	3.71
Young Areas: 1960-1966			
Cutlassing	1.43	1.90	1.67
Ring cutlassing	0.70	0.81	0.75
Opening rides	1.19	1.29	1.24
Pruning..	1.37	1.23	1.30
TOTAL	4.69	5.23	4.96

Harvesting

The total yield of palm bunches harvested in 1966 was 4,452 tons as against 6,132 tons in 1965. The monthly production of fruit bunches from January to December 1966 was as follows:

Month	*Number of bunches*	*Weight of bunches tons*
January	40,437	323
February	48,426	390
March	73,217	449
April	43,477	341
May	45,268	341
June	54,598	339
July	52,912	376
August	54,678	437
September	46,532	401
October..	45,691	415
November	37,323	381
December	24,870	259
TOTAL	567,429	4,452

The total area under production at the beginning of 1966 was 1,713 acres, which was estimated to be equivalent to a mature acreage of about 1,625. The average yield of bunches per mature acre was 2.7 tons as against 4.1 tons in the previous year.

Routine Application of Fertilizers

Routine application of fertilizers was carried out at the same rates as in the previous years.

Road Construction and Maintenance

About 500 yards of new road were constructed in Isiuwa village and a further 500 yards on the south side of Field 26. A drive-way was constructed for the new Senior Staff Quarter P.23. Maintenance operations were carried out as usual.

Livestock

There were 143 cattle at the beginning of the year. There were 33 births, six deaths, 20 beasts were slaughtered for beef and nine were sold off. Thus at the end of the year, there were 141 animals in the herd.

On 1st April 1966, there were 61 pigs. During the year, 165 births were recorded, 112 pigs were slaughtered for pork and 20 deaths were recorded.

The state of pig herd at 31st March 1967 was as follows:

Stud boars ..	3	Hog fatteners ..	21
Sows	6	Gilt fatteners ..	23
Reserved boars	4	Piglets	37
		TOTAL ..	94

Three hundred and fifty-three tons of farmyard manure were produced. This was mixed with bunch refuse, composted and applied to the nurseries and the vegetable garden.

THE SUB-STATION, ABAK

STAFF

Mr. D. S. Udom, Technical Officer, was promoted Acting Higher Technical Officer with effect from 1st August 1966. He took his annual leave in December 1966 and January 1967 and was relieved by Mr. C. I. Nneji, Assistant Technical Officer.

SEED PRODUCTION

Forty-eight palms were selected in July 1966 for seed production. A total of 16,545 seeds was produced in February and March 1967. Fruit and bunch analysis was continued with a further 31 palms.

HYDRAULIC HAND PRESS

Between April 1966 and March 1967, 314.5 tons of bunches were processed, yielding 43.6 tons of oil, at an average extraction rate of 13.8%. A further 250 tons of bunches were sold during the period.

ADVISORY AND INFORMATION DIVISION

STAFF

Chief S. A. Omenai, Senior Advisory Officer, spent seven months of the year in the U.S.A. studying extension education, under the auspices of NIFOR and the United States Agency for International Development. While returning from the U.S.A., he visited the Central Office of Information, London, and Reading University. Alhaj M. O. Otubu, Advisory Officer, returned from Trinidad in September 1966, after the successful completion of a course of study at the University of the West Indies. Mr. I. O. N. Nwaokolo, Librarian, was on duty throughout the year.

GENERAL PROGRAMME

With the Senior Staff of the Division absent for much of the year, the Division confined itself to routine work. An expanded programme of work, including the installation of a "Rotaprint" printing machine is planned for 1967.

VISITORS

Apart from individual visitors reported elsewhere the following groups of students and trainees were shown round the Main Station by the Division:

Schools of Agriculture	3 groups
Other Schools	2 groups
Universities	1 group

In addition the Main Station was visited by a group of Principals of Grammar Schools in Mid-Western Nigeria and the Consortium for the study of Nigerian Rural Development from the U.S.A. The present unsettled situation in the country reduced the number of visitors to the Institute.

Courses and Special Parties

Courses of instruction were held at the Main Station for the following: Agricultural Assistants-in-training, Akure, from 19th to 22nd June 1966, and from 26th to 29th June 1966 Mr. O. Onyejekwe and Mr. S. P. S. Koko of the Eastern Nigerian Development Corporation from 4th to 8th April 1966 and four Agricultural Extension Workers, Northern Nigeria, from 4th to 25th April 1966.

LIBRARY SECTION

During the year the library acquired 308 books and pamphlets and 72 other items on microfilm. A total of 230 current periodicals was received and twenty-seven volumes of periodicals were bound. NIFOR Annual Reports, Journals, Farmers Booklets and Advisory Sheets were distributed.

AUDIO VISUAL SECTION

The photographic section produced 969 full plate enlargements, 951 half plates, 1,039 quarter plates and 3,576 photo-copies.

S. A. OMENAI

PART II. RESEARCH

AGRONOMY DIVISION

STAFF

Mr. J. M. A. Sly, Agronomist, retired from the service of the Institute in May 1966. Mr. R. D. Sheldrick, Agronomist, returned from vacation leave in June 1966 and was appointed Acting Senior Agronomist from 1st August. Mr. A. E. Okeke, Technical Officer, was appointed Acting Higher Technical Officer from 1st August. He was on duty throughout the year apart from his annual leave period in August and September 1966.

GENERAL PROGRAMME

In June 1966, a factorial fertilizer experiment was laid down on newly planted palms at the Eket Oil Palm Estate of the Eastern Nigeria Development Corporation. Two small field plantings were undertaken at the Main Station during 1966. They were a replanting of part of the more closely spaced plots of the Spacing and Grazing Experiment, where the yields per palm had been declining for some years, and seven acres of Field 1 to study the basic water requirements of the oil palm. In the pre-nursery, a major experiment on the use of polyethylene bags for growing oil palm seedlings was started.

Yields from the Implement Combination Trial for the six months, July to December 1966, have shown a strong positive response to the use of the Rome disc harrow. The implement is used at the end of the rainy season to reduce the vigour of the legume cover crop and to cultivate the ground. In the Fertilizer Experiment on a replanted area there has been a positive response in yield to the borate fertilizer (46% B_2O_3) applied in 1965.

As was mentioned in the WAIFOR Twelfth Annual Report, page 24, it is the Institute's practice to prepare four year summaries for long-term agronomic experiments except where the results of a particular year are of particular interest.

PRE-NURSERY AND NURSERY EXPERIMENTS

The use of polyethylene bags in raising oil palm seedlings is popular in the Far East. This technique requires a precise programme for planting to avoid the seedlings becoming pot-bound and a system of overhead sprinkler irrigation is essential. Early experiments at WAIFOR had shown that seedlings cannot be grown satisfactorily in baskets or "Whale-hide" pots under Nigerian conditions (Gunn, Sly and Chapas, 1961). In order to test the "polbag" system for Nigerian conditions, a comprehensive experiment in both the pre-nursery and nursery was planned.

Polybag Nursery Experiment: Pre-nursery Stage (*Expt. A.666*)

Planted in pre-nursery 1966. No. of seedlings, 7,500.
Layout: 25 randomized blocks of three treatments.
100 seedlings per plot.

Treatments:

1. Normal raised tray technique. Seedlings spaced 3 in. square.
2. Black polybag. Height 10 in. Diameter 4½ in.
3. Clear polybag. Height 10 in. Diameter 4½ in.

Heat treated top-soil was used for filling both the trays and the bags, which were stacked so that the seedlings were spaced at approximately 4½ in. square. The seedlings in the polybags had the advantage of a wider spacing over those in the normal raised trays.

Standard NIFOR Extension Work Seed was used for the experiment. The seed was set in the germinator in August 1966 and, to ensure uniformity, only material in the main flush of germination was planted. Whole blocks were completed at each planting. The bags were mulched with chopped bunch refuse and the trays, as usual, with spikelet refuse. Normal manuring and watering was carried out.

Full assessment of the pre-nursery experiment was delayed until May 1967, because the polybags required for the nursery stage of the experiment were not available in time. The data obtained at the final assessment are shown in Table 5. The significant increase in the number of leaves per seedling in the polybags may be due to the wider spacing and therefore fewer leaves being removed during sanitary pruning. The significant increase in height of seedlings grown in the clear polythene bags cannot be completely explained.

TABLE 5

EXPT. A.666. POLYBAG NURSERY EXPERIMENT, MAIN STATION

Data collected May 1967

Treatment	*Vacancies*		*Mean No. leaves per seedling*	*Mean height per seedling*
	No.	*%*		*in.*
1. Normal raised tray ..	236	9.4	4.88	12.70
2. Black polythene bag ..	220	8.8	5.61	12.42
3. Clear polythene bag ..	219	8.8	5.84	13.18
Least significant differences:				
P = 0.05	N.S.		0.17	0.48
P = 0.01			0.23	0.64
P = 0.001			0.30	0.84

Development of Late Germinating Seeds (Expt. A.668)

It has been observed that there are often many vacancies in pre-nursery trays planted with seed germinating after the main flush. Such seedlings as survive are often less vigorous than their earlier-germinating counterparts. In order to confirm this observation the following experiment was laid down in the pre-nursery. The survival rate was analysed in conjunction with the material in the Polybag Nursery Experiment (Expt. A.666) which used seed from the main flush. Experimental details are given overleaf.

Planted December 1966–April 1967. No. of seedlings, 1,890 (maximum).
Layout: Non-statistical. 105 seedlings per plot.

Treatments:

Inclusive of the main flush of germination of the 10,000 seed set for Expt. A.666, one tray of 105 seeds was planted each week for eighteen weeks. The seeds were chosen at random from those germinating in each week. Thus:

1st tray planted	3rd December 1966
18th tray planted	1st April 1967

Towards the end of the experiment fewer than 105 seeds germinated each week, in which case, all were planted. The observations are still continuing.

ESTABLISHMENT OF PALMS IN THE FIELD

Transplanting Experiment: Main Station (Expts. A.662, A.672)

This experiment, designed to test the value of a plastic spray for minimizing water losses from the seedling during and immediately after transplanting, was described in the NIFOR Second Annual Report, page 29. Height measurements and the counts of leaves produced were made regularly. The analysis of the data obtained confirmed the anticipated superiority of the Ball-of-earth transplanting method over the Improved Naked Root method, but showed no effect of either spraying leaves with or dipping roots in the plastic material. The plastic was also being examined as a possible alternative to the clay slurry that is used for the Improved Naked Root technique of transplanting oil palm seedlings.

The failure to detect any advantage of spraying leaves with the plastic coating might have been due to a very heavy rain-storm that broke in the afternoon of the day of planting. For this reason, the technique was modified slightly and the experiment (A.672) was repeated in late March 1967. All the palms were treated and lifted on the one day, stored overnight and then planted on the following day. It was hoped that the period of storage would increase moisture losses, and so the full benefit of the plastic material might be realized. No data is available yet from the modified experiment.

Transplanting Experiment: Main Station (Expt. 3–8)

Planted 1960. Area 13.7 acres. No. of palms, 820.

Layout: Three replications of a 4 × 2 factorial experiment. Plots of 30 palms with guard rows on the periphery only. (The nitrogen manuring experiment, Experiment 3–7 is superimposed on this experiment, one plot of Experiment 3–8 forming a block of Experiment 3–7.)

Treatments:

Nursery

1. High density; 2 ft. square spacing. 10,890 seedlings per acre.
2. Low density; 2½ ft. square spacing. 6,960 seedlings per acre.

At Transplanting

A. Normal root pruning. Leaves cut back to 3 ft. at lifting. Ball-of-earth planting.
B. Widest possible root-pruning (halfway between pairs of seedlings). Leaves cut back to 3 ft. at lifting. Improved naked-root planting.
C. Normal root pruning. Leaves cut back in early March. Ball-of-earth planting.
D. Control. Normal root pruning. No cutting back of leaves. Ball-of-earth planting.

This experiment was planted in May 1960 with seedlings raised from Ogba and NIFOR $D \times T$ Extension Work Seed. Harvesting commenced in July 1963 and the yields per acre since then have been as follows:

Treatment	*Yield per acre*				*Total*
	*1963**	*1964*	*1965*	*1966*	*1963-66*
	lb.	*lb.*	*lb.*	*lb.*	*lb.*
A. Ball-of-earth, leaves cut back at lifting	2,822	3,737	7,909	11,144	25,612
B. Naked root planting, leaves cut back at lifting	1,495	2,759	6,145	9,393	19,792
C. Ball-of-earth, leaves cut back 1 month before lifting	2,635	3,277	6,882	10,197	22,991
D. Ball-of-earth, leaves left entire	2,686	3,359	7,221	10,724	23,990
Least significant differences:	P = 0.05				976
	P = 0.01				1,355
	P = 0.001				1,884

*part year only

The figures show that the $D \times T$ material formerly issued by the Institute is capable of excellent yields, although the oil produced per acre from the mixture of *dura* and *tenera* bunches will be less than what could be obtained from a similar weight of *tenera*.

The experiment justifies the Institute's normal practice of cutting back all tall seedlings at the time of lifting and re-emphasizes the advantages of ball-of-earth planting over the naked root technique. Seedlings established by the latter technique do not appear to reach the same level of yield until several years after planting. There were no residual effects of the different nursery spacings used at the beginning of the experiment.

Field Planting Experiment: Main Station. (Expt 32–15)

Details of this experiment appeared in the NIFOR First Annual Report, page 26. The mean yield per acre in the sixth year of harvest (1966) was 10,734 lb.

Field Mulching Experiment: Main Station (Expt. 1–20)

Details of this experiment were given in the NIFOR First Annual Report, page 27. Harvesting commenced in July 1965 but the yield for the six month period, July to December 1965, was unusually low, averaging only 878 lb. per acre. The mean yield per acre for 1966, the first full year of harvesting, was 5,676 lb. The experimental site allowed room for only four replications of the randomized block design and the yields do not show any significant differences between treatments. However an interesting trend can be seen:

Treatments	*Yield per acre, 1966* lb.
1. Black polythene mulch (4 ft. × 4 ft.)	6,151
2. Vegetable mulch in the weeding circle	5,835
3. Hoeing of the weeding circle at ends of rains	5,583
4. Control (normal NIFOR ring weeding)	5,134 N.S.

Field Mulching Experiment: Main Station (Expt. 17–2)

This experiment contains some treatments which are similar to those in Experiment 1–20 (NIFOR First Annual Report, page 27), and was laid down in 1963 as split-plot treatments in the Mechanical Maintenance Experiment (17-2). Details are as follows.

Planted 1963. Area 32.2 acres. No. of palms 1,800.

Layout: Five randomized blocks each of eight whole-plot treatments. In two of the blocks, the plots are split into three sub-plots each of nine palms. In the other three blocks, the plots are split into two sub-plots each of 13 palms.

Treatments (to sub-plots):

Blocks I and II

1. Hand ring weeding
2. Mulch of cutlassings
3. Polythene mulch (4 ft. × 4 ft.)

Blocks III–V

4. Hand ring weeding
5. Mulch of cutlassings

Harvesting commenced in July 1966 and the yield per acre for the six month period to December 1966 was:

Treatments	*Yield per acre 1966* lb.	*Treatments*	*Yield per acre 1966* lb.
Hand ring weeding ..	1,263	Hand ring weeding ..	1,459
Mulch of cutlassings ..	1,458	Mulch of cutlassings ..	1,663
Polythene mulch ..	1,307		

The polythene mulch in this experiment became damaged much sooner than the polythene mulch used in Experiment 1–20 and this may explain the difference in the relative yields from the palms mulched with cutlassings and those mulched with polythene in the two experiments.

SEEDLING SELECTION

Nursery Seedling Selection Experiment: Main Station (Expt. 33–10)

Planted 1955. Area 27.6 acres. No. of palms 1,650.

Layout: This experiment (WAIFOR Eighth Annual Report, page 55) is a 3 × 2 × 2 factorial fertilizer experiment with six replications and plots of 12 palms. Each of the 72 plots is split into two sub-plots of six palms each for comparing two different methods of seedling selection.

Treatments:

1. On four replications of Experiment 33–39:
   - A. Tallest 50% of the seedlings from nursery beds.
   - B. Unselected (random) seedlings from these beds.
2. On two replications of Experiment 33–9:
   - A. Tallest 50% of the seedlings from nursery beds.
   - B. Smallest 50% of the seedlings from nursery beds.

The seedlings were selected by height, as judged by the length of the youngest fully open leaf, this being the method advocated by Devuyst (1954), and the selection methods were tested over a wide range of planting material (*dura* × *dura* and *dura* × *pisifera* Extension Work Seed from various stations, and progenies of selfed *dura* palms). The same material was not used in comparisons 1 and 2.

Data relating to leaf production and height measurements taken while the palms were immature appear on page 68 of the WAIFOR Sixth Annual Report. Harvesting commenced in January 1959 and the yields for the two four-year periods, 1959-62 and 1963-66, were:

Treatments	*Mean yield of bunches per acre per annum* 1959-62	1963-66
	lb.	*lb.*
1. 50% largest	7,417	11,519
Unselected	7,126	11,264
Least Significant Difference P = 0.05 ..	350	413
2. 50% largest	7,721	14,921
50% smallest	6,651	13,506
Least Significant Difference P = 0.05 ..	—	1,044
P = 0.01 ..	944	1,464

This experiment has certainly failed to substantiate Devuyst's claim that by eliminating 50% of the seedlings in the nursery it should be possible to increase bunch production by as much as 40%.

Seedling Selection Experiment: Main Station (Expt. A.653)

This experiment, described in detail in NIFOR First Annual Report, page 28, was planted into the field in May 1966 and was re-numbered as Experiment 33-13. It is now under the control of the Statistics Division.

PREPARATION OF LAND AND MANAGEMENT OF YOUNG PLANTATIONS

Establishment Experiments: Main Station and Abak (Expts. 33–1 and 506–2)

Mean yields per acre for 1966 were Main Station (33–1), 9,476 lb. and Abak (506–2), 4,803 lb.

De-flowering Experiment: Elele Estate (Expt. 654–2)

Details of this experiment were given in the NIFOR Second Annual Report, page 33. Height measurements taken in April 1967 did not show any significant differences between treatments. The mean height of the palms was 97.9 in. Routine dressings of NK fertilizer mixture were applied.

THE COMBINATION OF PLANTING PALMS AND FARMING

Planting and Farming Experiment: Main Station (Expt. 24–1)

Full details of this experiment were given in the NIFOR First Annual Report, pages 29 and 30. Palms planted at normal spacing gave a mean yield of 9,474 lb. of bunches per acre in 1966, the sixth year of harvesting. The whole-plot treatments of establishment method or of fertilizer application did not affect the yields significantly.

Planting and Farming Experiment: Abak (Expt. 507–3)

The details for this experiment, previously published in WAIFOR Sixth Annual Report, page 65, were wrongly recorded and the corrected details are as follows:

Planted 1957. Area 21.1 acres. No. of palms 907.

Layout: Five replications of a 2 × 2 factorial experiment with plots of 24 palms, split into three sub-plots of eight palms comparing three different systems of planting. Guard rows surround whole plots.

Treatments:

Factor	*Level 0*	*Level 1*	
A. Fertilizer (to palms)	Nil	Fertilizer in April	
B. Establishment intercropping	Nil	Intercropping for two years	
C. System of planting (split-plots)	Normal density (60 per acre)	Half density (30 per acre)	Two-thirds density (45 per acre)

The half and two-thirds density plantings allow rotational farming of the wide inter-lines. These are at present under bush fallow. In treatment A, the fertilizer mixture which involves an annual application of 3 lb. of sulphate of ammonia and a triennial dressing of 5 lb. sulphate of potash and 3 lb. of calcined magnesium sulphate caused a significant increase in crop during 1966:

Treatments	*Yield of fruit bunches per acre 1966* lb.
1. No fertilizer	4,849
2. Fertilizer each April	6,480
Least significant difference: P = 0.01	1,697

This effect has been averaged over the density (split-plot) variable. The mean yield per acre of the palms at normal spacing was 7,328 lb. of fruit bunches.

MIXED CROPPING

Oil Palm and Coffee Experiment: Njala (Sierra Leone) (Expt. 910–4)

Summaries of the yield of fresh coffee cherries and oil palm fruit bunches from this experiment for 1966 appear in Table 6. Although the earlier data reported on page 29 of the WAIFOR Eleventh Annual Report indicated that both crops yielded best when in pure stand (Treatment A), the highest total weight of produce, derived from the combined mean yield per acre for both crops has come from the interplanted Treatment C as shown in Table 6. However, there is no apparent reason why the yield of palm fruit from Treatments B and D should be lower than that from Treatment C, when the palm population per acre is similar. A more accurate assessment of the different treatments will be based on the cash value of the total produce per acre, rather than on weights.

Oil Palm and Cocoa Experiments: Onishere Farm Settlement (Expt. 210–2) and Gambari Experiment Station (Expt. 205–1)

The palms in these two young experiments continued to make satisfactory growth. Routine applications of fertilizers have been made. Height measurements taken in both experiments in October 1966 showed no significant influence of the different treatments. The mean heights per seedling were:

Experiment 210–2 (30 months from planting) ..	109 in.
Experiment 205–1 (18 months from planting) ..	76 in.

At Onishere, there were again severe infestations of grasshoppers (*Zonoceros variegatus*) during the dry season. These were controlled by incorporating dieldrin in the routine fungicidal spray. Palms at Gambari suffered from depredations by cutting-grass (*Thryonomys swinderianus*) and 12% of the stands had to be supplied in April 1967.

TABLE 6

EXPT. 910–4. OIL PALM AND COFFEE EXPERIMENT: NJALA (SIERRA LEONE)

Mean yield of coffee (fresh cherry) and palm bunches, 1966

Treatments	*Yield of coffee per acre (1965-66 season)*	*Yield of bunches per acre 1966*	*Total weight of produce per acre*
	lb.	*lb.*	*lb.*
A. Pure stand of coffee and oil palm. Oil palm 30 ft. triangular (55.6/acre). Coffee 10 ft. square (435.6/acre)	1,742	6,694	4,218*
B. Oil palm at 30 ft. triangular with one row in three omitted (37.1/acre). Coffee at 10 ft. square in wide interlines (130.1/acre)	574	4,762	5,336
C. Oil palm at 30 ft. × 40 ft. (36.3/acre). Coffee interplanted at 10 ft. square (286.7/acre) ..	833	5,156	5,989
D. Oil palm at 30 ft. square with alternate palms in alternate rows omitted (36.3/acre). Coffee at 10 ft. square in the hollow squares so formed (289.2/acre)	724	4,351	5,075

**i.e.* half an acre of coffee and half an acre of oil palm.

Oil Palm and Cocoa Experiment: Ikom (Expt. 670–1)

The nursery established at Ikom in April 1966 (see page 36, NIFOR Second Annual Report) made very good growth. A site for the experiment was chosen in December 1966 at the western boundary of the Cocoa Research Institute of Nigeria Sub-Station, where it adjoins the Eastern Nigeria Development Corporation Cocoa Estate. The area was felled, burnt and marked out in February and March 1967. The palm seedlings were due for planting in April 1967. The great quantity of timber remaining on the ground after the burning will necessitate postponing the planting of the cocoa seedlings till 1968. Details of the experiment are as follows:

Planted 1967. Area 21 acres. No. of palms 742.

Layout: Seven replications of randomized blocks of three treatments. Plots 210 ft. square (approx. 1 acre).

Treatments:

X. *Control.* Pure stands of oil palm and cocoa at 30 ft. triangular and 5 ft. × 5 ft. respectively (33 palms, 646 cocoa bushes per plot).

Y. *Avenue planting.* One line in three omitted and cocoa planted 5 ft. × 5 ft. in the wide interline (33 palms, 684 cocoa bushes per plot).

Z. *Hollow squares.* Palms planted 30 ft. × 30 ft. with alternate palms in alternate lines omitted. Cocoa planted at 5 ft. × 5 ft. in the "hollow squares" so formed (40 palms, 648 cocoa bushes per plot).

SPACING

Spacing-Grazing-Intercropping Experiment: Main Station (Expt. 22–1)

Details and a discussion of this experiment appeared in the NIFOR First Annual Report, pages 32-34. The yield data for 1966 followed the same trends as previously. The young seedlings in the replanted plots (see NIFOR Second Annual Report, page 36) have received routine dressings of fertilizer and are making satisfactory growth.

Spacing and Intercropping Experiments, Ghana: Aiyinasi and Bunsu (Expts. 803–1; 812–1)

In both experiments the highest yield per acre in 1966 came from the palms at 29 ft. triangular spacing. The average production from these palms at normal spacing was:

Expt. 803–1	5,381 lb. per acre
Expt. 812–1	5,244 lb. per acre

This was the seventh year of harvesting.

MANURING

The Institute's recommendation for application of potash fertilizer is equivalent to the K_2 level (5 lb. K_2SO_4 per palm triennially) in most of the general fertilizer experiments where there are four levels of potash. Several experiments have shown that the K_1 (2½ lb. K_2SO_4) dressing usually causes a significant response in yield and the K_2 and K_3 (7½ lb. K_2SO_4) dressings only occasionally produce a statistically significant or economic increase beyond the K_1 yield. It has been suggested that the Institute's recommended rate of potash manuring is too low, but from available experimental evidence it would appear to be quite justified.

A new major element fertilizer experiment was laid down in June 1966 on newly planted palms in the Etebi Division of the Eket Oil Palm Estate of E.N.D.C.

Exploratory Fertilizer Experiments

These experiments have fertilizers applied at only two levels (presence and absence) because they are designed only to give basic information.

Fertilizer Experiment: Abak (Expt. 506–3)

Planted 1951. Area 14.6 acres. No. of palms 877.

Layout: One replication of a 2^5 confounded factorial experiment. Plots of 12 palms separated or surrounded by a single guard row.

Treatments (nil levels not shown):

Fertilizer	*Levels*	*Year from planting*					
		12	*13*	*14*	*15*	*16*	*17*
		1962	*1963*	*1964*	*1965*	*1966*	*1967*
		lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
N. Sulphate of ammonia ..	2	3	3	3	3	3	3
P. Superphosphate ..	4	8	—	—	8	—	—
K. Sulphate of potash ..	4	2½	—	—	2½	—	—
		5	—	—	5	—	—
		7½	—	—	7½	—	—
Mg. Calcined $MgSO_4$ ..	2	5	—	—	5	—	—

Between 1951 and 1959 the experiment included lime, and all fertilizers were applied on the basis of 1 lb. per palm per year of age. An assessment of the experiment in 1959 (see WAIFOR Eighth Annual Report, page 61) showed that wholly uneconomic quantities of fertilizer had been applied which could never be paid for by the extra crop. All fertilizer applications were therefore suspended until 1962 when the modified schedule shown above was introduced. As explained on page 31 of the WAIFOR Eleventh Annual Report, an additional level of potash was included instead of the previous application of lime.

Yields for the period 1963-66 have been analysed and show a significant response to potash applications:

Treatments	*Yield per acre, 1963-66*
	lb.
K_0	19,125
K_1	26,368
K_2	32,269
K_3	31,600
Least significant differences:	
P = 0.05	8,081
P = 0.01	11,494
P = 0.001	16,637

Considering the type of soils at Abak and the age of the palms, the mean yield per acre for the K_2 treatment of 8,067 lb. per annum is quite satisfactory. The mean for this treatment in the previous four-year period 1959-62 was 8,361 lb. per acre.

Fertilizer Experiment: Kwa Falls Estate (Expt. 554–1)

Experimental details were given in the NIFOR Second Annual Report, page 38. All fertilizers were applied in 1967 according to schedule. This was the fourth general application, previous ones being in 1958, 1961 and 1964. The yields for 1966 repeated the same trends as shown previously. The mean yield per acre for 1966 was 8,056 lb.

Fertilizer Experiments, Ghana: Aiyinasi (Expt. 801–1), Assin Foso (Expt. 809–1), Bunsu (Expt. 810–1), Kwadaso (Expt. 821–1), Bechem (Expt. 822–1) and Akaa (Expt. 831–2)

These experiments were established by the Ghana Ministry of Agriculture using WAIFOR Extension Work Seed. The mean yields per acre for 1966 were:

Site	*Expt. No.*	*Year*	*Yield per acre 1966*
			lb.
Aiyinasi	801–1	1954	5,802
Assin Foso	809–1	1955	6,796
Bunsu	810–1	1954	8,898
Kwadaso	821–1	1955	5,342
Bechem	822–1	1957	8,030
Akaa	831–2	1957	5,568

Yields from the experiments in Ghana appear to have dropped sharply in 1966.

General Fertilizer Experiments

Fertilizer Experiment: Onishere Farm Settlement (Expt. 210–1)

Fertilizers were applied in April 1966 and 1967 according to treatment (see NIFOR First Annual Report, page 37). Although the rainfall at Onishere for 1966 totalled 79 inches, the dry season was again intense. Grasshoppers (*Zonoceros variegatus*) again caused damage to the palms during the dry weather and the Pathology Division arranged for regular spraying with dieldrin to control the grasshoppers.

Statistical analysis of height measurements taken in October 1966 showed that none of the treatments had significantly affected the heights:

Treatments	*Mean height per palm October 1966*	*Treatments*	*Mean height per palm October 1966*
	in.		*in.*
N_0 ..	100.2	K_0 ..	101.7
N_1 ..	101.8	K_1 ..	99.0
N_2 ..	100.2	K_2 ..	102.9
N_3 ..	101.3	K_3 ..	100.0
P_0 ..	102.8	Mg_0 ..	101.6
P_1 ..	99.1	Mg_1 ..	100.2
P_2 ..	99.4		
P_3 ..	102.2		

Fertilizer Experiment: Abak Sub-Station (Expt. 508–1)

Details of this experiment were given in the NIFOR First Annual Report, page 38. A further application of 3 oz. of borate (46% B_2O_3) per palm was made in May 1967. The yield per acre for 1966 (the first full year of harvest) has been analysed and all the major elements have significantly increased the yield per acre, but unlike Expt. 2–15, there has not been a response to boron.

Experiment 508–1

Treatments	*Yield per acre 1966*	*Treatments*	*Yield per acre, 1966*
	lb.		*lb.*
N_0	3,280	Mg_0	3,348
N_1	3,806	Mg_1	3,895
N_2	3,900	Mg_2	3,765
N_3	3,891	Mg_3	4,358
		L.S.D.	
K_0	2,704	P = 0.05 ..	438
K_1	3,780	P = 0.01 ..	583
K_2	4,035	P = 0.001 ..	758
K_3	4,358		
L.S.D.		P_0	3,531
P = 0.05 ..	438	P_1	3,907
P = 0.01 ..	583	L.S.D.	
P = 0.001 ..	758	P = 0.05 ..	310
		P = 0.01 ..	412

Fertilizer Experiment on a Gneiss Soil: Calaro Estate (Expt. 556–1)

Planted 1959. Area 45 acres (approx.). No. of palms 2,541.

Layout: Half replicate of a partially confounded $4^3 \times 2^2$ factorial design in blocks of 16 plots, with nine palms per plot and plots separated or surrounded by a single guard row. Provision was made for the later introduction of another treatment by leaving one of the two-level factors un-allocated at the start of the experiment.

Treatments (nil levels not shown):

Fertilizer		*Year*								
		0-9	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*
			1959	*1960*	*1961*	*1962*	*1963*	*1964*	*1965*	*1966*	*1967*
		lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
N	Sulphate of	10	¼	½	1	1¼	1¼	1¼	1¼	1¼	1¼
	ammonia	20	½	1	2	2½	2½	2½	2½	2½	2½
		30	¾	1½	3	3¾	3¾	3¾	3¾	3¾	3¾
P	Superphosphate	10	¼	½	1	3¾	—	—	4½	—	—
		20	½	1	2	7½	—	—	9	—	—
		30	¾	1½	3	11¼	—	—	13½	—	—
Mg	Magnesium	12	¼	¾	1½	4½	—	—	5	—	—
	sulphate	24	½	1½	3	9	—	—	10	—	—
	(46/48% $MgSO_4$)	36	¾	2¼	4½	13½	—	—	15	—	—
K	Potassium sulphate	12	½	1	2	3½	—	—	5	—	—
X	Un-allocated										

The fertilizers were applied for the first time in April 1960, when the quantities due in 1959 and 1960 were given. All fertilizers were broadcast evenly around the palms, the area covered being gradually increased each year as the palms grow. Harvesting started in March 1963. The yields for the four-year period 1963-66 have been analysed and show strong positive responses to both phosphate and magnesium.

Treatments	*Yield of fruit bunches per acre*				
	*1963**	*1964*	*1965*	*1966*	*Total 1963-66*
	lb.	*lb.*	*lb.*	*lb.*	*lb.*
P_0	1,162	2,270	5,375	5,002	13,809
P_1	1,343	3,028	6,560	6,237	17,168
P_2	1,259	3,040	6,616	6,483	17,398
P_3	1,317	2,938	6,681	6,507	17,443
Mg_0	1,124	2,814	5,890	6,063	15,891
Mg_1	1,209	2,576	5,959	5,634	15,378
Mg_2	1,375	3,002	6,667	6,053	17,097
Mg_3	1,373	2,885	6,717	6,478	17,453
Least significant difference: P = 0.05					1,829
P = 0.01					2,429
P = 0.001					3,153

*part year only

Fertilizer Experiment on a Mica Schist Soil: Calaro Estate (Expt. 556–2)

This experiment sited on the other main soil type at Calaro Estate was planted in 1962 and the treatments started in the same year. Full details were given on pages 42-3 of the NIFOR Second Annual Report. Harvesting commenced in September 1965. Yields for 1966 (the first full year of harvesting) have been analysed and show positive responses to both nitrogen and phosphate applications:

Treatments	*Yield per acre, 1966*	*Treatments*	*Yield per acre, 1966*
	lb.		*lb.*
N_0	2,718	P_0	2,501
N_1	2,851	P_1	3,353
N_2	3,287	P_2	3,235
N_3	3,114	P_3	2,882
Least significant differences for N and P treatments:		P = 0.05 ..	334
		P = 0.01 ..	444
		P = 0.001 ..	576

There were also significant interactions between nitrogen and phosphate, nitrogen and magnesium, and nitrogen and potash applications. Nitrogen fertilizer was applied according to schedule in March 1967.

Fertilizer Experiment: Eket Estate (Expt. 570–1)

This experiment commenced in June 1966. The details are as follows:

Planted 1966. Area 20.7 acres. No. of palms 1,152.

Layout: Quarter replicate of $4^4 \times 2$ factorial in eight blocks of 16 plots each. Plots of nine palms with shared guard rows.

Treatments (nil levels not shown):

Fertilizer		*No. of levels*	*0-9*	*Year* 0 1966 lb.	1 1967 lb.	2 1968 lb.	3 1969 lb.	4 1970 lb.	5 1971 lb.	6 1972 lb.	7 1973 lb.	8 1974 lb.
N	Sulphate of ammonia	4	10	¼+¼	½	1	1*	1	1½	1½	1½	1½
			20	½+½	1	2	2	2	3	3	3	3
			30	¾+¾	1½	3	3	3	4½	4½	4½	4½
P	Single super-phosphate	4	10	¼	½	1	3¾	—	—	4½	—	—
			20	½	1	2	7½	—	—	9	—	—
			30	¾	1½	3	11¼	—	—	13½	—	—
Mg	Calcined magnesium sulphate	4	6	¼	½	¾	2	—	—	2½	—	—
			12	½	1	1½	4	—	—	5	—	—
			18	¾	1½	2¼	6	—	—	7½	—	—
K	Sulphate of potash	4	6½	¼	½	1¼	2	—	—	2½	—	—
			13	½	1	2½	4	—	—	5	—	—
			19½	¾	1½	3¾	6	—	—	7½	—	—
X	—	2	Vacant at the start of the experiment.									

*The data from Experiment 654–1 (see below) at Elele Estate will be reviewed in 1969 and a decision taken whether the nitrogen manuring should continue after that year.

Fertilizers for 1966 and 1967 have been applied according to schedule. The palms are making satisfactory growth.

Fertilizer Experiment: Elele Estate (Expt. 654–1)

Full details of this experiment were given on pages 43 and 44 of the NIFOR Second Annual Report. Yields for 1966 (the first full year of harvesting) have been analysed but there are no significant effects of the fertilizer applications. The co-efficient of variation in the analysis was high, probably due to the variable ages of the seedlings resulting from the frequent supplying necessitated by the severe rodent damage in the earlier years.

Nitrogen fertilizer was applied according to schedule in March 1967.

Fertilizer Experiment on the "Bad Lands": Umuabi (Expt. 756–1)

There was a full discussion of the treatments in this experiment in the NIFOR Second Annual Report, pages 44-46 and the NIFOR First Annual Report, page 41. Harvesting commenced in 1966, four years from planting, on a fortnightly basis as the yield of fruit bunches did not warrant more frequent harvesting. Many plots have not yielded bunches and statistical analysis is not therefore possible. However, in the bearing plots, all the major elements appear to have increased the yield.

Treatments	*Yield per acre, 1966 lb.*	*Treatments*	*Yield per acre, 1966 lb.*
K_0	89.7	N_1	57.1
K_1	128.3	N_2	205.6
K_2	176.0		
P_0	114.0	Mg_0	72.5
P_1	148.7	Mg_1	190.2

Boron, applied as a split-plot treatment, has not affected the yield.

Fertilizer Experiment: Acharu (Expt. 762–3)

Details of this experiment appeared in the NIFOR First Annual Report, pages 42-3. Owing to serious fires in the dry season of 1965-66, there was little fruit to harvest in 1966. Regular harvesting was resumed in January 1967. Nitrogen fertilizers were applied according to schedule in April 1967.

Fertilizer Experiment on a Concretionary Soil: Njala (Sierra Leone) (Expt. 904–1)

The yields from this experiment continue to be disappointingly low, but the trend in response to phosphate applications has continued. The 1966 data also show a response to nitrogen which suggests that excessive application can depress yields.

Treatments	*Yield per acre, 1966 lb.*	*Treatments*	*Yield per acre, 1966 lb.*
N_0	1,726	P_0	1,483
N_1	2,028	P_1	2,208
N_2	2,437	P_2	2,170
N_3	1,831	P_3	2,161

Least significant difference for N and P treatments:	$P = 0.05$ ..	457
	$P = 0.01$ ..	607
	$P = 0.001$ ..	787

Fertilizer Experiments on Replanted Areas

Fertilizer Experiment on a Replanted Area: Main Station (Expt. 2–15)

Details of this experiment were given in the NIFOR First Annual Report, pages 43 to 45. The trace element variable, which had been left vacant at the beginning of the experiment, was introduced in May 1965 when borate (46% B_2O_3) was applied according to treatment. This was repeated in March 1967 at the same time as the three-yearly application of other fertilizers.

Yields for 1966, the second year of harvesting, show significant responses to applications of potash, ground rock phosphate and boron. Boron shows a strong interaction with magnesium applications.

Treatments	*Yield per acre, 1966*	*Treatments*	*Yield per acre, 1966*
	lb.		*lb.*
K_0	7,505	P_0	7,949
K_1	8,508	P_1	8,727
K_2	8,593		
K_3	8,746		
L.S.D.		L.S.D.	
P = 0.05 ..	836	P = 0.05 ..	585
P = 0.01 ..	1,109	P = 0.01 ..	777
P = 0.001 ..	1,440	P = 0.001 ..	1,008

Treatments	*Yield of fruit bunches per acre, 1966*		
	Without Boron	*With Boron*	*Mean*
	lb.	*lb.*	*lb.*
Mg_0	8,182	8,264	8,223
Mg_1	7,818	9,088	8,453
Mean	8,000	8,676	

Least significant differences:	P = 0.05	P = 0.01	P = 0.001
	lb.	*lb.*	*lb.*
Within the body of the table	836	1,109	1,440
On the same border ..	585	777	1,008

Nitrogen Fertilizer Experiments

Nitrogen Fertilizer Experiment: Main Station (Expt. 3–7)

In two earlier nitrogen manuring experiments (Expts. 5–4 and 911–2) the emphasis was on determining the best time of application of nitrogen rather than finding the most suitable form of nitrogen to apply to the oil palms. In this experiment, four *types* of nitrogenous fertilizer were used including, for the first time, a nitrate source of nitrogen. Details of the experiment are given opposite.

Planted 1960. Area 13.7 acres. No. of palms, 820.

Layout: Twenty-four randomized blocks of five treatments. Plots of six palms with guard rows on the periphery only.

Treatments:	*Rate per palm in year of planting*	*Rate per palm in 1963 and 1964*
	g.	*lb.*
A. Nitrate of soda (16% N)	290	4
B. Sulphate of ammonia (20.6% N)	227	3
C. Ammonium phosphate (11.0% N)	422	6
D. Urea (42% N)	109	1½
E. Control	Nil	Nil

The palms were planted in May 1960 and the first application of fertilizers took place six weeks after planting. Twice the initial quantities were applied in 1961, and four times the quantities in April 1962. In 1963 and 1964 the rates were increased as shown. Each treatment supplies an equal quantity of nitrogen on any one occasion.

Height measurements taken during early years showed that the application of nitrogen had significantly increased the growth of the palms but showed no differences between the types of nitrogenous fertilizer.

Harvesting commenced in July 1963 and the yields for the three and a half years to December 1966 have been analysed. This has not revealed any significant differences between treatments. The mean yield per acre in 1966 was 10,362 lb.

Treatments	*Total yield of fruit bunches per acre 1963-66*
	lb.
A. Nitrate of soda	23,030
B. Sulphate of ammonia	23,153
C. Ammonium phosphate	23,449
D. Urea	23,060
E. Control	22,886

Phosphate Fertilizer Experiments

Phosphate Fertilizer Experiment: Kwa Falls Estate (Expt. 555–1)

Details of this experiment were given in the NIFOR Second Annual Report, page 48. The yields in 1966 showed the same non-significant trend in favour of phosphate applications. The mean yield for 1966 of 7,876 lb. per acre was a big drop on previous years.

Potassium Fertilizer Experiments

Potash Fertilizer Experiment: Ogba Farm (Expt. 104–2)

This experiment was discussed in the NIFOR Second Annual Report, page 49. The response to the potash applications has continued.

Treatments		*Adjusted mean yield per acre 1966*
		lb.
K_0		3,094
K_1		5,670
K_2		5,215
Least significant differences:	P = 0.05	1,141
	P = 0.01	1,578
	P = 0.001	2,181

The rate K_1 is approximately the same as the Institute's recommended rate of potash manuring.

Potash Fertilizer Experiment: Main Station (Expt. 33–12)

Details of the experiment were given in the NIFOR Second Annual Report, pages 49 and 50. Fertilizers were applied according to schedule in April 1967. The earlier treatments did not have any significant effect on the yield of fruit bunches in 1966. Details of foliar analyses are given on page 96.

Magnesium Fertilizer Experiments

Magnesium Fertilizer Experiment: Njala (Sierra Leone) (Expt. 916–1)

Details of this experiment appeared in the NIFOR First Annual Report, pages 46 and 47. Yields for 1966 dropped sharply and differences between treatments were not significant. The mean yield per acre was 6,314 lb. of fruit bunches.

Trace Element Experiments

Trace Element Experiments: Main Station (Expt. 32–16) and Abak (Expt. 506–7)

The yield data for 1966 showed a positive response to applications of zinc at Abak:

Treatments (Abak)		*Adjusted yield per acre 1966*
		lb.
Z_0		8,920
Z_1		10,082
Least significant difference:	P = 0.05	904
	P = 0.01	1,224

There was also a significant interaction of manganese and copper applications at Abak. In the experiment at the Main Station there were significant interactions between boron and zinc, and boron and copper applications. Palms in the two experiments received a uniform dressing of 2 lb. of sulphate of ammonia in April 1967. This was followed later in the same month by the trace element treatments.

Micro-Nutrient Experiment: Main Station (Expt. 9–2)

Details of this experiment were given in the NIFOR Second Annual Report, pages 50 and 51. The foliar application of the micro-nutrients by the Soil Chemistry Division has continued. In view of the interaction between boron and magnesium applications in Experiment 2–15, magnesium was included in the routine dressing of major elements made in April 1967.

Height measurements were made in October 1966. Statistical analysis showed that iron applications which previously had reduced frond production, now depressed growth. There was also a negative interaction between applications of boron and molybdenum.

Treatments	*Mean height of youngest fully open frond in.*
Fe_0	101.3
Fe_1	97.7
Least significant difference: P = 0.05 ..	3.1
P = 0.01 ..	4.1

Time and Frequency of Application

Frequency of Potash Manuring Experiment: Main Station (Expt. 9–3)

This experiment was planted in March 1967, using Special Grade E.W.S. seedlings from the main nursery. It forms a replanting of part of the former Experiment 9–1 where the old palms were felled and burnt in such a way that mechanized operations could be introduced from the outset. Establishment has been excellent. Experimental details are as follows.

Planted 1967. Area 17.1 acres. No. of palms, 1,023.

Layout: Six replications of 2 × 4 factorial layout, with 12 palms per plot separated or surrounded by a single guard row.

Treatments:

A. *Frequency of K application.* For the first three years routine applications of potash will be given. Thereafter potash applications will be annual, two-yearly, three-yearly or four-yearly according to treatment.

B. *Form of K fertilizer.* Half the plots will receive sulphate of potash, the others muriate of potash.

Routine nitrogen and magnesium dressings will also be given. Sulphate of ammonia and magnesium sulphate will be used in the sulphate of potash plots, and urea and calcined magnesite will be applied in the muriate of potash plots. Thus it will be possible to evaluate the effect of sulphate and chloride ions on the palms' growth.

Time of Manuring Experiment: Main Station (Expt. 33–9)

Planted 1955. Area 27.6 acres. No. of palms, 1,650.

Layout: Six replications of a 3 × 2 × 2 factorial experiment. Plots of 12 palms separated or surrounded by a single guard row. Fertilizers applied in 1956 at half rates, thereafter annually at the full rate per palm, until 1964.

Treatments:

1. Time of application: April; October; half in April plus half in October.
2. Bunch refuse: Nil and 56 lb. per palm.
3. Fertilizer: 6 lb. per palm of 1 : 1 : 1 : PKMg mixture.

Results from the former Bunch Refuse Experiment (Expt. 3–3) indicated that the time of application had an important effect on flowering and hence on yield (see Table 47, page 81, WAIFOR Sixth Annual Report). The present experiment was planned with the object of confirming these results, for both organic and inorganic manures.

The early growth of the palms was uniform and very satisfactory (WAIFOR Sixth Annual Report, page 76). Harvesting commenced in January 1959 and yields have been above average throughout. The yields for neither the first four-year period (1959-62) nor the second (1963-66) have shown any significant effects of the treatments. The experiment will be concluded at the end of 1967.

Treatment		*Mean yield per acre per annum 1963-66*
		lb.
1. Time of application:	April	11,223
	October	11,535
	April + October ..	11,417
2. Bunch refuse:	Nil	11,290
	56 lb. per palm ..	11,494
3. Fertilizer:	PKMg mixture ..	11,053
	NPKMg mixture ..	11,730

Fertilizer Experiments on Former Arable Land

Former Arable Fertilizer Experiments: Main Station (Expts. 20–9 and 33–11)

Full experimental details concerning these experiments were published in the NIFOR Second Annual Report, pages 51 and 52. Yields for 1966 have been analysed and show a response to potash applications in Experiment 20–9 (the less fertile site) and a response to phosphate in Experiment 33–11.

Expt. 20–9		*Expt. 33–11*	
Treatment	*Yield per acre, 1966 lb.*	*Treatment*	*Yield per acre, 1966 lb.*
K_0	4,358	P_0	8,856
K_1	4,461	P_1	9,926
K_2	5,033	P_2	10,152
L.S.D. $P = 0.05$ ..	631	L.S.D. $P = 0.05$ ..	1,227
$P = 0.01$ ..	844	$P = 0.01$ ..	1,695

PRUNING

Establishment Pruning Experiment: Main Station (Expt. 17–3)

Details of the experiment were given in the NIFOR First Annual Report, page 48. Harvesting commenced in July 1966. The six months yields from July to December 1966 have been analysed, but showed no effect of the pruning treatments upon yield.

REPLANTING

Replanting Experiment: Main Station (Expt. 6–6)

Experimental details were given in the NIFOR Second Annual Report, page 53. The yields from the three blocks replanted in 1959 have been summarized for the period 1959-66 and details are shown in Table 7. In the three blocks replanted in 1960, the young palms in the clear felled treatment continued to give the highest yield in 1966:

Treatment (1960 replanting)	*Yield per acre, 1966 lb.*
A. Alternate E-W rows felled at replanting, remainder two years later	5,283
B. Alternate N-S rows felled at replanting, remainder two years later	4,461
C. Pruning to half canopy at replanting, again three months later and to spear one year later. Fell after two years	5,024
D. All old palms felled before replanting	6,446
E. Yaligimba method: Fell one-third palms at replanting, alternate rows one year later, remainder after two years	4,675
Least significant differences: $P = 0.05$	877
$P = 0.01$	1,216

Trenches were dug late in 1966 to demarcate the sub-plot boundaries and the first of a new series of regular three-yearly applications of KMg fertilizers was made according to treatment in April 1967.

TABLE 7

EXPT. 6–6. REPLANTING EXPERIMENT: MAIN STATION

Total yield of fruit bunches per acre (1959 replanting only)

Treatments	*Yield from old palms: 1959 + 1960*	*Yield from replanted palms*				*Total yields 1959-66*
		1963	*1964*	*1965*	*1966*	
	lb.	*lb.*	*lb.*	*lb.*	*lb.*	*lb.*
A. Alternate E-W rows of old palms felled in year of replanting; remainder two years later	9,062	1,058	2,538	5,123	5,054	22,835
B. Alternate N-S rows of old palms felled in year of replanting; remainder two years later	9,432	1,154	2,709	4,865	4,706	22,866
C. Old palms pruned to half canopy at replanting, again three months later and to spear one year later. Felled after two years	11,582	1,745	3,089	4,678	5,920	27,014
D. All old palms felled before replanting	Nil	2,855	3,705	7,312	5,152	19,024
E. Yaligimba method: one-third last productive old palms felled at planting; alternate rows felled one year later and remainder after two years	9,241	1,236	2,549	4,889	5,134	23,049
Least significant differences: P = 0.05						4,157
P = 0.01						6,048
P = 0.001						9,088

MECHANICAL MAINTENANCE OF PALM FIELDS

Mechanical maintenance proceeded satisfactorily during the year and is now a routine operation in a number of fields including the experimental fields mentioned below. Modifications were carried out to the draw-bar of the triple-gang Holt Mk. VIIIA Weedbreaker, so that the draw-bar could be carried on the 3-point linkage of the tractor. Despite this, the implement still had too great a draught for operation behind an MF 165 tractor on the soil at the Main Station.

The Agronomy Division held an open day at the experimental site at Umuabi, near Udi, in November 1966 and demonstrated different types of slashers and the Holt Weedbreaker to a large party of students from the University of Nigeria, Nsukka, local farmers and school children.

A paper was prepared for publication in *World Crops* setting out the Institute's ideas on how mechanical maintenance could be introduced into farm settlements.

Mechanical Maintenance Experiment on Adult Palms: Main Station (Expt. 3–9)

Details of the experiment were given in the NIFOR First Annual Report, page 50. Treatments have continued according to schedule. The mean yield of fruit bunches per acre in 1966 was 6,587 lb.

Implement Combination Trial: Main Station (Expt. 17–1)

Planted 1963. Area 59.1 acres. No. of palms, 3,300.

Layout: Four randomized blocks of nine plots. Plots of 56 palms, fully guarded. (The plots are split for a comparison of herbicide ring-weeding.)

Treatments (whole plot):

	Early rains	*Mid-rains*	*Late rains*
1.	Marden roller	Marden roller	Marden roller
2.	Marden roller	Marden roller	Disc harrow
3.	Marden roller	Other implements as necessary*	
4.	Ring roller	Ring roller	Ring roller
5.	Ring roller	Ring roller	Disc harrow
6.	Ring roller	Other implements as necessary*	
7.	Wilder scrub-cutter	Wilder scrub-cutter	Wilder scrub-cutter
8.	Wilder scrub-cutter	Wilder scrub-cutter	Disc harrow
9.	Wilder scrub-cutter	Other implements as necessary*	

*To date, the implement used has been the ring roller

A description of the establishment of this experiment was given in the WAIFOR Twelfth Annual Report, pages 41 and 42. Both 1965 and 1966 were exceptionally wet years and the *Pueraria phaseoloides* cover grew very fast. This necessitated maintenance four times each year and this was achieved within the framework of the experimental design, by repeating the "Mid-rains" treatments twice (June and September).

The plots treated with the ring roller have a thick, luxuriant cover of *Pueraria*. In plots treated with other implements the legume cover was less dense and some grasses and herbaceous annual weeds were present. The treatment with the disc harrow at the end of the rainy season was the most successful. The harrow cuts up the legume runners and incorporates them partly in the cultivated surface soil. The *Pueraria* recovers quickly from this treatment when the rains commence the next year. It is assumed that the harrowing greatly reduces the competition for water by the cover crop during the dry season. As can be seen from the yields for the six-month period July-December 1966, the treatment has significantly increased the crop of fruit from the young palms:

Treatment	*Yield per acre, July-December, 1966*
	lb.
1. Marden/Marden/Marden	1,408
2. Marden/Marden/Discs*	1,688
3. Marden/Rings/Rings	1,318
4. Rings/Rings/Rings	1,372
5. Rings/Rings/Discs*	1,634
6. Rings/Rings/Rings	1,330
7. Scrub-cutter/Scrub-cutter/Scrub-cutter	1,411
8. Scrub-cutter/Scrub-cutter/Discs*	1,692
9. Scrub-cutter/Rings/Rings	1,439
Least significant differences: P = 0.05	252
P = 0.01	342
P = 0.001	457

*The yields from Treatments 2, 5 and 8 are all significantly greater than the rest.

Mechanical Maintenance Experiment: Main Station (Expt. 17–2)

Planted 1963. Area 32.3 acres. No. of palms, 1,800.

Layout: Five randomized blocks of eight plots. Plots of 26 palms, fully guarded. (The plots are split for a comparison of different mulches in the weeded rings.)

Treatments:

1. Regular hand maintenance of the interlines.
2. Cambridge Ring Roller.
3. Tasker Rotary Slasher, with chains.
4. Wilder "Multi Masta" Scrub cutter, set about 9 in. high.
5. Wilder "Multi Masta" Scrub cutter, set about 5 in. high.
6. Holt Mark VIIIB Weedbreaker.
7. Marden Duplex Roller.
8. Rome disc harrow.

Mechanical maintenance treatments commenced in 1964, after allowing one year for the legume cover crop to establish fully. Maintenance was carried out whenever it was judged necessary that is, four times each year. In Treatments 1, 2, 4 and 5 there is now a moderately weed-free cover of *Pueraria phaseoloides*. The rotary chain slasher in Treatment 3 has almost eliminated the legumes and grasses are now the dominant vegetation. In Treatments 6 and 7 there are herbaceous weed species in association with *Pueraria* while in Treatment 8 there is bare ground with scattered plants of various weed species, notably *Amaranthus spinosus*.

Harvesting commenced in July 1966 and the yield for the six months from July to December has been analysed. Although not statistically significant, it is interesting to note that the highest yield has come from the plots treated with the Rome disc harrow:

Treatment	*Yield per acre, July-December, 1966*
	lb.
1. Hand maintenance	1,477
2. Cambridge ring roller	1,442
3. Rotary chain slasher	1,549
4. Scrub-cutter, blades set 9 in.	1,371
5. Scrub-cutter, blades set 5 in.	1,469
6. Holt weedbreaker	1,536
7. Marden roller	1,432
8. Disc harrow	1,907

This result emphasizes the considerable competition for available moisture and, possibly, nutrients that must occur between the legume cover and the palms.

Details of the rates of work of the different implements in both Experiments 17–1 and 2 were published on page 55 of the NIFOR Second Annual Report and have not altered materially since.

WEED CONTROL

During the year, papers were prepared for the Institute's Journal summarizing the Division's investigations into:

(*a*) screening of herbicides for tolerance by the oil palm seedling,

(*b*) development of herbicide ring-weeding techniques,

(*c*) control of Siam weed (*Eupatorium odoratum*).

A paper was also prepared for the *Pesticides Abstracts and News Summary* (*Section C*) from the results of the Bipyridyl Herbicide Investigation (Expt. A.635) (see NIFOR First Annual Report, pages 53 and 54).

New Advisory Sheets on the establishment of legume cover crops, the use of herbicides for ring weeding and methods of controlling Siam weed are being prepared in conjunction with the Advisory and Information Division.

Ring Weeding Experiment: Main Station (Expt. A.628)

Planted 1962. Area 4.2 acres. No. of palms, 252.

Layout: Three replications of a 4 × 3 factorial experiment. Plots of seven palms, not guarded.

Treatments:

The following herbicides are applied from a knapsack sprayer in 100 gallons of water per sprayed acre:

Herbicide	*Low Rate lb. a.i./acre*	*Medium Rate lb. a.i./acre*	*High Rate lb. a.i./acre*
1. Atrazine ..	2½	3¾	5
2. Prometone ..	2½	3¾	5
3. Monuron ..	2½	3¾	5
4. Diuron ..	2½	3¾	5

Paraquat is included in the spray at 1 lb. (ion) per acre.

Weeding rings were initially of 3 ft. radius but were increased to 4 ft. radius in 1965. The application was first made two months after planting and has continued on a twice yearly basis.

Yields for 1966, the first full year of harvesting, have been analysed and do not show significant effects from either the type or rate of herbicide used. The mean yield per acre was 4,720 lb. of fruit bunches. It would appear that the herbicides do not yet have any harmful effect on the palms.

Ring Weeding Experiment: Main Station (Expt. 17–1)

This experiment was laid down on a split-plot basis in the Mechanical Maintenance Experiment 17-1. Details are as follows.

Planted 1963. Area 59.1 acres. No. of palms, 3,300.

Layout: Each plot of Experiment 17–1 is split into four. At random in each plot two sub-plots are hand-weeded and two receive herbicide treatment. Fifteen palms per sub-plot. Guard rows between whole plots only.

Treatments:

Experiment 17–1 is divided into three parts, one each for the following comparisons of ring weeding technique:

1. Hand *v.* atrazine + paraquat
2. Hand *v.* monuron + paraquat
3. Hand *v.* diuron + paraquat

Rates	*lb. a.i. per acre*
Atrazine	3¾
Monuron	4
Diuron	4
Paraquat (ion) ..	1

The herbicides were applied between 1963 and 1965 from a tractor mounted sprayer. After 1965, the spread of the palms' fronds made it impossible to take the sprayer down the rows and so knapsack sprayers were used. When the palms are sufficiently tall, the tractor-mounted machine will be re-introduced. The spraying volume was initially 100 gallons per sprayed acre on 3 ft. radius rings. In 1965, the rings were increased to 4 ft. radius and to simplify the problems of carrying large volumes of liquid to the men using the knapsack sprayers, the volume rate was dropped to 50 gallons per sprayed acre. This rate has proved quite satisfactory. The herbicides have been applied twice each year, except in 1965 when they were applied three times.

Harvesting commenced in July 1966 and the yields for the six months from July to December are shown in Table 8. Earlier height measurements are also given.

TABLE 8

EXPT. 17–1. RING WEEDING EXPERIMENT: MAIN STATION
Height measurements and yield per acre, 1966

Weed control method	*Mean height of youngest fully open frond*			*Mean yield of bunches per acre*
	April 1964 in.	*October 1964* in.	*April 1965* in.	*July-December 1966* lb.
1. (*a*) Atrazine + paraquat	77.7	106.6	131.6	1,539
(*b*) Hand	70.3	98.3	132.8	1,534
2. (*a*) Monuron + paraquat.. ..	72.4	100.5	131.3	1,595
(*b*) Hand	70.1	99.8	128.0	1,403
3. (*a*) Diuron + paraquat	70.0	97.4	127.6	1,557
(*b*) Hand	70.9	98.7	126.3	1,568
Least significant difference: P = 0.05				1,820

Both this experiment and Experiment A.628 will be continued to check whether an accumulation of herbicide residues persists in the soil and if it will become toxic to the palm.

Control of Siam Weed (Eupatorium odoratum): Mbiri Farm Settlement (Expt. A.6214)

This investigation into mechanical control of Siam weed has continued. The Cambridge ring roller, offset behind the tractor because of the spreading canopy of the palms, was used to crush the Siam weed three times during 1966 (April, July and October) and once so far in 1967 (February). The plots of palms have now been allocated to the settlers and the harvesting and ring weeding have improved considerably. The control of Siam weed is now excellent.

Control of Epiphytes: Main Station (Expt. 2–19)

Details of this experiment were given in the NIFOR First Annual Report, page 54. The treatments were repeated in October 1966. Yields for 1966 show no statistically significant differences between treatment means. However, as in 1965, the palms receiving the higher rates of herbicide have given the smaller yield:

Treatment	*Rate lb. a.e./100 gallons spray*	*Yield of fruit bunches per acre*	
		1965	*1966*
		lb.	*lb.*
A. 2,4-D	2.4	13,201	8,159
B. 2,4-D	9.6	11,174	8,069
C. 2,4,5-T/2,4-D	2.4	13,120	7,152
D. 2,4,5-T/2,4-D	9.6	12,378	7,017

Paraquat Residues in Palm Oil (Expt. A.665)

The question of herbicide residues in foodstuffs has recently become very important. In order to check on the possibility of paraquat residues occurring in palm oil, eight six-year-old palms with almost ripe fruit bunches were selected and treated as follows:

A. Control—not sprayed.
B. Ring weeded with paraquat. Fruit harvested after three days.
C. Ring weeded with paraquat. Fruit harvested after seven days.
D. Ring weeded twice with paraquat. Fruit harvested three days after second spraying (ten days after initial spraying).

The paraquat was sprayed on a 12 ft. radius circle round each palm at a rate equivalent to 2 lb. paraquat ion per acre, in 100 gallons of water.

Oil was expressed from the fruits as soon as the bunches were harvested and the samples were stored in a refrigerator until the last one had been collected. They were despatched by air freight to Plant Protection Ltd., England, who carried out the analysis for herbicidal residues. No trace of paraquat was found.

Demonstration of Herbicide Damage to Oil Palm Seedlings (Expt. A.667)

The purpose of the demonstration was to impress upon visitors to the NIFOR Main Station that it is not enough to read the label on the container of herbicide and then apply the recommended quantity for the destruction of a particular weed species. The susceptibility of the crop plants to herbicide damage must also be taken into account. Details of the demonstration were as follows.

Planted into nursery, April 1966. No. of palms, 96.

Layout: Non-replicated demonstration plots of 24 seedlings each.

Treatments (applied October 1966):

	Rate per acre
1. TCA	30 lb. a.i.
2. 2,4-D	10 lb. a.e.
3. Simazine	10 lb. a.i.
4. Amitrole	10 lb. a.i.

The herbicides were applied at a volume rate of 100 gallons per acre from a knapsack sprayer fitted with a small boom with four nozzles. TCA, 2,4-D and amitrole (ATA) caused typical distortion of the palm seedlings (see NIFOR Journal No. 12) and many deaths. The seedlings sprayed with simazine continued to make normal growth.

NATURAL PALM GROVES

Oil Palm Survey: Asutan Ekpe (Expts. 560–1 and 2)

Harvesting in the survey continued during 1966. The yields per acre plot are summarized by grove type as follows:

*Grove Type**	*Mean yield per plot, 1965*
	lb.
A. Primary compound palms	1,230
B. Palms in typical dense groves ..	2,937
C. Farmland palms in degraded groves	1,721
D. Open farmland groves	785
E. Compound palms near homesteads	2,485
F. Replanted palms (including NIFOR and Ministry of Agriculture replantings)	3,955

*After Hartley, 1954

Results from the replanted plots in the survey continue to be encouraging. Yields for 1966 were:

Year replanted	*Plot No.*	*Yield per acre, 1966*
		lb.
1959	4	4,305
	45	4,248
	59	4,925
	71 (½ density)	2,587
	76 (⅔ density)	3,395
1961	2	2,763
	9	2,939
	20	5,602
	53	8,029
	73	2,139

Surveys of coconut palms and *Raphia hookeri* are being made, so that the distribution of these two species can be studied.

Palm Grove Improvement Experiment: Obio Akpa (Expt. 505–2)

Details of this experiment were published in the NIFOR First Annual Report, pages 56 and 57. Yields for 1966 reflect the same trends as previously reported and are summarized below:

Treatments	Yield per acre, 1966			Total yield 1953-66
	Replanted palms	Wild palms	Total	
	lb.	lb.	lb.	lb.
A. Control. Grove palms	—	5,057	5,057	49,787
B. Old palms felled 1953. Complete replanting	7,857	—	7,857	62,013
C. Old palms thinned 1953 on practical basis, replanting in open spaces	1,229	6,540	7,769	84,059
D. Old palms thinned 1953 on yield basis, replanting in open spaces ..	2,881	4,574	7,455	73,847
E. Complete replanting under 30 tall palms/acre. Old palms felled 1958	7,325	—	7,325	73,799

A routine dressing of 3 lb. sulphate of ammonia, 5 lb. sulphate of potash and 3 lb. calcined magnesium sulphate was made to each palm in the experiment in March 1967. Leaf and flowering observations have continued.

Grove Replanting Experiment: Abak (Expt. 509–1)

Details of this experiment are as follows.

Wild palms of uncertain age. Replanted 1963.
Area 22.4 acres. No. of palms: 355 wild; 1,092 replanted.

Layout: Five randomized blocks of six treatments. Plots of 0.7 acre.

Treatments:

A. Control. Grove thinned to a density of c.70 old palms/acre. Some vigorous young palms are growing under canopy but no seedlings remain.

B. Complete replanting: all old stands felled.

C. Complete replanting: 21 old palms/acre left in year of planting (1963).
7 old palms/acre felled in year 1 (1964).
7 old palms/acre felled in year 2 (1965).
remaining 7 old palms felled in year 3 (1966).

D. Complete replanting: 12 old palms/acre left until year 2 (1965).

E. Complete replanting: 12 old palms/acre left until year 4 (1967).

F. Complete replanting: felling of old palms as in Treatment C but all replanted palms to receive additional potash.

Treatment F is included to test a hypothesis that young palms growing in shade need more potash than plants growing in the open. All replanted palms received adequate NKMg manuring while Treatment F received an extra 1⅝ lb. of sulphate of potash per palm in the first three years. The replanting commenced in April 1963 and the felling has proceeded according to the above schedule. The young palms were brought into the harvesting schedule in July 1966. The wild palms still standing in Treatments A and E were harvested throughout the year. The yields per acre for 1966 were:

Treatment	*Yield per acre, 1966*		
	Wild palms	*Planted palms**	*Total*
	lb.	*lb.*	*lb.*
A. Control	4,470	—	4,470
B. Complete felling 1963	—	927	927
C. Sequential felling 1963-66	—	1,798	1,798
D. Felling in 1965	—	809	809
E. Felling in 1967	4,596	730	5,326
F. As C, but extra fertilizer	—	1,740	1,740

*Part year only

ROOTING STUDIES AND IRRIGATION

These investigations were carried out jointly with the Soil Chemistry Division. The purpose is to assess the influence of irrigation during the dry season on the growth and yielding of the oil palm and in particular on the surface feeding roots, which are known to die back during the dry season. The activity of the feeding roots is assessed from the uptake of P^{32}.

Field Watering Experiment: Main Station (Expt. A.644)

Experimental details were given in the NIFOR First Annual Report, page 58. Watering was carried out according to schedule between November 1966 and March 1967. This was the third dry season that watering had taken place. Recorded yields for 1966 were very low due to an error in harvesting procedure and do not show any differences between treatments.

Field Irrigation Experiment: Main Station (Expt. 1–21)

Details of this experiment are as follows.

Planted 1966. Area 7.7 acres. No. of palms, 460.

Layout: Six randomized blocks of three whole plot treatments. Whole plots of nine palms, split into three sub-plots.

Treatments:

Whole Plot: Irrigation

0 No additional watering.

1 Irrigation* in the dry season each year (15th November-15th March).

2 Irrigation* at any time in the year, when weekly rainfall less than 2 in.

*Water to bring total precipitation to the equivalent of 2 in. of rainfall.

Sub-Plot Fertilizers:

a No fertilizers.

b Fertilizers to NIFOR recommendations in April.

c Fertilizers as above in both April and October each year.

The old palms were felled early in 1965 and the sites for the new stands marked out. Each site was enclosed with a 12 ft. diameter bund and the soil inside the bund was carefully levelled. All sites were allowed to consolidate for one year and to grow a natural weed cover before planting was undertaken. Planting took place in May 1966 using Special Grade E.W.S. seedlings grown in the dry season nursery. The small dry season nursery seedlings were used because it was felt the differences between the irrigation treatments would be further enhanced. Fertilizers have been applied according to schedule.

Irrigation water is supplied to the site through an underground 2 in. polythene main with branch outlets to each plot. Water is distributed to each bund within the plot by means of a 2 in. portable aluminium pipe line and a length of 1 in. rubber hose. The rate of delivery from the hose has been timed and the irrigation is carried out on this basis. Some irrigation was required in Treatment 2 in June and August 1966 and regular irrigation took place throughout the 1966-67 dry season.

Height measurements to the tip of the youngest fully open frond were made in January 1967 and are summarized below:

Treatment	*Mean height of youngest fully open frond: January, 1967*
Whole plot	*in.*
1 No extra water	44.4
2 Irrigation dry season only	48.1
3 Irrigation whenever necessary	49.5
Least significant difference: P = 0.05	4.7
Sub-plot	
a No fertilizer	42.8
b Fertilizer each April	46.6
c Double fertilizer: April + October	52.8
Least significant differences: P = 0.05	2.6
P = 0.01	3.6
P = 0.001	4.9

COCONUTS

Coconut Germination Experiment: Main Station (Expt. A.664)

Details of this experiment are as follows.

No. of nuts, 480.

Layout: Three randomized blocks of the four treatments, at each planting date. Twenty nuts per plot. No guard rows.

Treatments:

To nuts	*Planting dates*
1. Nuts mulched *v.* nuts not mulched	(*a*) May, 1966
2. Husk opened on one side *v.* husk entire	(*b*) September, 1966

The nuts were collected from the Northern Nigerian Ministry of Agriculture at Kabba. They were planted into the nursery beds and spaced 1 ft. apart and 2½ ft. between the rows. Nuts planted in May commenced to germinate in September and germination has continued till as late as 31st March, 1967. Very few of the nuts planted in September germinated and it is assumed that the embryos must have been killed during the extra months of storage.

So far, counts of transplantable seedlings and height measurements have shown no effects of the treatments.

HERBARIUM AND LEGUME MUSEUM PLOTS

Further specimens have been collected for the Herbarium and when possible have been identified. The legume museum plots have been maintained and most of them will be replanted in April 1967. The legume collection now has sixteen species.

R. D. SHELDRICK.

REFERENCES

DEVUYST, A. (1954). Selection of the oil palm (*Elaeis guineensis*) in Africa. *Trop. Agriculture Trin.*, **31** (2), 133-148.

GUNN, J. S., SLY, J. M. A., and CHAPAS, L. C. (1961). The development of improved nursery practices for the oil palm in West Africa. *J. W. Afric. Inst. Oil Palm Res.*, **3** (11), 198-232.

HARTLEY, C. W. S. (1954). The improvement of natural palm groves. *J. W. Afric. Inst. Oil Palm Res.*, **1** (2), 8-41.

PLANT BREEDING DIVISION

STAFF

Mr. T. Menendez, Plant Breeder, was promoted to the post of Acting Senior Plant Breeder with effect from 1st August. He was on duty throughout the year. Mr. C. O. Obasola, Plant Breeder, was on leave from December 1966 to January 1967. Mr. E. C. Egbufor, Technical Officer, was on vacation leave from October to November 1966. Mr. M. O. Otedoh, graduate officer, joined the staff of the Institute in June 1966 for a period of in-service training.

GENERAL PROGRAMME

In addition to routine collection and collation of data on field trials of the main and subsidiary breeding programmes a further planting of 69 acres of progeny trials was carried out. The production of Extension Work Seed was started from *dura* selections at the Sub-Station, Abak, Eastern Nigeria. New work has begun on methods of oil analysis and pollen processing.

PRODUCTION BREEDING

Field Operations

The 1967 planting consisted of a few remaining crosses of the Institute's Main Breeding Programme and new Deli *dura* introductions resulting from the participation of NIFOR in the Sabah Breeding Programme. A summary of the trials planted is given below:

Programme	*Acreage*	*Layout*
Dura × *tenera* *Dura* × *Dura* *Dura* selfs	41.0	5 × 5 balanced lattice 4 × 4 balanced lattice
Tenera × *tenera*	21.1	two Youden squares
Nigerian Gene Pool	2.2	unreplicated plots
Elaeis guineensis × *Corozo oleifera*	4.0	unreplicated plots
Museum	1.6	unreplicated plots

Seedlings of 121 progenies were planted into the 1966 main and dry season nurseries and a further 58 progenies were prepared for planting into the 1967 main nursery. Overall germination of breeding programme seed intended for these plantings was 59%. Seed from 85 progenies was sent to the germinator in February 1967.

Yields

A summary of the cumulative yields obtained from all progenies planted in connection with the main breeding programme is presented at the end of this section of the report on pages 77 to 84. The yield obtained from the different plantings of the standard cross is shown on page 91.

Bunch Quality

Summaries of bunch quality for the progenies planted in 1962 appear at the end of this section of the report on pages 84 to 90.

Segregation

In both Nigerian and Deli *dura* × *dura* progenies segregation was correct to 99% and no family deviated significantly from expectation. *Tenera* × *tenera* progenies segregated 2.8% more *dura* palms than was expected ($\chi^2 = 5.8$, $p = <0.05$) and *dura* × *tenera* progenies segregated 1.9% ($\chi^2 = 9.4$, $p = <0.01$) more *dura*. Details of segregation in each progeny are shown in the appendix on pages 84 to 90. Further discussion of segregation in the *dura* × *tenera* progeny trials appears on page 69 of this report. Experience gained in Experiment 24–6 has again shown that the field

TABLE 9

ELAEIS GUINEENSIS × COROZO OLEIFERA: MAIN STATION, 1960, 1961, 1962 (EXPT. 21–5)

Area 3.1 acres *No. of palms, 184*

Yearly and cumulative yield of bunches per acre up to 31st December, 1966

Progeny 1960	*1964*			*1965*			*1966*			*Total*	
	No.	*Weight* lb.	*Single bunch weight* lb.	*No.*	*Weight* lb.	*Single bunch weight* lb.	*No.*	*Weight* lb.	*Single bunch weight* lb.	*No.*	*Weight* lb.
61.271 × 1.1375P	1,009	6,114	6.0	561	7,700	13.7	531	10,765	20.3	2,101	24,579
61.271 × 1.3147T	803	6,784	8.4	316	5,448	17.2	422	8,672	20.5	1,543	20,904
61.271 × 1.556P	783	5,072	6.5	871	9,562	11.0	399	6,395	16.0	2,053	21,029
61.271 × 5.158D	672	5,065	7.5	527	9,485	18.0	359	6,414	17.9	1,558	20,964
61.271 × 1.352P	806	4,770	5.9	768	9,210	12.0	462	7,779	16.8	2,630	21,759
32.356T × 21.271	864	3,623	4.2	906	7,420	8.2	918	8,848	9.6	2,688	19,893
1961											
61.271 × 5.1295 Deli ..	—	—	—	725	6,624	9.1	179	3,850	21.5	904	10,474
1962											
5.1225 Deli × 21.271 ..	—	—	—	—	—	—	762	5,807	7.6	762	5,807

TABLE 10

ELAEIS GUINEENSIS × COROZO OLEIFERA: MAIN STATION

Fruit form segregation and bunch quality

Progeny		Segregation*		Tenera					Dura					
		tenera	*dura*	*Fruit/ bunch*	*Single fruit weight*	*Pulp/ fruit*	*Shell/ fruit*	*Ker/ fruit*	*Fruit/ bunch*	*Single fruit weight*	*Pulp/ fruit*	*Shell/ fruit*	*Ker/ fruit*	*Oil/ pulp*
				%	g	%	%	%	%	g	%	%	%	%
61.271	× 1.1375 P ..	8	0	55.8	6.2	67.5	22.9	9.6	—	—	—	—	—	22.7
61.271	× 13.147 T ..	4	10	53.8	5.6	65.7	25.0	9.3	60.3	6.6	43.0	47.0	10.0	32.3
61.271	× 1.556 P ..	31	0	57.5	6.1	71.5	21.2	7.3	—	—	—	—	—	36.2
61.271	× 5.158 D ..	0	27	—	—	—	—	—	61.1	8.5	44.6	42.7	12.7	23.9
61.271	× 1.352 P ..	32	0	56.1	6.0	67.0	25.7	7.2	—	—	—	—	—	33.7
32.256	× 21.271 ..	18	12	68.1	5.4	72.1	17.4	10.5	70.1	7.4	43.3	44.4	12.3	33.6
61.271	× 5.1295 Deli ..	0	5	—	—	—	—	—	63.8	10.3	56.2	37.3	6.5	—
5.1225 Deli	× 21.671 ..	4	19	—	—	—	—	—	71.2	8.5	51.2	39·8	9.1	41.6

*Distinguished by position and discontinuity in the distribution of per cent shell/Fruit

method of determination of fruit form can be in error, especially when extremes of the *tenera* range are involved. In these circumstances, confirmation has to rely on detailed examination. It is unlikely that errors in field determinations will inflate the proportion of palms scored as *dura* in progenies of the main breeding programme. This is because (*a*) thick shelled *tenera* or fertile *pisifera* are not expected, (*b*) the heritability of shell content is very high (WAIFOR Eleventh Annual Report, page 63; WAIFOR Twelfth Annual Report, page 69) and (*c*) the fertility of *pisifera* palms is correlated with shell thickness (WAIFOR Eleventh Annual Report, page 64; WAIFOR Twelfth Annual Report, page 71).

The Elaeis guineensis × *Corozo oleifera Hybrid*

The hybrid palms planted on the Main Station in 1960 have continued to give promising yields. Summaries of yield and bunch quality are given on pages 61 and 62. A single plot of one Deli × *Corozo oleifera* progeny was planted at the Sub-Station, Abak in 1962 and yielded 5,626 lb./acre in 1966. This was just below the high average yield (6,109 lb./acre) of *Elaeis guineensis* progenies planted at the same time in the adjacent Experiment 502–5. The programme referred to on page 61 of the NIFOR First Annual Report and page 62 of the NIFOR Second Annual Report has made good progress at the NIFOR Main Station. Sixty intercrosses have been made on five test parents of *Elaeis guineensis* hybrid var. *tenera*, some more than once. In certain intercrosses the seed set and subsequent germination and growth was poor, with the result that it was not practicable to plant a fully randomized field trial in 1967. It seems, therefore, more prudent to restrict plans for the field trials at outstations to observation blocks only.

Two hundred and sixty-seven seedlings from six progenies were sent to Ilorin, Northern Nigeria, during the year for planting in that locality during 1967. Some naked root seedlings were established near Bida. At Acharu, in Igala Division, one hundred seedlings from two progenies planted into a nursery there in 1966 will go into an observation block. At Kabba, a small plot is to be planted from the 100 seedlings of three progenies established in the nursery there in 1966.

The details of germination, the proportion of normal plantable seed, and the percentage emergence after sowing, have been recorded for 32 families of hybrid seed. An average of 345 seeds were set from each pollination. Of these, 41.0% germinated and 67.5% of the germinated seed were suitable for sowing. Emergence after sowing was 78.5% giving an overall recovery of 22% from the seed. Total correlations between seed set, germination, sprouting, emergence and the period for which the pollen had been stored indicate that better seedlings are likely to be derived from families which germinate relatively well ($r = 0.6$, $p = 0.001$). There was no consistent relationship between age of pollen and the fate of the seed.

Variations in seed set were considerable between the individual *Corozo oleifera* palms tested and between the different pollinations of the same inter-cross. Germination, however, did not show any marked differences in compatibility. The data is insufficient to suggest yet whether or not individual specimens of *Corozo oleifera* will show differences in general or specific compatibility with *Elaeis guineensis*.

The Gene Pool

The situation in the country did not permit the tours of prospection that had been planned in the Northern and Eastern Regions of Nigeria. Seedlings from fifteen localities in the Igala Division and two in the Eastern Region were planted into the field in April 1967.

Introductions from overseas are summarized in the section below.

Exchange Programmes

No new programmes of exchange of oil palms were initiated during the year. Progress made with current programmes with organizations outside Nigeria is as follows:

		NIFOR Contribution sent		*Contribution to NIFOR received*
Country	*Organization*	*Crosses*	*Pollen packets*	*Crosses*
Cameroun	Pamol (Cameroun) Ltd.	18	5	1
Ecuador	I.N.I.A.P.	12	—	6
Sabah	Dept. of Agriculture	2	16	15
Malaya	Oil Palm Genetics Lab.	15	2	21

Short-Stem Programme: Pobé Dumpy Trial, Main Station, 1959 (Expt. 14–4)

A summary of the first four years' yield is given below.

Origin	*Progeny*	*No.*	*Bunch weight*	*Single bunch weight*
			lb.	*lb.*
Yangambi *dura* × *pisifera*†		2,007	24,940	12.4
Pobé Dumpy	111.125 × 38.54	1,719	19,981	11.6
tenera × *tenera*(‡)	111.125 × 99.125	1.985	15,968	8.0
	Overall (whole plots)	1,789	16,196	9.0
LaMé *tenera* ×	L2T × D11D	2,494	42,470	17.0
Dabou Deli†	L16D × D8D	2,724	35,233	12.9
	L35T × D112	2,007	28,894	14.4
	L11T × D8D	1,976	30,441	15.4
	Overall (whole plots)	2,301	34,291	14.9
Dabou Deli ×	D15D × C.17.18.10	1,086	21,378	19.7
Sibiti *pisifera*†	DaD × C.17.4.6	801	14,353	17.9
	D21D × C17.3.4	1,162	19,101	16.4
	D10D × A97.6.16	1,051	20,372	19.4
	Overall (whole plots)	1,026	18,818	18.3
NIFOR *dura* × *tenera*	5.1654 × 32.364	3,301	40,599	12.3
	*6.594 × 5.1450	2,829	27,389	9·7
	Overall (whole plots)	3,093	34,028	11.0

*Standard Cross †Dry season nursery seedlings ‡Yield per bearing Palm

Outstation Progeny Trials: Jema'a (Expt. 766–3), Acharu (Expt. 762–3), Kabba (Expt. 761–1) and Abak (Expt. 502–3)

Of the progeny trials repeated at Jema'a (planted 1963,) Kabba, Acharu and Abak (1960 and 1961) the only one visited during the year was at Kabba. It was apparent that the poorest area at the site of the trial was not only stony (slope wash) but had impeded drainage. Yields from these trials are summarized on page 66.

The 1966-67 dry season was protracted and severe and it is anticipated that Dry Basal Rot will again affect the palms. Widespread symptoms of the disease had been seen at Kabba and Acharu in May 1966. A survey carried out in June 1966 showed advanced symptoms of the disease in Experiments 761–1 (5.0%), 761–2 (5.5%), 762–1 (6.8%) and 762–2 (9.4%). By the time of another visit to Kabba (Expts. 761–1 and 761–2) in September 1966, almost all the leaf symptoms of Dry Basal Rot had disappeared. The disease appears to be a serious limiting factor in the early years of production in localities with a prolonged or intense dry season. Yields during the fourth and fifth years after planting were given facing page 67 of the NIFOR Second Annual Report. During 1966 the trial at Kabba gave only 14% of the yield obtained at Abak, Eastern Nigeria, in the oil palm belt and only a quarter as many or individually as heavy bunches. At Acharu, the yield was better, being 33% of the yield at Abak. The site of the experiments has had a considerable effect on the growth and yield of palms in the trials in the Northern Region. Although establishment from naked root seedlings was poor at Acharu, subsequent care of the palms and more favourable soil conditions have benefited the palms. The mean rainfall at Acharu for the last five years was 56.2 inches, distributed as follows:

	Jan.	*Feb.*	*Mar.*	*Apr.*	*May*	*June*	*July*	*Aug.*	*Sept.*	*Oct.*	*Nov.*	*Dec.*
Acharu	0.5	0.5	2.2	4.1	4.9	8.1	10.6	7.8	9.5	6.1	1.5	0.6

Two other progeny trials were established in 1961 at the Sub-Station, Abak (Expt. 502–5) and at Acharu (Expt. 762–2) together with some observation plots at Kabba, consisting of miscellaneous progenies from the main breeding programme. These trials were planted from seedlings established in nurseries on the spot. One replication of Experiment 762–2 was abandoned but was replanted in 1962. At Kabba, seedlings remaining in the nursery from which the Experiment 761–1 had been planted were used to plant up a strip of land between the experiment and the main road. Yields recorded during 1966 are summarized on page 66.

EXTENSION WORK SEED TRIALS AND PRODUCTION

International Extension Work Seed Trials: Main Station, 1959 (Expts. 7–2 and 7–3)

A summary of the first four years' yields in Experiment 7–2 is given on page 91. A similar summary for Experiment 7–1 (1958) appeared in the NIFOR Second Annual Report, facing page 68. These trials are now principally of historic interest and bear no relationship to the seed currently being issued. The growth and yields of the palms in Field 7 are considered to be below average for the Main Station. The behaviour of the standard cross indicates that yields from this area are only three-quarters of those obtained over the same period, from plantings elsewhere on the station having similar fertilizer treatment (Table on page 91).

Outstation Progeny Trials: Abak (Eastern Nigeria), Kabba and Acharu (Northern Nigeria), 1960 (Expts. 502-3, 761-1, 702-1)

Yield of bunches per acre, 1966

Progeny	Origin		Expt. 502–3			Expt. 761–1*			Expt. 762–1*		
			No.	Expt. 502–3 weight lb.	Single bunch weight lb.	No.	Expt. 761–1* weight lb.	Single bunch weight lb.	No.	Expt. 762–1* weight lb.	Single bunch weight lb.
6.594 × 32.364	Aba × Calabar	..	630	6,521	10.3	132	1,068	8.1	238	1,666	7.8
6.594 × 5.1450	Aba × Calabar	..	443	7,906	17.8	114	604	5.3	338	1,864	5.5
5.1654 × 32.364	Calabar ..	..	576	7,528	13.1	139	856	6.2	318	2,248	7.1
5.1654 × 108.5	Calabar ..	..	710	7,007	9.9	161	822	5.1	379	1,928	5.1
108.5 × 1.2229	Calabar × Angola	..	622	8,390	15.1	145	1,022	7.0	230	1,413	6.1
1.2227 × 1.3056	Calabar × Angola	..	475	8,126	17.1	129	1,046	8.1	280	2,612	9.5
5.368 × 1.3352	Deli × Calabar	..	617	10,418	16.9	160	1,655	10.3	357	3,611	10.1
5.368 × 1.3056	Deli × Calabar	..	602	11,425	19.0	116	886	7.6	598	3,438	5.7
32.364 × 5.642	Deli × Calabar	..	510	8,175	16.0	163	1,321	8.1	234	2,064	8.8
32.364 × 203.133	Deli × Calabar	..	417	7,940	19.0	103	1,408	13.7	251	2,641	10.5
1.2227 × 1.2229	Angola	..	447	5,783	12.9	107	901	8.4	280	2,594	9.3
1.2209 × 1.2224	Angola	..	370	5,979	16.2	84	825	9.8	301	2,854	9.5
201.32 × 201.51	Deli	..	456	9,098	20.0	136	1,500	11.0	305	3,516	11.5
201.32 × 203.93	Deli	..	288	6,166	21.4	144	1,076	7.5	273	2,529	9.3
5.1295 × 5.642	Deli	..	540	8,902	16.5	120	809	6.7	284	2,359	8.3
5.642 × 203.93	Deli	..	419	8,852	21.1	120	1,605	13.5	212	1,854	8.7
E.W.S. $D \times P$	Ogba	..	671	8,214	12.2	154	995	6.5	318	1,800	5.7
E.W.S. $D \times P$	Ibadan	..	611	8,214	13.4	179	1,166	6.5	303	1,903	6.3
E.W.S. $D \times P$	Nkwelle ..	..	—	—	—	130	477	7.5	—	—	—
G103 $(T \times T)$	Pobé	..	476*	6,088*	12.8	84	514	6.1	229	1,245	5.4
G104 $(T \times T)$	Pobé	..	434*	5,602*	12.9	166	1,458	11.3	209	1,961	9.4

*Yield per bearing palm

SPACING TRIAL: MAIN STATION, 1959 (EXPT. 7-3)

Yield of bunches per acre

Treatment	*1963* No.	*1963* Weight	*1963* Single bunch weight	*1964* No.	*1964* Weight	*1964* Single bunch weight	*1965* No.	*1965* Weight	*1965* Single bunch weight	*1966* No.	*1966* Weight	*1966* Single bunch weight	*Total* No.	*Total* Weight	*Total* Single bunch weight
		lb.	*lb.*		*lb.*	*lb.*		*lb.*	*lb.*		*lb.*	*lb.*		*lb.*	*lb.*
Outside rows* ..	436	2,486	5.7	419	2,964	7.1	490	5,760	11.8	300	3,658	12.2	1,637	14,867	8.9
Second rows* ..	436	2,355	5.4	411	3,243	7.9	511	6,477	12.7	282	3,890	13.8	1,692	15,963	9.3
Inner rows* ..	502	3,247	6.5	463	3,953	8.5	531	7,109	13.4	301	4,320	14.5	1,808	18,626	10.1
Twin rows ..	425	2,423	5.7	474	3,144	6.6	476	5,809	12.2	290	3,937	10.1	1,610	15,312	9.2
Least significant differences:															
P = 0.05 ..	..	..	..	..	..	..		347						1,097	
P = 0.01 ..	..	..	..	..	..	..		486						—	

*Regular 29 ft. triangular spacing

ar origin to that in
win row planting are
significant difference
econd Annual Report
s and also in the total
ne first year's harvest.
e bunch weight and
observed differences,
ld. Significant levels

- *Main Station, 1961*

ment is given below.
om the comparison.
the Extension Seed

ember, 1966

hes	*Single bunch*
Veight	*weight*
lb.	*lb.*
11,278	8.0
12,345	10.5
11,335	10.1

measurements at the
and yields for 1965
e to give the higher

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tension Work Seed
, and in selfed *dura*
elected for the pro-
quarter of the year
e *dura* selections is

Average Quality of Selected Dura at the Sub-Station, Abak

	lb.
Yield of bunches/palm/year (years 1-4)	129
Yield of bunches/palm/year (fifth year)	187
	%
Oil/bunch	17.88
Kernel/bunch	9.4

Exploitation of *dura* palms at the Sub-Station will now be extended to include the progeny trials planted in 1960 and 1961 (Expts. 502–3 and 502–5 described on page 65 of this report).

FRUIT AND BUNCH ANALYSIS

Routine analysis was completed for all progenies planted in 1962. This included quarterly estimates of the oil content of the pulp, using the indirect method described on page 71 of the NIFOR Second Annual Report. Individual analysis by solvent extraction was continued for selected palms and those included in the investigation of continuous variation in bunch composition. During the year, 23,213 mechanical analyses were completed and 7,901 bunches were analysed for oil content by the direct method. In the record section, summaries of yield and bunch analysis data were prepared, calculations of quality were completed for 29,299 bunches and data from 25,667 were entered on permanent record cards. The feasibility of using punch cards for sorting bunch analysis data, particularly for palms selected for the production of Extension Work Seed, was considered in detail and this system may be introduced during 1968.

Bunch Analysis

The result of the continuous analysis of progenies planted from 1952 to 1959 is now being summarized. Two seasonal maxima for the oil content of pulp are indicated for the periods May-June and November-December. It is hoped to obtain a specific period when the results will represent an average oil content and bunch analysis value for the year and so make it possible to formulate a practical minimum sampling system.

GENETICAL AND BOTANICAL STUDIES

Segregation of Fruit Form

Dura × *tenera* progenies in the test crosses of the breeding programme include Deli and African *dura* as male or female parents. Overall segregation of fruit form in the progenies varied significantly from expectation ($\chi^2 = 9.4$, $p = <0.01$), there being an excess of *dura* palms. This was due largely to the poor segregation from crosses in which Deli *dura* palms were the female parents. Deli pollen did not disturb the segregation in this way, slightly more *tenera* palms were found in such progenies. Overall segregation of African *dura* × *tenera* and *tenera* × Deli *dura* did not, however, deviate significantly from the expected ratios. Overall segregation of fruit form in the progenies is given in Tables 84 to 90 at the end of this section of the report.

Segregation in Dura × Tenera Progeny Trials

	No. of families	Segregation	
		dura	*tenera*
African *dura* × *tenera* ..	23	541	472
African *tenera* × *dura* ..	16	387	371
Deli × African *tenera* ..	19	556	361
African *tenera* × Deli ..	34	676	751

The reason has not been found for the poor segregation reported previously in Deli × Nigerian progenies (NIFOR Second Annual Report, page 71 and NIFOR First Annual Report, page 69) and investigations are continuing. There is some evidence from the distribution of shell and mesocarp content in *dura* palms obtained from Deli × *tenera* crosses that two sub-divisions of *dura* palms may be produced.

Seedling Selection Experiment: Main Station, 1957 (Expt. 24–2)

This experiment was described originally on page 95 of the WAIFOR Seventh Annual Report. The highly significant correlation between the number of leaflets on fronds 4 and 10 in the nursery and single bunch weight was reported on page 72 of the NIFOR Second Annual Report. Analysis of yield in 1966 and the cumulative yield from 1961 to 1966 confirms this result and suggests that correlation with single bunch weight appears as the palms age and the bunches become heavier. Significantly fewer bunches were produced from palms with relatively few leaflets per frond in both the nursery and the field.

Fruit Character Inheritance: Main Station, 1962 (Expt. 24–6)

This planting consisted of miscellaneous progenies and included selfs and crosses involving palms of indefinite fruit form. The latter included a palm with only 2% shell/fruit and a very thick shelled but possibly *tenera* palm. In the WAIFOR Twelfth Annual Report, page 71, attention was drawn to the difficulty of making an exact determination, by field methods, of the fruit form of some palms. This was again experienced in the segregation of palms in Experiment 24–6 and re-emphasized that the correct diagnosis of the *tenera* form can be made only on the basis of the presence or absence of a distinct fibre ring around the shell. If this ring is present around the germ pore only, or around a small sector of the cross section of the fruit, the palm is more likely to be *dura* and more exact determinations are required. In this experiment the two "indeterminate" parents (32.2687, shell to fruit 28.6% and 2.4358, shell to fruit 25.3%) were identified as *tenera* palms. The thick shelled *tenera* exemplified well the high heritability of shell content, giving the following segregation:

	Segregation		Shell/Fruit	
	dura	*tenera*	*dura*	*tenera*
			%	%
32.2687 × 32.2687	11	23	47.7	31.6
32.2687 × 2.4358	9	24	52.4	30.8

In all cases, careful, visual identification by an expert agreed with the interpretation of fruit form accorded by the frequency distribution for shell/fruit in each progeny.

Removal of Inflorescences in Young Palms: Main Station (Expts. B.625a and b)

Experiment B.625a was superimposed on a *dura* × *tenera* progeny trial (Expt. 31–3) and was described on page 67 of the NIFOR First Annual Report. Significant responses have still not been obtained. The second experiment (B.625b) also described on page 67 of the NIFOR First Annual Report, has shown a highly significant increase in yield during 1965 and 1966. In this experiment, inflorescences were removed during the first 9, 15 or 18 months of the 24 months period prior to harvesting. The increase in yield was due largely to enhanced single bunch weight. During this period there was a significant ($p = 0.05$) interaction between whole plots (progenies) and flower removal. In the second year there was a highly significant interaction for single bunch weight and yield ($p = 0.01$). Biometric data have been collected and will be analysed for the effect of flower removal on growth. Variation in bunch composition is also being examined.

Flower Removal Trial: Main Station, 1960 (Expt. B.625a)

Period of flower removal	*1964*			*1965*			*1966*		
	No.	*Weight*	*Single bunch weight*	*No.*	*Weight*	*Single bunch weight*	*No.*	*Weight*	*Single bunch weight*
		lb.	*lb.*		*lb.*	*lb.*		*lb.*	*lb.*
Nil	629	3,699	5.9	671	8,382	12.9	581	8,131	14.4
Mar. '62-Oct. '62	598	3,277	5.5	656	7,872	13.0	617	8,639	14.3
Mar. '62-Apr. '63	610	3,695	6.1	643	7,690	12.5	628	9,088	14.8

Flower Removal Trial: Main Station, 1961 (Expt. B.625b)

No. of palms, 1,302. Yield of bunches per acre

Period of flower removal	*1965*			*1966*		
	No.	*Weight*	*Single bunch weight*	*No.*	*Weight*	*Single bunch weight*
		lb.	*lb.*		*lb.*	*lb.*
Nil..	730	6,388	8.9	678	9,388	14.7
Jan. '63-Oct. '63	770	6,606	8.5	537	8,350	16.9
Jan. '63-Apr. '64 ..	830	8,174	9.9	605	8,884	16.3
Jan. '63-July '64	695	8,095	11.9	654	10,094	16.3
Least significant differences: P = 0.05	45	454	1.0	45	638	0.7
P = 0.01	59	600	1.3	59	844	0.9
P = 0.001	76	773	1.7	76	1,088	1.1

Isolation Bags for Controlled Pollination

An experiment was reported in the NIFOR Second Annual Report, page 73, indicating that the samples of compressed terylene bags used for the isolation of inflorescences up to the end of 1965 were fully effective in preventing the setting of illegitimate seed even though small amounts of pollen could pass through the walls of the bags. The bags received during 1966 gave less favourable results and could not have been up to the exact specification of those originally supplied and tested in 1962. This observation has been reported to the suppliers of the bags as well as to the manufacturers of the fabric. Double bags of the 1966 material were tested in the field and results showed that they gave complete isolation, but the single bags allowed illegitimate seed set of up to an estimated 2% for both dry weather conditions and when the bags were watered daily *in situ* during the period of receptivity of the female flowers. The pollen which penetrated the bags was of normal size but samples trapped within the bags on glass slides coated with 10% sucrose agar have failed to show any germination. It has now been found that a dilute spray (1 : 20) of acid stable wax emulsion effectively blocks the interstices of the fabric and renders the bags impermeable to pollen. So far, the bags treated in this way have not had any adverse effect on the development of pollinated inflorescences. Spraying with the wax emulsion is being adopted as a routine. Tests of the most suitable deposit of wax and its durability continue to be made. The bags used for the collection of pollen have been treated in the same way.

Pollen Dilution and Storage (*Expt. B.656*)

Good seed set and germination were obtained after pollinations with fresh pollen which had been diluted serially with up to 20 parts of inert carrier (clay) and one month old pollen diluted with 13 parts of inert material (30% viable *in vitro*). The month-old pollen had been stored at approximately 40% relative humidity. Fruit to bunch ratio of treated bunches was not affected by the dilutions. Analysis of χ^2 for germination showed that significantly poorer germination was obtained from the stored pollen ($P = 0.001$). Poorer germination from stored pollen had been observed by the Institut de Recherche pour les Huiles et Oléagineux.

Pollen Storage

Towards the end of the year, a deep freeze and a high vacuum pump were received. They are components of a standard laboratory freeze drying unit.

Samples of pollen sent to the Coconut Industry Board, Jamaica for freeze drying were returned to NIFOR and are being used in test crosses. The first two samples of fresh pollen were despatched to Jamaica in sealed 500 gauge layflat polythene tubing, enclosed in metal foil envelopes. Freeze dried samples were returned in ampoules and the rest in their original packing. A second series of samples, which had been treated and stored in a deep freeze for two months in Jamaica, were returned to NIFOR and after further storage for two months have been used to study the effect of air transportation and of storage on pollen. Pollen dried in the freeze drier for 20 minutes retained most viability *in vitro*, followed by that dried for 30 minutes. Such conditions as drying

for 10 minutes, prolonged storage of freeze-dried samples at ambient temperature or simply sealing pollen either under vacuum or atmospheric pressure, did not preserve their viability. In this series of trials the pollen was germinated on a sucrose-agar medium.

Tests of Pollen Viability

The time requirement for assessing viability from visual counts, either of stained grains or those that have been germinated on nutrient agar limits considerably the design of experiments involving their use. Attempts to alleviate this by estimation from photographic negatives or positives did not give satisfactory results. It was reported in the NIFOR Second Annual Report, page 73, that investigations had started into the suitability of tetrazolium chloride for determining the viability of oil palm pollen. It was found that a 2% aqueous solution of tetrazolium chloride usually gave a complete stain reaction after two hours incubation at 40° under a cover slip, that staining became intense after eighteen hours and that disorganization of the cell contents occurred after twenty-four hours.

Physical and chemical methods of inhibiting further staining of pollen after a set period of contact were examined and it was found that sodium sulphite darkened and differentiated stained grains clearly and that storage in a refrigerator or on ice was a practicable method for inhibiting staining for a period of up to twenty-four hours. In the series of trials carried out with tetrazolium chloride, it was not possible to establish a predictable relationship between stain reaction and germination on 10% sucrose agar for the pollen samples tested. It is unlikely therefore that the reagent, as used in the present series of trials, will prove useful for determining pollen viability.

The Interrelationship between Leaf Morphology and Yield

On page 70 of this report and page 72 of the NIFOR Second Annual Report attention was drawn to the significant correlation found in the seedling selection experiment (Expt. 24–2) between the number of leaflets on a frond and single bunch weight during the first four years' yield. A similar relationship has since been reported for palms in a high rainfall area in the Cameroun. During the year, leaflets were counted on leaf nine of 720 palms growing on the NIFOR Main Station in an old Extension Work Seed Experiment (Expt. 32–6). The yield history of the palms for the period from 1951 to 1965 has been collated and multivariate analysis of the interactions between leaflet number and yield is being undertaken.

The Application of Growth Active Substances

Although 100 p.p.m. of α 2,4,5-TP is now sprayed on to female inflorescences 48 hours after anthesis as a routine aid to the identification of sterile *pisifera* palms, instances of poor response from thin-shelled *tenera* palms are still being recorded. For this reason, the induction of parthenocarpy, including shell formation, is being examined in a range of thin-shelled *tenera* palms. In all cases where shell has not been detected, differentiation of tissues around the aborted embryo sac have been distinctive. This investigation continues.

Responses of sterile *pisifera* palms to α 2,4,5-TP are being collated prior to setting up a field experiment. This will test the effectiveness of attempts at improving selection against quantitative shell content factors by assessing and examining the extended range of detectable sterility.

It is possible that the growth active substances being sprayed on selected palms may influence growth and yield. Plots of palms in a *dura* × *tenera* progeny trial (Expt. 35–36, planted 1960) have been split for application versus no application of growth active substance at 100 p.p.m. Leaf growth, flowering and bunch quality are being recorded. These investigations were started in July 1966. Treatment of the palms will continue for at least eighteen months.

Susceptibility to Diseases: Dry Basal Rot

Inoculation trials were carried out to test seedling susceptibility to Dry Basal Rot.

Susceptible palms were selected for use as recurrent parents in a series of test crosses, intended to test the resistance to Dry Basal Rot of selected *pisifera* palms used in the production of extension work seed.

Results from inoculation trials have proved very variable, as external factors markedly affect the severity of disease symptoms shown by inoculated seedlings. The interpretation of the segregation into resistant and susceptible plants has therefore been hampered. However, segregation has been obtained which indicates the action of a single dominant gene for the resistance. Tri-model frequency distributions for the severity of leaf symptoms have been observed. Ways to achieve greater uniformity in inoculation trials and more accurate standardization of the inoculum are being studied by Pathology Division.

Twin Bunches

The oil palm occasionally produces "twin" bunches, that is, two bunches in the axil of a single frond. Two palms of Calabar origin growing on the NIFOR Main Station have been associated with this phenomenon. One of these reverted to normal behaviour after a period of yielding "twins". The second palm yielded 21 bunches (total bunch weight 409 lb.) in two successive harvests. For each pair of bunches, the bigger one had a significantly higher fruit to bunch ratio, more mesocarp to fruit, more oil in the pulp but less kernel. The analysis suggested that compression by the larger bunch affected the proportions of the components of the smaller one. Average bunch weight in one of these palms was as follows:

Palm 3.520. Single bunch weight

	lb.
Normal bunches (mean for previous eight years) ..	22.6
Larger "twin" bunch	11.9
Smaller "twin" bunch	5.4

The Coconut Palm

Collections

A start has been made to collect coconuts from different places in Nigeria. It is to be noted that phytosanitary restrictions have limited the extent of introductions for research purposes and the establishment of a comprehensive gene pool. In Nigeria, nuts have been collected from palms at Kurama waters, near Lagos, and in the Badagry area of Western Nigeria. The palms already planted on the Main Station include selected types from the Main Station and Badagry and some green dwarf palms from Umuahia which were originally introduced from India. Recent introductions have included high yielding green, yellow and red dwarf palms from Lower Perak (United Plantations), Malaya and a very precocious green dwarf palm from the Cameroun. Germinating nuts are being screened and the first planting into the field will be made in May, 1967. This is the first stage in establishing a gene pool.

Work on the coconut will, for sometime, concentrate on the collection and classification of the coconuts of Nigeria.

Breeding

Methods of pollen collection and controlled pollination are being tried out. It is not intended that a programme of breeding will be started at this early stage in the Institute's work.

The Raphia Palm

Raphia Hookeri, selected at Abak in Eastern Nigeria, has started flowering in the Palmetum and will be used to propagate more palms. Three hundred seeds have been introduced from Ohanso, Eastern Nigeria, and are at present growing in the nursery. Some seed of *Raphia vinifera* is being germinated.

Palmetum

Seeds of palm species have continued to be received from overseas. The Palmetum has been surveyed and a large scale plan has been drawn. Observations on the germination and flowering of the different species of palms have continued. The current list of this expanding collection is given below. Seedlings of a further ten species are in the greenhouse and seed from fourteen more is being germinated.

Palm Species in the NIFOR Palmetum: May 1967

*Acrocomia aculeata
Acrocomia armentalis
Actinorhytis calapparia
Aiphanes acanthophylla
*Ancistrophyllum secundiflorum
Archontophoenix alexandrae
Areca sp.
*Areca catechu
*Arecastrum Romanzoffianum
*Arenga pinnata
Arenga microcarpa
Arenga tremula

*Arikuryoba schizophylla
Attalea macrocarpa
*Bactris major
Bentincka nicobarica
*Borassus aethiopum
Butia capitata
*Butia eriospatha
Calyptrocalyx spicatus
*Caryota mitis
Chamaedorea elatior
Chamaedorea Tepijilote
Chamaerops humulis
*Chrysalidocarpus lutescens
*Coccothrinax argentea
*Cocos nucifera
Coleospadix oninensis
Copernicia alba
Copernicia glabrescens
Copernicia macroglossa
Copernicia prunifera
*Coroso oleifera
Cyrtostachys lakka
Cyrtostachys Renda
Coccothrinax martii
Coccothrinax miraguama
Caryota urens
Dictyosperma aureum
*Elaeis guineensis—Deli
*Elaeis guineensis var. nigrescens
*Elaeis guineensis var. virescens
*Elaeis guineensis var. albescens
*Elaeis guineensis var. dura
*Elaeis guineensis var. tenera
*Elaeis guineensis var. pisifera
*Elaeis guineensis var. idolatrica
*Elaeis guineensis var. poissoni
*Euterpe sp.
Eugeissona utile
Gaussia attenuata
Hyphaene shatan
*Hyphaene thebaica
Jubaea spectabilis
Latania loddigessii
Latania lonteroides
Licuala spinosa
*Livistona chinensis
*Livistona rotundifolia
Mascarena lagenicaulis
*Onchosperma horrida
Oncocalamus acanthocnemis
Orania palindan
*Orbignya cohune
Paurotis wrightii
Phoenicophorium Bersigianum
Phoenix sp.
*Phoenix acaulis
Phoenix canariensis
Phoenix dactylifera
*Phoenix reclinata
Phoenix Roebellinii
Phoenix rupicola
Ptychandra glauca
*Ptychosperma elegans
Ptychosperma Macarthuri
Pseudophoenix sargentii
*Raphia hookeri
Raphia sudanica
*Raphia vinifera
*Roystonea oleracea
*Sabal sp.
*Sabal palmetto
Sabal yapa
Serenoa repens
Sabal mauritaeformis
Thrinax parviflora
Thrinax microcarpa
Veitchia Merrillii
Veitchia winin
Verschaffeltia splendida
Washingtonia filifera
Washingtonia robusta
Zombia antillarum
I 205

*Fruiting palms indicated with an asterisk.

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Dura Progeny Trials: Main Station, 1961, 1962

Cumulative yield per acre up to 31st December, 1966

Progeny	Year planted	Expt. No.	Bunches No.	Bunches Weight lb.	Single bunch weight lb.
1.2227 × 1.2227	1961	31-4	869	9,745	11.2
1.3340 × 1.3340	1961	31-7	1,335	12,153	9.1
1.3307 × 1.3307	1961	31-7	715	6,519	9.1
3.361 × 3.361*	1962	30-4	452	1,774	3.9
32.2824 × 32.2824* ..	1962	30-4	417	1,163	2.8
907.261 × 907.261	1962	24-7	541	3,814	7.0
1.2209 × 1.2209	1962	24-7	134	714	5.3
2.1997 × 2.1997	1962	30-2	506	2,482	4.9
3.2538 × 3.2538	1962	30-2	467	2,470	5.3
32.658 × 32.658	1962	30-2	686	3,551	5.2
907.261 × 907.262	1961	31-4	1,326	7,815	5.9
1.3340 × 1.3307	1961	31-7	1,408	16,419	11.7
1.3307 × 3.361	1961	31-7	1,114	13,840	12.4
32.2824 × 3.361	1961	31-7	1,822	17,385	9.5
32.2824 × 1.3340	1961	31-7	1,690	15,166	9.0
3.361 × 3.2538*	1961	31-8	1,653	15,346	9.3
3.361 × 32.658*	1961	31-8	1,470	13,058	8.9
2.1997 × 3.2538	1961	31-8	1,799	15,127	8.4
39.402 × 39.419	1962	24-6	651	5,995	9.2
39.418 × 39.450	1962	24-6	606	5,181	8.5
39.418 × 39.419	1962	24-6	448	4,269	9.5
2.1997 × 3.361	1962	30-2	972	7,424	7.6
3.2538 × 1.53	1962	30-2	726	6,228	8.6
3.2538 × 32.658	1962	30-2	827	6,187	7.5
32.658 × 1.53	1962	30-2	772	7,659	9.9
2.1997 × 1.3340	1962	30-2	852	7,500	8.8
2.1997 × 3.2538	1962	30-2	907	6,828	7.5
1.3307 × 32.658	1962	30-2	487	4,106	8.4

**=dry season nursery*

Deli Dura Progeny Trials: Main Station, 1959, 1960, 1961, 1962

Cumulative yield per acre up to 31st December, 1966

Progeny	Year planted	Expt. No.	Bunches No.	Bunches Weight lb.	Single bunch weight lb.
5.368 × 5.368*	1959	35-1	1,034	7,566	7.3
5.642 × 5.642*	1959	35-1	1,161	9,239	8.0
5.2153 × 5.2153*	1959	35-1	1,448	11,237	7.8
5.1295 × 5.1295*	1959	35-1	1,429	10,250	7.2
203.93 × 203.93	1960	35-2	337	2,777	8.2
201.32 × 201.32	1960	35-2	686	9,257	13.5
201.51 × 201.51	1960	35-2	585	6,539	11.2

**=dry season nursery*

(continued overleaf)

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DELI DURA PROGENY TRIALS: MAIN STATION, 1959, 1960, 1961, 1962

Cumulative yield per acre up to 31st December, 1966

Progeny	Year planted	Expt. No.	Bunches No.	Bunches Weight lb.	Single bunch weight lb.
203.48 × 203.48	1960	35-2	661	7,804	11.8
203.133 × 203.133	1960	35-2	1,431	14,390	10.0
5.114 × 5.114*	1962	30-4	516	4,783	9.3
5.368 × 5.368*	1962	30-4	518	3,400	6.6
5.2153 × 5.642	1959	35-1	1,314	11,140	8.5
5.1295 × 5.642	1959	35-1	1,430	13,058	9.1
5.2153 × 5.368	1959	35-1	1,349	10,769	8.0
5.1295 × 5.368	1959	35-1	1,289	10,234	7.9
5.1295 × 5.2153	1959	35-1	1,474	12,911	8.8
5.368 × 5.642	1959	35-1	1,262	11,401	9.0
5.642 × 5.368*	1960	35-2	1,764	16,324	9.2
201.32 × 203.93	1960	35-2	496	5,813	11.7
203.93 × 201.51	1960	35-2	853	8,800	10.3
203.93 × 201.55	1960	35-2	659	6,041	9.2
201.32 × 201.51	1960	35-2	1,001	15,422	15.4
201.32 × 203.48	1960	35-2	663	9,310	14.0
201.51 × 201.55	1960	35-2	710	8,098	11.4
5.368 × 203.93	1960	35-2	748	8,905	11.9
5.368 × 201.32	1960	35-2	875	10.675	12.2
5.642 × 203.93	1960	35-2	801	10,702	13.4
5.1295 × 201.55	1960	35-2	811	11,570	14.3
5.2153 × 201.51	1960	35-2	925	13,038	14.1
5.2153 × 201.51	1960	35-2	829	11,366	13.7
5.368 × 26/0932	1961	31-7	861	14,455	16.8
5.368 × 26/0932* ..	1961	31-8	736	8,824	12.0
5.1295 × 26/0932	1961	31-7	823	14,777	18.0
5.642 × G98	1961	31-7	711	13,214	18.6
201.32 × G98	1961	31-7	469	7,603	16.2
5.642 × 5.368	1961	31-7	1,075	15,327	14.2
5.642 × 201.32	1961	31-7	522	10,692	20.5
5,1080 × 203,93*	1962	30-4	584	5,145	8.8
5.1080 × G140	1962	30-4	604	5,396	8.9
203.93 × G143*	1962	30-4	581	4,496	7.7
5.1295 × G144*	1962	30-4	696	6,536	9.4
5.114 × G143*	1962	30-4	672	6,421	9.6
5.368 × 5.642*	1962	30-4	758	5,714	7.5
5.12 × 5.1295	1962	30-2	566	5,859	10.4
26/0932 × 26/0932	1962	30-2	159	2,318	14.6
5.12 × 5.12	1962	30-2	456	3,423	7.5
112.18 × 112.18	1962	30-2	338	2,861	8.5
203.93 × 26/0932	1962	30-2	366	3,760	10.3
5.642 × 5.368	1962	30-2	464	5,812	12.5
26/5767 × 26/0932	1962	30-2	94	1,950	20.7
38/4163 × 12/8163	1962	30-2	492	5,388	11.0
15/6201 × 3AR/3902 ..	1962	30-2	458	5,516	12.0

**=dry season nursery*

TENERA PROGENY TRIALS: MAIN STATION, 1959, 1960, 1961, 1962

Cumulative yield per acre up to 31st December, 1966 from bearing palms

Progeny	*Year planted*	*Expt. No.*	*Bunches*		*Single bunch weight*
			No.	*Weight lb.*	*lb.*
32.364 × 32.364*	1959	31-1	2,446	28,065	11.5
108.5 × 108.5*	1959	31-1	2,285	12,456	5.4
2.3495 × 2.3495	1959	31-1	2,720	15,076	5.5
1.2229 × 1.2229	1960	24-4	2,119	17,408	8.2
907.263 × 907.263	1960	24-4	1,626	11,100	6.8
907.264 × 907.264	1960	24-4	1,722	18,289	10.6
1.2815 × 1.2815	1960	35-4	1,623	17,015	10.5
1.2860 × 1.2860	1960	35-4	843	5,258	6.2
1.2883 × 1.2883	1960	35-4	1,521	12,933	8.5
1.3231 × 1.3231	1960	35-4	1.028	7,877	7.7
1.2998 × 1.2998	1960	35-4	1.501	12,645	8.4
3.398 × 3.398	1960	31-2	1.540	12,453	8.1
1.3352 × 1.3352	1960	31-2	1,510	12,558	8.3
1.3056 × 1.3056	1960	31-2	1,788	14,917	8.3
T372 × T372	1961	31-5	1,404	14,279	10.2
1.3208 × 1.3208	1961	31-5	1,287	8,468	6.6
32.3005 × 32.3005	1961	31-5	1,218	12,234	10.0
32.2612 × 32.2612* ..	1961	31-6	1,715	7,959	4.6
907.265 × 907.265	1961	24-5	1,474	9,253	6.3
907.266 × 907.266	1961	24-5	1,521	9,938	6.5
1.3079 × 1.3079	1961	24-6	1,461	7,108	4.9
39.715 × 39.715	1962	24-6	442	1,598	3.6
32.2687 × 32.2687	1962	24-6	707	2,828	4.0
39.719 × 39.719	1962	24-6	673	2,558	3.8
3.1035 × 3.1035	1962	30-5	632	2,336	3.7
907.263 × 907.263	1962	24-7	668	4,448	6.6
1.3352 × 1.3352*	1962	30-3	811	4,227	5.2
4.1811 × 4.1811*	1962	30-3	750	3,362	4.5
4.3488 × 4.3488*	1962	30-3	850	4,050	4.8
1.3379 × 1.3379	1962	30-3, 30-1	1,132	4,586	4.0
1.3056 × 1.3056	1962	30-3, 30-1	646	3,596	5.6
1.3208 × 1.3208	1962	30-3, 30-1	675	3,515	5.2
38/0401 × 38/0401	1962	30-3, 30-1	1,024	6,050	5.9
3.1035 × 3.1035	1962	30-1	744	2,618	3.5
3.398 × 3.398	1962	30-1	593	6,573	11.1
32.2612 × 32.2612	1962	30-1	1,021	3,440	3.4
1.3352 × 1.3352	1962	30-1	527	3,664	7.0
108.5 × 32.364	1959	31-1	2,519	27,959	11.1
32.364 × 2.3495*	1959	31-1	2,188	22,392	10.2
1.2229 × 32.364	1959	31-1	1,486	21,420	14.4
108.5 × 2.3495	1959	31-1	2,585	19,028	7.4
1.2229 × 2.3495	1959	31-1	2,013	23,401	11.6
1.2224 × 1.2229	1960	24-4	1,466	16,113	11.0
907.264 × 907.263	1960	24-4	2,180	20,654	9.5

** =dry nursery season*

(continued overleaf)

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Tenera Progeny Trials: Main Station, 1959, 1960, 1961, 1962

Cumulative yield per acre up to 31st December, 1966 from bearing palms

Progeny	Year planted	Expt. No.	Bunches No.	Bunches Weight lb.	Single bunch weight lb.
907.266 × 907.263	1960	24-4	1,469	15,385	10.5
907.265 × 907.264	1960	24-4	1,906	21,488	11.3
907.264 × 907.266	1960	24-4	1,723	15,703	9.1
907.266 × 907.265	1960	24-4	1,783	14,683	8.2
1.2229 × 108.5	1960	31-2	1,872	17,587	9.4
32.364 × 1.3056	1960	31-2	1,986	24,333	12.2
1.3208 × 2.3495	1960	31-2	2,452	20,173	8.2
1.3208 × 1.2229	1960	31-2	1,962	21,408	10.9
1.3056 × 1.3352*	1960	31-2	2,011	21,848	10.9
1.3208 × 1.3352	1960	31-2	2,181	21,433	9.8
G103	1960	31-2	1,579	13,157	8.3
G104	1960	31-2	1,542	14,634	9.5
1.3352 × 32.3005	1961	31-5	1,325	17,849	13.5
1.3056 × 32.3005	1961	31-5	1,464	18,726	12.8
32.2612 × 1.2229	1961	31-5	1,191	16,283	13.7
1.3208 × 1.3056	1961	31-5	1,602	13,582	8.5
2.3495 × 32.2612	1961	31-5	1,878	15,792	81.4
2.3495 × 1.3379	1961	31-5	1,319	13,430	10.2
32.3005 × 1.3379	1961	31-5	1,814	21,013	11.6
32.364 × 1.3352	1961	31-5	1,205	13,828	11.5
1.3208 × 1.3379	1961	31-5	2,033	15,896	7.8
1.3208 × 2381D	1961	31-5	1,818	18,730	10.3
4.3488 × 2381D	1961	31-5	1,882	20,922	11.1
1.2224 × 2381D	1961	31-5	1,364	16,385	12.0
4.17 × 2381D	1961	31-5	1,516	17,927	11.8
4.868 × 2381D	1961	31-5	1,540	17,338	11.2
4.1811 × 2381D	1961	31-5	1,441	16,276	11.3
32.2612 × 32.3005	1961	31-5	1,361	12,074	8.9
13.4929 × 2381D	1961	31-5	1,194	10,971	9.2
1.2844 × 2381D*	1961	31-6	1,261	13,627	10.8
32.3005 × 2381D*	1961	31-6	1,410	17,189	12.2
14.253 × 2381D*	1961	31-6	1,463	15,475	10.6
32.2612 × 2381D*	1961	31-6	1,962	17,136	8.7
4.2534 × 2381D*	1961	31-6	1,319	13,914	10.5
2419D × 2381D*	1961	31-6	1,178	12,213	10.4
2407D × 2381D*	1961	31-6	1,281	14,231	11.1
2425D × 2381D*	1961	31-6	1,369	15,182	11.1
1393B × 1211A*	1961	31-6	841	9,097	10.8
69Mab × 233B*	1961	31-6	1,673	13,521	8.1
13.1440 × 2381D*	1961	31-6	1,595	13,687	8.6
32.2612 × 1.3079	1961	24-6	2,123	13,165	6.2
1.3079 × 103.3	1961	24-6	1,354	12,341	9.1
39.715 × 32.3005	1962	24-6	550	5,837	10.6
1.3056 × 39.715	1962	24-6	554	4,489	8.1
1.3079 × 1,3286	1962	24-6	517	3,772	7.3
1.3079 × 103.3	1962	24-6	609	4,841	7.9

** = dry nursery season*

32.2687 × 2.4358	1962	24–6	676	5,099	7.5
1.2815 × 1.2860	1962	24–6	636	4,892	7.7
39.119 × 32.3005	1962	24–6	609	5,155	8.5
1.3056 × 39.719	1962	24–6	582	4,782	8.2
39.719 × 39.715	1962	24–6	839	3,902	4.6
69Mab × 233B	1962	30–5	881	7,363	8.4
1393B × 1211A	1962	30–5	900	6,853	7.6
2425D × 2381D	1962	30–5	884	8,202	9.3
2407D × 2381D	1962	30–5	614	6,012	9.8
2419D × 2381D	1962	30–5	588	5,902	10.0
4.838 × 4.3488*	1962	30–3	976	6,782	6.9
1.3379 × 1.3056*	1962	30–3	994	6,522	6.6
4.1935 × 4.838*	1962	30–3	873	4,834	5.5
4.1935 × 4.1624*	1962	30–3	641	3,948	6.2
1.3208 × 32.3005*	1962	30–3	862	7,582	8.8
4.2411 × 32.3005* ..	1962	30–3	925	6,496	7.0
3.1035 × 32.2612	1962	30–1	1,186	5,886	5.0
3.1035 × 32.3005	1962	30–1	835	6,363	7.6
1.3379 × 32.2612	1962	30–1	1,194	6,091	5.1
3.1035 × 1.2229	1962	30–1	806	6,110	7.6
1.3352 × 3.1035	1962	30–1	785	5,814	7.4
3.1035 × 1.3208	1962	30–1	963	6,006	6.2
23/10215 × 23/9889	1962	30–1	484	4,621	9.5
16R6 × 176B	1962	30–1	545	4,724	8.7
32.3005 × 2381D	1962	30–1	752	7,521	10.0

* = *dry season nursery*

DURA × TENERA PROGENY TRIALS: MAIN STATION, 1960, 1961, 1962

Cumulative yield per acre up to 31st December, 1966

Progeny	*Year planted*	*Expt. No.*	*Bunches*		*Single bunch weight*
			No.	*Weight*	
				lb.	*lb.*
1.2227 × 1.2229	1960	24–5	1,042	11,725	11.2
1.2209 × 1.2224	1960	24–5	1,332	13,375	10.0
1.2209 × 1.2229	1960	24–5	1,062	10,808	10.2
1.2227 × 1.3056	1960	24–5	1,436	20,303	14.1
907.261 × 907.263	1960	24–5	1,578	16,372	10.4
6.594 × 108.5	1960	31–3	2,029	18,690	9.2
1.3307 × 1.3352	1960	31–3	1,415	18,159	12.8
3.398 × 1.3307	1960	31–3	1,657	15,676	9.5
6.544 × 32.364	1960	31–3	1,541	20,775	13.5
5.1654 × 32.364	1960	31–3	2,173	26,392	12.1
5.1654 × 108.5	1960	31–3	2.316	20,668	8.9
1.2227 × 1.3056	1960	31–3	1,706	22,330	13.1
5.368 × 1.3056	1960	31–3	1,753	21,755	12.4

(*continued overleaf*)

—*continued*

DURA × TENERA PROGENY TRIALS: MAIN STATION, 1960, 1961, 1962

Cumulative yield per acre up to 31st December, 1966

Progeny	*Year planted*	*Expt. No.*	*Bunches*		*Single bunch weight*
			No.	*Weight*	
				lb.	*lb.*
5.368 × 1.3056	1960	35–3b	1,794	24,780	13.8
5.368 × 32.364	1960	35–2	1,684	23,574	14.0
5.368 × 32.364	1960	35–3b	1,940	28,050	14.4
5.368 × 1.3352	1960	35–3b	1,589	17,479	11.0
1.3056 × 1.3307*	1960	35–3a	1,355	8,873	6.5
1.3307 × 1.3352*	1960	35–3a	1,216	8,408	6.9
1.3352 × G98*	1960	35–3a	633	7,570	12.0
108.5 × 201.32*	1960	35–3a	1,059	10,391	9.8
108.5 × 203.133* ..	1960	35–3a	1,002	7,523	7.5
32.364 × 203.133* ..	1960	35–3a	1,015	11,103	10.9
32.364 × 5.642*	1960	35–3a	1,325	13,235	10.0
5.368 × 1.3352*	1960	35–3a	1,192	12,532	10.5
5.2153 × 108.5*	1960	35–3a	1,370	14,330	10.4
1.3352 × 203.93*	1960	35–3a	902	9,036	10.0
1.3352 × G98	1960	35–2	622	6,854	11.0
13.1440 × 2381D	1961	31–6	1,595	13,687	8.6
1.2227 × 1.2224	1961	31–4	775	9,156	11.8
3.361 × 1.2229	1961	31–4	1,213	12,660	10.4
907.265 × 907.261	1961	31–4	861	6,993	8.1
907.261 × 907.264	1961	31–4	847	7,606	9.0
907.266 × 907.261	1961	31–4	1,153	9,710	8.4
907.261 × 907.263	1961	31–4	1,156	10,032	8.7
112.18 × 1.2998	1961	24–6	1,302	11,744	9.0
32.3005 × 3.361*	1961	35–5	1,364	12,546	9.2
32.3005 × 3.2538*	1961	35–5	1,445	13,394	9.3
2.1997 × 1.3208*	1961	35–5	1,402	8,398	6.0
3.361 × 1.3352*	1961	35–5	1,172	9,356	8.0
32.2612 × 32.2824* ..	1961	35–5	1,088	10,914	10.0
3.314 × 2381D*	1961	35–5	1,434	13,047	9.1
3.369 × 2381D*	1961	35–5	1,528	10,916	7.1
32.2824 × 2381D*	1961	35–5	1,560	12,000	7.7
3.1588 × 2381D*	1961	35–5	1,303	9,654	7.4
32.3005 × 203.93*	1961	35–5	977	12,705	13.0
32.3005 × 201.32*	1961	35–5	701	10,428	14.9
5.1084 × 2381D*	1961	35–5	1,156	12,587	10.9
201.51 × 2381D*	1961	35–5	914	9,959	10.9
5.1225 × 2381D*	1961	35–5	1,337	13,389	10.0
26/5767 × 2381D*	1961	35–5	787	10,256	13.0
932Der × 648Li*	1961	35–5	1,261	11,517	9.1
14.2598 × 2381D*	1961	35–5	947	9,166	9.7
32.2612 × 26/0932	1961	35–5	961	9,715	10.1
3.361 × 1.2229	1961	35–6	1,465	17,172	11.7
32.2824 × 32.3005	1961	35–6	1,590	16,805	10.6
1.3056 × 3.361	1961	35–6	1,492	17,551	11.8
1.3208 × 32.658	1961	35–6	1,404	13,491	9.6

* = *dry season nursery seedlings*

1.3379 × 3.361	1961	35–6	1,533	12,579	8.2
1.3340 × 2.3495	1961	35–6	1,346	14,274	10.6
1.3340 × 1.3208	1961	35–6	1,520	17,955	11.8
2.3495 × 3.361	1961	35–6	1,489	14,548	9.8
32.658 × 32.3005	1961	35–6	1,342	16,491	12.3
32.2824 × 1.3352	1961	35–6	1,397	11,643	8.3
5.368 × 32.3005	1961	35–6	1,320	22,157	16.8
5.1295 × 1.3352	1961	35–6	1,162	15,237	13.1
5.368 × 32.2612	1961	35–6	1,889	21,144	11.2
5.642 × 1.3352	1961	35–6	1,133	16,673	14.7
108.5 × 201.32	1961	35–6	974	13,359	13.7
5.1295 × 32.2612	1961	35–6	1,851	19,466	10.5
5.12 × 32.3005	1961	35–6	1,148	20,449	17.8
32.2612 × 5.642	1961	35–6	1,865	21,018	11.3
32.364 × G98	1961	35–6	1,154	12,262	10.6
108.5 × G98	1961	35–6	970	15,603	16.1
5.642 × 1.3208	1961	35–6	1,486	21,274	14.3
201.51 × 2381D	1961	35–6	1,033	13,658	13.2
203.93 × 2381D	1961	35–6	1,061	15,168	14.3
5.444 × 32.3005	1961	35–6	1,113	19,360	17.4
32.2612 × G98	1961	35–6	1,534	14,421	9.4
1.3352 × G98	1961	35–6	622	11,598	18.6
39.419 × 32.3005	1962	24–6	598	5,640	9.4
907.262 × 907.263	1962	24–7	440	2,628	6.0
907.262 × 907.264	1962	24–7	476	2,614	5.5
1.2209 × 1.2229	1962	24–7	289	1,900	6.6
32.364 × 3.2538	1962	36–1	526	4,641	8.8
1.53 × 32.2612	1962	36–1	953	7,072	7.4
2.1997 × 3.1035	1962	36–1	989	6,362	6.4
3.1504 × 32.658	1962	36–1	817	6,117	7.5
1.3352 × 3.2538	1962	36–1	548	5,046	9.2
3.2538 × 3.1035	1962	36–1	755	4,544	6.0
3.1035 × 32.2824	1962	36–1	972	5,104	5.2
3.1504 × 3.361	1962	36–1	826	5,627	6.8
1.2229 × 1.53	1962	36–1	675	7,117	10.5
3.1504 × 3.417	1962	36–1	844	6,523	7.7
32.364 × 32.2824	1962	36–1	810	6,230	7.7
26/5767 × 2381D	1962	36–1	360	4,691	13.0
5.1225 × 2381D	1962	36–1	674	8,141	12.1
5.2153 × 32.2612	1962	36–1	838	7,354	8.8
3.1035 × 26/0932	1962	36–1	700	4,704	6.7
3.22612 × 201.32	1962	36–1	667	7,058	10.6
3.1504 × 201.32	1962	36–1	258	3,358	13.0
3.1504 × 5.368	1962	36–1	657	6,966	10.6
32.2612 × G140	1962	36–1	557	4,746	8.5
32.364 × 26/0932	1962	36–1	306	2,757	9.0
1.53 × 1.3352*	1962	36–2	786	5,965	7.6
32.2824 × 2.3495*	1962	36–2	848	4,525	5.4
1.3340 × 32.2612*	1962	36–2	797	4,795	6.0
1.3352 × 203.93*	1962	36–2	548	4,398	8.0
203.133 × 108.5*	1962	36–2	684	3,699	5.4
32.2612 × G143*	1962	36–2	834	5,439	6.5

* = *dry season nursery seedlings*

I

'61, 1962—*continued*

unches Weight *lb.*	*Single bunch weight lb.*
4,992	7.9
6,569	8.1
6,396	8.4
4,523	6.0
4,022	8.7
6,265	9.4
5,557	8.0
6,816	9.0
5,196	7.8
5,860	9.5
6,978	10.6
7,122	10.2
5,672	8.1
2,490	7.4
6,039	7.3
4,376	7.5
5,173	7.8
4,930	6.8
5,530	6.8

1962

year's harvest

'ulp/ 'uit	*Shell/ fruit*	*Kernel/ fruit*	*Oil/ pulp*
%	%	%	%
52.4	37.7	9.9	33.4
55.8	32.4	11.8	25.7
51.6	38.5	9.9	35.8
51.0	38.5	10.5	20.3
44.1	42.7	13.1	24.2
52.9	37.1	10.0	36.2
54.2	35.5	10.3	32.5
56.2	33.0	10.7	39.1
58.6	32.1	9.2	33.6
57.4	32.5	10.2	37.2
47.8	39.8	12.4	29.2
50.4	38.4	11.2	36.8
53.1	36.3	10.6	35.8
50.1	39.2	10.7	35.4
46.6	41.0	12.3	33.8
45.7	41.8	12.6	37.9
50.7	37.7	11.7	29.6

DELI DURA PROGENY TRIALS: MAIN STATION, 1962

Fruit form segregation and bunch quality during first year's harvest

Progeny		*Planted*	*Expt. No.*	*Segregation dura*	*tenera*	*Fruit/ bunch*	*Single fruit weight*	*Pulp/ fruit*	*Shell/ fruit*	*Kernel/ fruit*	*Oil/ pulp*
						%	g.	%	%	%	%
5.114	× 5.114	1962	30–4	39	0	70.3	11.1	54.2	36.9	8.9	19.0
5.368	× 5.368	1962	30–4	55	0	70.5	8.3	53.3	38.2	8.5	30.4
26/0932	× 26/0932	1962	30–2	55	0	76.7	12.2	43.5	47.0	9.6	34.4
5.12	× 5.12	1962	30–2	18	0	59.3	8.6	52.5	37.8	9.7	27.8
5.1080	× 203.93	1962	30–4	58	0	71.8	10.2	53.5	36.3	10.3	31.6
5.1080	× G140	1962	30–4	60	0	71.9	10.4	51.4	38.4	10.2	23.8
203.93	× G143	1962	30–4	53	3	68.4	9.3	47.8	40.8	11.5	29.4
5.1295	× G144	1962	30–4	60	0	72.6	9.3	58.4	32.9	8.7	33.6
5.114	× G143	1962	30–4	54	0	69.5	9.3	51.9	37.7	10.4	28.4
5.368	× 5.642	1962	30–4	57	0	71.0	8.6	56.0	35.0	9.0	23.2
5.12	× 5.1295	1962	30–2	59	0	70.0	9.3	51.3	38.3	10.4	34.5
203.93	× 26/0932	1962	30–2	53	6	71.5	9.1	43.3	44.4	12.2	34.7
5.642	× 5.368	1962	30–2	60	0	73.2	10.2	56.3	35.3	8.3	29.8
26/5767	× 26/0932	1962	30–2	60	0	77.1	10.9	47.4	42.1	10.5	31.1
38/4163	× 12/8163	1962	30–2	60	0	66.8	8.2	48.0	41.9	10.2	38.0
15/6201	× 3AR/3902	1962	30–2	60	0	71.5	10.6	44.2	47.3	8.5	47.8
112.18	× 112.18	1962	30–2	18	0	66.1	9.6	50.5	39.6	9.9	37.2

TENERA PROGENY TRIALS: MAIN STATION, 1962

Fruit form segregation and bunch quality during first year's harvest

Progeny		Planted	Expt. No.	Segregation		Tenera				Dura					
				dura	*tenera*	*Fruit/ bunch*	*Single fruit weight*	*Pulp/ fruit*	*Shell/ fruit*	*Kernel/ fruit*	*Fruit/ bunch*	*Single fruit weight*	*Pulp/ fruit*	*Shell/ fruit*	*Kernel/ fruit*	*Oil/ pulp*
						%	g.	%	%	%	%	g.	%	%	%	%
39.715	× 39.715	1962	24–6	—	—	65.1	4.0	70.2	20.6	9.2	67.3	5.0	40.3	48.8	10.9	41.9
32.2687	× 32.2687	1962	24–6	—	—	70.4	8.2	58.3	31.6	10.1	73.1	8.6	42.2	47.7	10.1	34.8
907.263	× 907.263	1962	24–7	20	21	66.1	6.7	77.6	11.6	10.8	66.9	8.2	49.6	40.9	9.5	35.4
1.3352	× 1.3352	1962	30–3	3	6	67.2	5.1	78.2	14.6	7.1	68.8	8.9	49.1	43.6	7.3	46.7
4.1811	× 4.1811	1962	30–3	17	29	62.1	9.1	83.6	10.3	6.2	68.1	11.9	45.5	46.3	8.3	23.6
4.3488	× 4.3488	1962	30–3	19	19	61.1	4.2	79.2	12.4	8.4	65.1	7.5	44.1	45.0	10.9	15.8
1.3379	× 1.3379	1962	30–3, 30–1	9	55	68.1	6.9	84.3	8.4	7.3	69.3	7.7	53.5	37.7	8.8	40.7
1.3056	× 1.3056	1962	30–3, 30–1	28	40	60.1	5.2	87.3	6.7	5.9	67.4	7.5	46.9	43.2	9.9	30.2
1.3208	× 1.3208	1962	30–1	18	28	55.5	5.3	85.0	6.9	8.1	62.8	8.5	53.1	37.1	9.9	47.8
38/0401	× 38/0401	1962	30–3, 30–1	25	39	65.2	6.8	79.3	13.3	7.3	70.0	8.5	46.6	44.6	8.8	21.2
3.1035	× 3.1035	1962	30–1, 30–5	8	19	65.3	6.8	83.3	9.4	7.2	75.8	10.9	44.5	46.3	9.2	40.4
3.398	× 3.398	1962	30–1	8	4	66.2	8.9	72.9	17.3	9.8	73.6	11.9	39.8	50.0	10.2	40.3
32.2612	× 32.2612	1962	30–1	11	25	66.7	5.6	87.8	7.7	4.5	69.4	7.3	50.4	41.8	7.7	42.2
1.3352	× 1.3352	1962	30–1	20	20	66.9	5.2	76.5	15.2	8.3	71.8	7.7	53.0	37.2	9.9	46.2
39.719	× 39.719	1962	24–6	—	—	58.7	4.4	59.8	27.7	12.5	62.5	6.1	34.0	50.5	13.6	28.3
39.715	× 32.3005	1962	24–6	—	—	69.6	6.2	71.3	19.1	9.6	67.4	8.9	43.2	46.0	10.8	44.8
1.3056	× 39.715	1962	24–6	—	—	66.2	5.0	75.3	15.5	9.1	72.0	7.0	44.5	44.9	10.7	41.3
1.3079	× 1.3286	1962	24–6	—	—	66.1	8.3	87.5	5.7	6.8	65.6	9.3	44.4	46.4	9.2	53.4
1.3079	× 103.3T×P	1962	24–6	—	—	68.2	6.6	83.9	8.1	8.0	—	—	—	—	—	44.4
32.2687	× 2.4358	1962	24–6	—	—	69.3	7.3	59.0	30.8	10.2	69.4	7.8	38.4	52.5	9.1	34.4
1.2815	× 1.2860	1962	24–6	—	—	66.2	7.7	76.5	15.2	8.3	65.9	10.0	50.4	40.2	9.4	40.2
39.719	× 32.3005	1962	24–6	12	5	67.7	5.3	65.1	23.1	11.8	70.2	6.8	45.1	49.7	12.5	37.4
1.3056	× 39.719	1962	24–6	7	5	63.9	4.8	71.8	18.0	10.2	70.0	6.4	39.0	49.6	11.4	37.1
39.719	× 39.715	1962	24–6	14	5	63.3	4.2	64.4	24.4	11.2	67.9	7.5	38.3	51.0	10.7	32.2
69.Mab	× 233B	1962	30–5	6	15	68.9	9.6	81.2	10.0	8.9	71.7	11.4	54.5	37.5	8.0	37.0
1393B	× 1211A	1952	30–5	6	13	68.0	9.4	83.4	8.4	8.2	65.5	9.4	50.7	41.4	8.0	43.5
2425D	× 2381D	1962	30–5	7	7	64.4	8.1	76.6	13.3	10.1	68.2	9.1	50.5	41.2	8.2	56.3

2407D	× 2381D	1962	30–5	2	9	68.2	6.5	79.4	10.2	10.4	70.1	8.3	50.2	40.3	9.5	34.2
2419D	× 2381D	1962	30–5	6	9	68.1	6.8	79.1	11.3	9.6	69.7	7.4	52.7	37.7	9.6	39.8
4.838	× 4.3488	1962	30–3	17	33	68.2	5.6	75.3	14.1	10.6	71.4	9.4	43.6	43.5	12.9	26.8
1.3379	× 1.3056	1962	30–3	20	40	65.2	6.3	82.6	8.5	8.9	70.5	8.6	46.4	42.5	11.1	42.9
4.1935	× 4.838	1962	30–3	25	35	68.5	7.4	75.4	14.9	9.7	70.7	10.4	46.0	42.9	11.1	29.8
4.1935	× 4.1624	1962	30–3	20	35	61.4	8.3	82.7	10.0	7.2	67.2	11.4	48.3	42.3	9.4	37.4
1.3208	× 32.3005	1962	30–3	23	40	65.5	5.4	83.6	8.6	7.8	66.2	7.9	49.9	38.5	11.6	36.0
4.2411	× 32.3005	1962	30–3	18	41	68.1	5.3	81.0	10.2	8.8	70.1	7.8	47.1	40.7	12.1	35.0
3.1035	× 32.2612	1962	30–1	16	39	64.3	5.8	81 2	10.9	7.9	74.4	8.8	44.6	46.3	9.1	32.8
3.1035	× 32.3005	1962	30–1	12	41	67.0	6.2	78.2	12.0	9.7	71.4	8.6	44.6	44.2	11.2	26.6
1.3379	× 32.2612	1962	30–1	25	41	66.5	6.4	82.9	9.4	7.7	70.9	10.2	49.3	41.4	9.3	40.4
3.1035	× 1.2229	1962	30–1	22	34	66.6	6.5	77.4	11.6	11.0	73.2	9.3	45.5	42.4	12.0	28.0
1.3352	× 3.1035	1962	30–1	26	37	66.9	5.3	75.0	14.8	10.2	70.3	8.2	46.2	42.3	11.5	27.0
3.1035	× 1.3208	1962	30–1	21	33	61.7	6.1	82.3	9.1	8.5	72.1	10.0	47.8	42.2	10.0	34.6
23/10215	× 23/9889	1962	30–1	20	32	64.1	5.9	68.7	20.8	10.5	67.9	7.5	41.0	47.7	11.4	29.1
16R6	× 176B	1962	30–1	20	34	60.1	9.8	79.4	10.3	10.3	70.9	10.6	45.4	44.4	10.2	38.0
32.3005	× 2381D	1962	30–1	22	37	67.8	6.8	72.8	14.7	12.4	69.3	8.8	45.3	43.1	11.5	54.8

DURA × TENERA PROGENY TRIALS: MAIN STATION, 1961, 1962

Fruit form segregation and bunch quality during first year's harvest

Progeny	Planted	Expt. No.	Segregation dura	Segregation tenera	Tenera Fruit/bunch	Tenera Single fruit weight	Tenera Pulp/fruit	Tenera Shell/fruit	Tenera Kernel/fruit	Dura Fruit/bunch	Dura Single fruit weight	Dura Pulp/fruit	Dura Shell/fruit	Dura Kernel/fruit	Dura Oil/pulp
					%	g.	%	%	%	%	g.	%	%	%	%
32.3005 × 3.361	1961	35–5	20	31	68.6	5.9	76.3	14.0	9.7	67.6	7.6	50.4	37.5	12.0	36.6
32.3005 × 3.2538	1961	35–5	16	33	68.8	5.3	77.7	13.7	8.6	68.4	7.5	51.7	36.8	11.5	38.2
2.1997 × 1.3208	1961	35–5	22	22	65.9	7.3	77.5	12.8	9.7	69.1	10.0	49.2	38.7	12.1	32.4
3.361 × 1.3352	1961	35–5	32	19	67.3	5.7	75.2	14.2	10.7	69.0	7.8	51.6	37.3	11.1	37.3
32.2612 × 32.2824	1961	35–5	28	27	67.2	6.2	83.3	9.5	7.2	73.4	9.4	51.8	38.8	9.4	36.5
3.314 × 2381D	1961	35–5	27	30	68.8	6.3	81.0	9.6	9.4	73.3	7.8	50.2	40.4	9.3	41.5
3.369 × 2381D	1961	35–5	29	25	66.3	5.8	82.4	8.8	8.7	73.4	8.3	48.3	43.3	8.5	39.3
32.2824 × 2381D	1961	35–5	30	21	69.7	6.5	83.5	7.1	9.4	72.2	8.6	52.8	37.2	10.0	36.7
3.1588 × 2381D	1961	35–5	20	21	66.9	6.9	84.1	6.9	9.0	73.1	9.3	52.1	37.8	10.0	36.8
32.3005 × 203.93	1961	35–5	27	25	71.8	6.8	79.4	11.7	8.9	70.8	9.6	52.2	37.4	10.4	29.5
32.3005 × 201.32	1961	35–5	22	20	73.7	7.6	79.8	12.0	8.2	72.4	9.8	53.5	35.5	10.9	28.5
5.1084 × 2381D	1961	35–5	28	23	70.5	7.8	80.4	9.5	10.2	71.6	10.0	57.0	33.9	9.2	40.0
201.51 × 2381D	1961	35–5	38	19	71.4	6.0	78.2	12.0	9.8	68.5	7.6	45.8	41.6	12.5	41.2
5.1225 × 2381D	1961	35–5	37	18	71.8	6.8	80.9	10.3	8.8	74.3	9.3	52.0	39.7	8.3	40.5
26/5767 × 2381D	1961	35–5	32	15	68.3	7.6	79.7	9.6	10.7	74.0	8.8	51.5	38.2	10.3	34.8
932Der × 648Li(D × P) 1961	1961	35–5	0	44	71.9	7.6	76.2	12.6	11.2	—	—	—	—	—	34.6
14.2598 × 2381D	1961	35–5	10	5	68.8	7.1	73.1	13.4	13.6	66.0	7.8	54.0	36.6	9.3	30.7
32.2612 × G118	1961	35–5	3	11	70.9	7.5	82.8	11.1	6.1	75.4	10.0	42.2	48.6	9.2	38.0
3.361 × 1.2229	1961	35–6	28	20	71.5	7.1	74.5	11.8	13.8	74.6	10.0	49.6	37.8	12.6	41.1
32.2824 × 32.3005	1961	35–6	22	24	71.0	6.9	77.1	11.9	11.0	71.2	9.6	53.3	34.2	12.5	29.0
1.3056 × 3.361	1961	35–6	24	21	63.0	5.9	78.5	11.6	9.9	68.7	7.9	48.7	39.2	12.1	49.5
1.3208 × 32.658	1961	35–6	24	21	68.4	6.8	77.4	13.0	9.6	71.0	9.1	52.6	36.9	10.4	34.6
1.3379 × 3.361	1961	35–6	19	23	66.6	7.5	80.7	10.6	8.6	71.1	8.8	48.5	40.3	11.2	28.6
1.3340 × 2.3495	1961	35–6	19	28	72.8	7.3	79.3	10.8	9.9	68.4	8.8	50.7	38.4	10.8	35.4
1.3340 × 1.3208	1961	35–6	25	23	66.1	6.9	78.4	11.4	10.1	63.8	7.7	53.7	34.8	11.5	36.4
2.3495 × 3.361	1961	35–6	27	19	65.8	5.9	80.0	10.6	9.4	72.0	8.6	51.8	37.8	10.4	31.8
32.658 × 32.3005	1961	35–6	22	24	70.8	6.3	74.1	15.9	10.0	70.6	8.6	50.0	38.8	11.2	35.3

32.2824 × 1.3352	1961	35–6	31	14	70.3	6.8	81.1	9.8	9.0	71.0	8.6	53.3	34.7	12.0	35.4
5.368 × 32.3005	1961	35–6	25	23	73.0	6.0	75.5	15.2	9.3	73.0	7.9	51.5	38.0	10.5	45.8
5.1295 × 1.3352	1961	35–6	40	8	71.1	5.9	78.6	13.5	7.9	74.4	8.2	54.6	36.2	9.2	34.9
5.368 × 32.2612	1961	35–6	22	25	69.9	5.7	78.4	14.6	6.9	74.3	8.1	51.1	40.4	8.4	36.0
5.642 × 1.3352	1961	35–6	36	12	73.4	5.8	80.8	12.0	7.2	72.4	7.1	55.2	34.9	10.0	30.3
108.5 × 201.32	1961	35–6	25	19	69.7	7.0	80.4	10.9	8.8	70.0	8.6	55.6	33.3	11.1	29.7
5.1295 × 32.2612	1961	35–6	25	23	69.3	5.5	77.6	15.0	7.4	72.8	8.8	52.0	40.0	8.0	34·5
5.12 × 32.3005	1961	35–6	22	26	73.4	6.2	73.8	15.7	10.5	74.9	8.9	51.5	36.7	11.8	29.8
32.2612 × 5.642	1961	35–6	17	30	69.4	6.2	80.7	11.9	7.4	69.6	8.5	52.3	38.8	8.8	30.6
32.364 × G98	1961	35–6	18	24	72.7	6.2	78.2	13.8	8.0	74.4	8.2	43.9	45.4	10.8	43.5
108.5 × G98	1961	35–6	31	15	69.2	6.4	75.6	12.9	11.5	67.4	7.5	51.1	36.8	12.0	34.5
5.642 × 1.3208	1961	35–6	19	27	68.0	6.9	81.2	10.8	8.0	69.2	7.7	57.8	32.6	9.6	40.3
201.51 × 2381D	1961	35–6	24	22	67.0	5.8	80.6	9.9	9.6	69.4	8.2	50.7	38.7	10.6	36.8
203.93 × 2381D	1961	35–6	23	24	71.8	6.8	77.9	11.1	11.0	72.0	9.1	50.5	37.9	11.6	26.2
5.444 × 32.3005	1961	35–6	30	18	71.9	6.1	76.4	14.2	9.4	74.3	9.3	52.8	36.0	11.2	35.7
32.2612 × G98	1961	35–6	8	11	67.7	6.5	78.9	13.3	7.7	71.6	9.4	50.9	40.7	8.4	40.3
1.3352 × G98	1961	35–6	9	9	71.3	6.5	78.5	12.3	9.2	69.0	7.5	54.2	35.9	9.9	42.3
39.419 × 32.3005	1961	24–6	15	7	65.6	8.8	80.3	11.8	7.9	71.4	9.4	51.7	37.1	11.2	42.8
907.262 × 907.263	1962	24–7	19	14	67.3	5.6	77.4	12.3	10.4	70.1	7.1	48.4	41.3	10.3	37.7
907.262 × 907.264	1962	24–7	21	26	70.8	6.6	76.9	10.6	12.4	72.4	8.9	45.6	43.2	11.2	36.5
1.2209 × 1.2229	1962	24–7	13	19	70.4	7.9	78.8	11.2	10.0	73.8	10.2	52.0	38.2	9.8	38.6
32.364 × 3.2538	1962	36–1	22	24	70.4	5.9	83.1	10.5	6.4	76.5	8.6	47.1	43.8	9.1	36.2
1.53 × 32.2612	1962	36–1	22	26	67.8	6.6	76.3	14.4	9.3	72.6	9.2	45.0	44.8	10.2	43.7
2.1997 × 3.1035	1962	36–1	26	22	68.6	7.1	71.0	17.1	11.8	72.7	9.2	42.4	45.6	12.1	24.8
3.1504 × 32.658	1962	36–1	17	28	67.7	6.8	73.8	15.1	11.1	70.9	9.4	48.6	39.8	11.6	38.7
1.3352 × 3.2538	1962	36–1	25	20	67.5	5.7	79.6	12.8	7.6	70.1	7.7	51.6	39.0	9.4	36.0
3.2538 × 3.1035	1962	36–1	37	10	66.4	4.8	81.0	11.7	7.3	73.0	8.5	45.9	43.9	10.3	34.8
3.1035 × 32.2824	1962	36–1	30	17	66.5	5.8	79.2	11.2	9.5	72.6	8.9	47.9	40.0	12.0	29.5
3.1504 × 3.361	1962	36–1	26	22	64.0	6.1	73.1	16.1	10.8	70.0	7.8	48.3	40.3	11.4	39.6
1.2229 × 1.53	1962	36–1	25	23	70.6	8.5	71.4	13.8	14.8	73.5	11.4	45.9	41.8	12.2	30.2
3.1504 × 3.417	1962	36–1	25	22	65.3	4.8	71.8	16.2	12.0	66.7	7.0	42.3	45.6	12.1	57.4
32.364 × 32.2824	1962	36–1	32	15	68.5	6.8	83.7	9.3	7.0	75.6	10.0	49.7	40.5	9.8	33.8
26/5767 × 2381D	1962	36–1	43	4	73.8	7.2	70.1	16.0	14.0	70.2	9.8	43.6	44.3	12.1	53.7
5.1225 × 2381D	1962	36–1	23	25	69.2	7.9	78.7	11.8	9.5	71.6	9.1	50.1	40.6	9.3	40.2
5.2153 × 32.2612	1962	36–1	24	24	68.7	6.8	77.3	14.6	8.2	72.0	8.1	49.4	41.3	9.3	40.2
3.1035 × G118	1962	36–1	24	20	65.7	6.5	75.1	15.4	9.5	71.1	8.1	41.9	47.3	10.8	28.1
32.2612 × 201.32	1962	36–1	27	21	70.5	7.7	81.2	11.6	7.2	73.9	9.6	54.8	36.6	8.7	35.0

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DURA × TENERA PROGENY TRIALS: MAIN STATION, 1961, 1962

Fruit form segregation and bunch quality during first year's harvest

Progeny	Planted	Expt. No.	Segregation dura	Segregation tenera	Tenera Fruit/bunch	Tenera Single fruit weight	Tenera Pulp/fruit	Tenera Shell/fruit	Tenera Kernel/fruit	Dura Fruit/bunch	Dura Single fruit weight	Dura Pulp/fruit	Dura Shell/fruit	Dura Kernel/fruit	Dura Oil/pulp
					%	g.	%	%	%	%	g.	%	%	%	%
3.1504 × 201.32	1962	36–1	21	26	70.4	7.9	78.8	12.3	8.9	72.2	10.2	52.8	36.5	10.7	50.0
3.1504 × 5.368	1962	36–1	13	35	68.7	7.8	72.3	17.6	10.0	73.9	10.0	47.4	42.0	10.6	36.6
32.2612 × G140	1962	36–1	22	26	71.5	7.0	75.8	15.2	9.0	75.0	9.8	48.5	42.5	9.1	34.8
32.364 × G118	1962	36–1	10	13	67.9	6.8	79.4	11.7	8.9	72.4	10.6	46.1	44.3	9.6	38.2
1.53 × 1.3352	1962	36–2	21	27	71.1	5.9	73.8	14.8	11.4	64.4	6.8	50.4	37.3	12.3	33.8
32.2824 × 2.3495	1962	36–2	22	25	71.6	6.5	81.0	9.2	9.8	74.7	9.2	49.0	39.9	11.0	23.2
1.3340 × 32.2612	1962	36–2	28	20	69.3	7.7	75.5	15.3	9.2	71.6	8.9	48.8	41.2	10.0	36.2
1.3552 × 203.93	1962	36–2	21	24	71.6	6.1	79.1	13.2	7.8	72.4	8.9	52.4	37.6	10.0	31.3
203.133 × 108.5	1962	36–2	42	4	69.3	6.0	73.5	16.1	10.4	68.4	6.5	40.0	46.2	13.8	28.0
32.2612 × G143	1962	36–2	19	27	68.3	6.0	79.0	14.4	6.6	69.8	8.5	48.0	43.4	8.6	35.8
3.1504 × G140	1962	36–2	21	25	73.4	8.1	74.0	15.8	10.2	72.8	9.4	49.3	39.7	11.0	44.1
4.1935 × 5.368	1962	36–2	20	27	68.6	7.2	77.3	15.1	7.6	70.0	9.6	51.1	40.9	8.0	38.4
3.1504 × G143	1962	36–2	28	19	66.4	6.1	75.1	15.6	9.3	68.5	8.9	48.9	39.9	11.2	27.9
3.1035 × G141	1962	36–2	20	26	65.7	5.4	79.4	13.6	7.0	71.8	8.1	44.7	46.0	9.3	25.6
4.17 × 203.93	1962	36–2	18	25	68.7	6.8	80.5	12.3	7.3	71.4	9.8	50.2	40.0	9.8	34.9
4.3488 × G145	1962	36–2	21	22	67.4	5.6	79.3	11.3	9.4	71.5	7.4	45.8	41.8	12.3	30.2
5.1080 × 3.1504	1962	36–2	23	21	73.6	7.1	75.9	14.3	9.8	72.2	8.9	49.7	39.1	11.2	34.8
4.3488 × G143	1962	36–2	19	24	68.1	5.3	77.3	14.4	8.3	70.9	8.9	44.3	45.1	10.6	30.6
4.2411 × G143	1962	36–2	21	24	70.0	6.2	78.0	13.9	8.1	71.1	9.2	47.1	42.1	10.7	39.6
4.1624 × G143	1962	36–2	16	27	69.1	7.0	77.4	14.3	8.3	68.5	10.0	47.8	41.6	10.6	34.6
4.1935 × G145	1962	36–2	22	25	70.4	6.9	81.2	11.0	7.8	72.8	9.8	48.0	41.6	10.4	31.8
4.1811 × 5.12	1962	36–2	28	19	71.5	8.2	77.1	14.2	8.8	73.6	10.2	50.5	40.3	9.3	35.7
14.892 × G141	1962	36–2	25	21	68.0	5.7	80.9	12.4	6.6	70.3	8.3	48.9	41.9	9.2	47.2
4.493 × G141	1962	36–2	22	17	68.6	4.8	80.0	12.2	7.7	68.1	7.4	44.4	44.0	11.6	36.0
4.3488 × G142	1962	36–2	17	29	65.9	4.6	75.8	14.3	9.9	67.0	7.5	46.0	42.4	11.6	37.3
4.1935 × G142	1962	36–2	23	23	72.0	6.9	77.1	14.4	8.5	70.7	8.6	46.7	42.8	10.5	28.2
4.493 × G142	1962	36–2	22	25	66.0	5.7	79.9	11.9	8.2	66.6	8.6	43.6	45.5	11.0	34.2
L_9T × $D_{10}D$	1962	36–2	32	33	67.3	5.6	74.3	16.2	9.5	70.0	8.1	45.3	43.4	11.4	25.8
32.2612 × 5.12	1962	36–2	11	9	69.8	6.4	78.6	13.2	8.2	69.9	8.9	49.9	41.7	8.5	39.5

PERFORMANCE OF THE STANDARD CROSS: MAIN STATION, 1959, 1960, 1961, 1962

Yield of bunches per acre

Field Expt. No.	Year planted	First Year			Second Year			Third Year			Fourth Year		
		No.	Weight lb.	Single bunch weight lb.	No.	Weight lb.	Single bunch weight lb.	No.	Weight lb.	Single bunch weight lb.	No.	Weight lb.	Single bunch weight lb.
7–2	1959	709	3,572	5.0	658	4,279	6.5	602	6,725	11.2	352	4,343	12.3
8–1	1959	625	2,943	4.7	662	4,020	6.1	773	6,966	9.0	272	2,689	9.9
14–4	1959	817	4,249	5.2	809	6,316	7.8	834	10,966	13.1	369	5,858	15.9
31–1	1959	828	3,990	4.8	721	4,719	6.5	763	8,492	11.1	522	7,481	14.3
35–1	1959	856	4,149	4.8	658	4,347	6.6	706	7,298	10.3	501	6,924	13.8
8–1	1960	856	4,416	5.2	919	7,412	8.1	499	4,187				
24–4	1960	745	4,052	5.4	841	8,261	9.8	755	10,097				
31–2	1960	723	3,057	4.2	826	7,180	8.9	1,025	12,004				
31–3	1960	705	2,802	4.0	851	6,394	7.5	734	7,805				
35–2	1960	602	2,594	4.3	653	5,083	7.8	653	7,560				
35–3b	1960	656	3,098	4.7	691	5,860	8.5	725	8,559				
8–1	1961	995	4,342	4.4	601	4,020	6.7						
31–6*	1961	690	5,638	8.2	623	5,560	8.9						
31–7	1961	875	5,297	6.0	861	8,521	9.9						
35–6	1961	851	4,995	5.9	734	6,948	9.5						
8–1	1962	783	4,128	5.4									
36–2*	1962	532	2,182	4.1									

* *dry season nursery seedlings*

PLANT NUTRITION DIVISION

STAFF

Mr. H. C. Okoye, Plant Physiologist (Nutrition), attended the I.A.E.A. course on the use of radio-isotopes in agricultural research at the TRICO Centre, University of Lovanium, Congo (Kinshasa) from 20th November to 19th December, 1966. Thereafter he was on vacation leave until mid-January 1967. Mr. M. J-P. Leyritz, Senior Laboratory Technologist, was on duty throughout the year. Mr. O. Sowande, Research Officer-in-Training, joined the Division in July 1966.

GENERAL PROGRAMME

The assessment of responses to fertilizer treatments by foliar analysis continues to be the major work of the Division. The relationship between leaf nutrient status and yield is still being studied and the results which have been compiled are awaiting analysis by computer. Methods for determining trace elements in palm material were worked out and are in use for the routine determination of trace elements.

LEAF ANALYSIS

Leaf Sampling Studies: Diurnal Variation in Nutrient Levels (Expt. N.6606)

In assessing the nutrient status of the oil palm by foliar analysis, it has been suggested by Chapman and Gray (1949) and Scheidecker and Prevot (1959) that changes occurred in leaf composition during the day and, in order to avoid this, sampling in the morning hours between 06.30 and 11.00 hours was recommended. An investigation was conducted to assess the diurnal variation of six major elements (N, P, S, K, Ca and Mg) in leaf 17 of the oil palm. Samples were taken at 8.00, 11.00, 14.00 and 17.00 hours local time from five plots of five palms each, on five consecutive days. The result of the investigation will be published shortly.

NUTRIENT DISTRIBUTION IN THE OIL PALM

Mineral Content of Inflorescences (Expt. N.6601)

This investigation is part of the programme to examine the distribution of nutrients in the oil palm, and was first mentioned in the NIFOR First Annual Report, page 75. The nutrient composition of the component parts of a male inflorescence at anthesis and a ripe bunch was determined for *dura*, *tenera* and *pisifera* palms. Composite samples of each component part of the bunch were analysed. The result is as shown opposite.

Mineral Content (% on Dry Matter) of Ripe Fruit Bunch

Element	*Palm*	*Kernel*	*Shell*	*Pulp*	*Bracts*	*Rachis of Spikelets and Spines*	*Stalk*	*Total*
		%	%	%	%	%	%	%
	Dura	1.27	0.43	0.55	0.53	0.43	0.75	3.96
N	*Tenera*	1.54	0.54	0.52	0.67	0.54	0.88	4.69
	Pisifera	1.46	0.76	0.48	0.88	0.54	0.87	5.00
	Dura	0.37	0.02	0.06	0.07	0.04	0.08	0.64
P	*Tenera*	0.35	0.02	0.06	0.07	0.05	0.01	0.66
	Pisifera	0.65	0.10	0.06	0.08	0.06	0.10	1.05
	Dura	0.09	0.04	0.11	0.12	0.08	0.08	0.52
S	*Tenera*	0.09	0.08	0.09	0.11	0.08	0.08	0.53
	Pisifera	0.11	0.16	0.06	0.13	0.09	0.08	0.63
	Dura	0.40	0.14	0.24	0.82	1.02	2.68	5.30
K	*Tenera*	0.39	0.35	0.23	0.88	1.12	2.74	5.71
	Pisifera	0.51	0.62	0.21	1.32	1.60	3.17	7.43
	Dura	0.04	0.02	0.15	0.31	0.31	0.52	1.35
Ca	*Tenera*	0.04	0.05	0.14	0.35	0.29	0.58	1.45
	Pisifera	0.06	0.10	0.05	0.30	0.36	0.52	1.39
	Dura	0.16	0.03	0.16	0.14	0.12	0.13	0.74
Mg	*Tenera*	0.19	0.13	0.18	0.18	0.08	0.13	0.89
	Pisifera	0.29	0.17	0.07	0.23	0.19	0.17	1.12

(for *pisifera*, the thickened fibrous tissue surrounding the kernel has been regarded as a "*pseudo*-shell".)

The analytical results for the *dura* and *tenera* bunch are similar but the *pisifera* has a higher mineral content, except for calcium which is of the same order as for the other palms. The fruit retains a greater amount of nitrogen and phosphorus than other parts of the bunch whereas the bracts and the bunch stalk have a high potassium, nitrogen and calcium content. Magnesium and sulphur seem to be distributed uniformly. The figures for the nutrient distribution in the male inflorescence are shown overleaf:

Mineral Content (% on Dry Matter) of Male Inflorescence at Anthesis

Element	*Type*	*Pollen*	*Anthers*	*Bracts*	*Rachis of Spikelet*	*Central Rachis*	*Stalk*	*Total*
		%	%	%	%	%	%	%
	Dura	5.78	1.83	2.78	1.34	1.02	0.66	13.41
N	*Tenera*	5.70	1.95	2.82	1.46	1.37	0.72	14.02
	Pisifera	5.77	1.79	2.68	1.54	1.29	0.70	13.77
	Dura	1.12	0.42	0.46	0.25	0.22	0.09	2.56
P	*Tenera*	1.04	0.29	0.39	0.28	0.28	0.09	2.37
	Pisifera	1.11	0.42	0.33	0.22	0.24	0.08	2.40
	Dura	0.43	0.17	0.22	0.18	0.13	0.06	1.19
S	*Tenera*	0.42	0.20	0.22	0.18	0.12	0.18	1.22
	Pisifera	0.39	0.22	0.23	0.19	0.14	0.12	1.29
	Dura	0.84	0.52	1.24	1.48	1.97	3.09	9.14
K	*Tenera*	0.81	0.63	1.18	1.52	1.92	2.37	8.43
	Pisifera	0.79	0.78	1.24	1.59	2.61	2.48	9.49
	Dura	1.08	0.85	0.77	0.56	0.54	1.04	4.84
Ca	*Tenera*	1.16	0.72	0.57	0.37	0.34	0.93	4.09
	Pisifera	1.90	0.86	0.63	0.86	0.68	1.23	6.16
	Dura	0.49	0.41	0.56	0.73	0.78	0.85	3.82
Mg	*Tenera*	0.51	0.52	0.71	0.80	0.95	1.04	4.53
	Pisifera	0.43	0.35	0.41	0.71	0.68	0.86	3.44

The distribution of the minerals is similar in all the three forms. There is a polar distribution in the contents of nitrogen, phosphorus and sulphur, which show a gradual increase from the stalk to the pollen except for slight drop in the anthers. The calcium and magnesium contents tended to increase towards the stalk. This is apart from the high calcium content of the pollen.

Mineral Content of Female Bunch Stalk (Expt. N.6604)

This experiment examines the variation of major elements in the bunch stalk of the oil palm. The palms in Expt. 1–6 on the Main Station which were showing typical symptoms of "Mid-crown Yellowing" were selected for this investigation. About a hundred bunch stalks were collected from the different palms and analysed for the major elements. The statistical analysis of the results is as opposite:

Variance ratio	*N*	*P*	*K*	*Ca*	*Mg*
Between palms.. ..	15.51*	4.47	0.27	1.46	7.39*
Between bunches ..	3.83	3.47	0.13	0.40	1.70
Coefficient of variation:	% 7.77	% 15.07	% 5.71	% 16.26	% 35.68

The results show a significant variation in the levels of nutrients from palm to palm with respect to magnesium and nitrogen only. The variation between bunches is not significant. In the NIFOR Second Annual Report, page 87, it was observed that the degree of health and the leaf nitrogen appeared to be related only in *tenera* palms.

This investigation was continued by analysing the bunch stalks from a single palm and the coefficient of variation obtained was N = 8.98%, P = 10.46%, K = 12.22%, Ca = 40.70% and Mg = 59.69%. These figures help to explain the above result for different palms, as the variations in the magnesium and calcium contents are seen to be large while those for nitrogen and potassium are small.

The mineral content of the bunch stalk was correlated with the yield obtained from *dura* and *tenera* palms for the period from mid-1965 to mid-1966. The result is as follows:

Correlation Coefficients between Elements in Bunch Stalk and Yield (1965-66)

	N	*P*	*K*	*Ca*	*Mg*
Dura	0.0024	−0.0182	0.1120	0.0038	−0.1960
Tenera	−0.4266**	0.2100	0.3919*	0.1670	−0.0150

*P = 0.05 **P = 0.01

Here again, as was observed for leaf factors (NIFOR Second Annual Report, page 87), both *dura* and *tenera* palms behave as different populations. None of the minerals in the *dura* bunch stalk were related to yield, while in *tenera* bunches nitrogen (negatively) and potassium (positively) were correlated with yield.

Yellowing of Corozo oleifera hybrids (Expt. N.6603)

The *Elaeis guineensis* × *Corozo oleifera* hybrids planted in Experiment 21–5 in 1960 have been showing a yellowing of fronds similar to "Orange Frond Disease". Leaf and soil samples have been taken from the experiment to determine the cause of the yellowing. A preliminary analysis showed a normal leaf magnesium content and a rather low nitrogen content, compared with the standard levels found in *Elaeis guineensis* on the Main Station. Health scores are being taken.

FERTILIZER EXPERIMENTS

Potassium Fertilizer Experiment (Expt. 33–12/Expt. N.6510)

This experiment examines the rate of recovery of leaf potassium content, following applications of potassium fertilizer in an area suspected to be deficient in that nutrient. The details were given in the NIFOR Second Annual Report, page 88. In order to correct deficiencies of nitrogen and phosphorus, dressings of appropriate fertilizers were made in April 1966.

Leaf samples taken at intervals of four months beginning in May, 1965 were analysed and the results are given below.

Potassium Content of Leaf 17 (Expt. N.6510)

Sampling Date		*Level of Application*				
		K_0	K_1	K_2	K_3	K_4
		%	%	%	%	%
1965	May (pre-treatment)	0.40	0.46	0.41	0.40	0.44
	September	0.45	0.53	0.45	0.52	0.53
1966	January	0.43	0.53	0.56	0.54	0.58
	May	0.48	0.56	0.55	0.64	0.72
	September	0.38	0.50	0.53	0.54	0.65
1967	January	0.46	0.58	0.61	0.69	0.79
Mean (excluding pre-treatment figures)		0.44	0.54	0.54	0.54	0.65
As percentage of control		100	123	123	134	149

The results show a general increase in the leaf content of potassium.

Fertilizer Experiment on a Replanted Area: Main Station (Expt. 2–15)

This experiment examines the fertilizer requirements of young palms on soil in an area known to be deficient in potassium. Details were given in the WAIFOR Tenth Annual Report, page 46 and in the NIFOR First Annual Report, page 43. The result of the analyses of the first leaf sampling of half of the blocks was reported in the NIFOR First Annual Report, page 77. The palms were sampled again in 1966 and the result of the leaf analysis is shown below:

FERTILIZER EXPERIMENT ON A REPLANTED AREA: MAIN STATION (EXPT. 2–15), 1961

Yield and Nutrient Level of Leaf 17 (as per cent Dry Matter)

Treatment	*Yield per palm*	*Mineral content of Leaf 17*				
	1966	*N*	*P*	*K*	*Ca*	*Mg*
	lb.	%	%	%	%	%
N_0 ..	139	2.67	0.171	0.80	0.89	0.40
N_1 ..	140	2.68	0.171	0.80	0.86	0.38
P_0 ..	134	2.67	0.167	0.82	0.90	0.39
P_1 ..	131	2.67	0.171	0.79	0.85	0.39
P_2 ..	145	2.67	0.167	0.82	0.84	0.40
P_1,P_2 ..	146	2.69	0.173	0.79	0.89	0.37
K_0 ..	125	2.65	0.169	0.73	0.88	0.41
K_1 ..	142	2.67	0.173	0.79	0.90	0.39
K_2 ..	144	2.67	0.171	0.81	0.87	0.39
K_3 ..	146	2.67	0.171	0.86	0.87	0.37
Mg_0 ..	137	2.67	0.170	0.80	0.89	0.39
Mg_1 ..	142	2.68	0.172	0.80	0.87	0.39
B_0 ..	134	2.66	0.171	0.78	0.89	0.39
B_1 ..	145	2.69	0.171	0.82	0.87	0.38

The nutrient status of the palms is above the "critical" level for all major elements, except potassium. Application of potassium fertilizer has thus led to significant increases in both potassium content of the leaves and in the yields. The correlation between the leaf content of potassium and the yield was found to be significant ($P = 0.001$; $r = 0.424$). The efficiency coefficient (*i.e.* bunch weight increase per 0.1% increase in leaf potassium content) is low, being 15 lb. per palm per annum.

Compared with the results of the 1963 sampling, the general content of phosphorus has increased and that of calcium decreased.

Fertilizer Experiment on a Mica-Schist Soil: Calaro (Expt. 556–2/Expt. N.6502). 1962

This experiment examines the response to fertilizer application of palms growing on a mica-schist soil at Calaro Estate. It was sampled before the March 1965 fertilizer application, and the results of the analysis and the yield per palm for the first four months of harvest are given below:

FERTILIZER EXPERIMENT ON MICA-SCHIST SOIL: CALARO (EXPT. 556–2/EXPT. N.6502)

Treatment	*Yield per palm 1965**	*Mineral content of leaf 17 (as per cent dry matter)*				
	lb.	*N*	*P*	*K*	*Ca*	*Mg*
N_0 ..	12.8	2.53	0.145	1.22	0.83	0.33
N_1 ..	11.3	2.45	0.138	1.17	0.82	0.35
N_2 ..	14.3	2.45	0.139	1.18	0.82	0.34
N_3 ..	12.6	2.53	0.141	1.16	0.84	0.34
P_0 ..	8.9	2.50	0.136	1.23	0.75	0.35
P_1 ..	13.7	2.48	0.140	1.18	0.79	0.33
P_2 ..	14.7	2.48	0.142	1.15	0.85	0.34
P_3 ..	13.7	2.51	0.145	1.17	0.91	0.35
K_0 ..	12.6	2.47	0.139	1.08	0.82	0.35
K_1 ..	12.8	2.52	0.142	1.29	0.82	0.33
Mg_0 ..	12.2	2.50	0.141	1.21	0.88	0.31
Mg_1 ..	14.0	2.54	0.143	1.11	0.83	0.34
Mg_2 ..	11.7	2.49	0.142	1.21	0.80	0.34
Mg_3 ..	13.0	2.45	0.137	1.22	0.80	0.38

*Four months only (September-December 1965)

When compared with a similar result for the palms on the gneiss soil at Calaro Estate (NIFOR First Annual Report, pages 82 and 83) the figures show slightly lower leaf nitrogen and phosphorus contents and a slightly higher leaf content of potassium. The calcium and magnesium levels are similar.

All the fertilizers significantly affected the quantity of their constituents in the leaf. The response took the form of a straightforward increase, except in the case of nitrogen, where intermediate levels of application of ammonium sulphate caused a depression in the nitrogen content of the leaves.

Correlation Coefficients between Yield and Leaf Mineral Content (Expt. 556–2)

N	0.4516***
P	0.2697**
Mg	0.2718**
K	0.0162

**P = 0.01; ***P = 0.001

The result suggests that the nutrients which have affected the yield in young palms on the basement complex soils derived from mica-schist in the Calabar district are nitrogen, phosphorus and magnesium.

Fertilizer Experiment: Mbawsi (Expt. 652–2)

This experiment assesses the response of oil palms in a farmer's plot to fertilizer applications (WAIFOR Seventh Annual Report, page 56 and NIFOR First Annual Report, page 83). It was last sampled in December 1965, prior to the closing down of the experiment. The last fertilizer application was made in 1961, so the result of the leaf analysis shown below is to a certain extent a measure of the residual effects of the fertilizer treatments.

Yield and Nutrient Level of Leaf 17 (as per cent dry matter)

Treatment	*No. of Bunches*	*Yield per palm 1965*	*Mineral content of leaf 17*				
			N	*P*	*K*	*Ca*	*Mg*
		lb.	%	%	%	%	%
−N	38	124	2.22	0.163	0.50	0.88	0.31
+N	36	137	2.31	0.167	0.48	0.90	0.31
−P	41	136	2.28	0.160	0.51	0.89	0.32
+P	33	123	2.27	0.170	0.47	0.89	0.30
−K	30	82	2.24	0.164	0.38	0.92	0.35
+K	44	179	2.29	0.166	0.60	0.86	0.27
− Lime	38	133	2.30	0.166	0.50	0.85	0.31
+ Lime	36	129	2.23	0.164	0.48	0.94	0.31
−Mg	38	131	2.27	0.165	0.50	0.88	0.26
+Mg	36	131	2.26	0.165	0.48	0.90	0.36
− Gypsum	36	131	2.28	0.167	0.49	0.87	0.32
+ Gypsum	38	131	2.25	0.163	0.49	0.91	0.30
− Trace elements	36	130	2.28	0.165	0.50	0.93	0.32
+ Trace elements	38	131	2.25	0.165	0.48	0.86	0.30

Statistical analysis of the results shows positive effects of all fertilizer treatments on leaf mineral content. The interactions are as anticipated. Application of calcium depressed both leaf nitrogen and potassium level. Phosphate, especially in the presence of nitrogen or potassium fertilizer, depressed the leaf potassium level. The leaf magnesium content is markedly depressed by potassium application and applied magnesium led to a slight decrease in leaf potassium content.

These results confirm the conclusion that potassium is the most important nutrient limiting yield in old palms. Application of potash doubled the yield and increased leaf potassium content by 150%.

TRACE ELEMENTS

Trace Element Survey

As a prelude to the work on the role of trace elements in the nutrition of the oil palm, the Plant Nutrition and the Soil Chemistry Divisions undertook a tour in which leaf and soil samples were collected from the oil palm areas of Eastern Nigeria. Preliminary results from the leaf analysis data show a considerable variation in the trace element content of the palm in the different areas. Detailed foliar analyses are still being carried out and it is hoped to relate these with the soil data.

Fertilizer Experiment: Abak (Expt. 508-1): 1963 Leaf Sampling

The description of this experiment was given in the WAIFOR Eleventh Annual Report, page 33, and the details of the leaf analyses for major elements were published in the WAIFOR Twelfth Annual Report, page 78. The trace element content of these samples is shown below:

Trace Element Content of Leaf 1: Expt. 508-1: 1963 Sampling

Fertilizer Treatment	*Height per palm March, 1963*	*Trace element content*				
		Mn	*Cu*	*Fe*	*B*	*Zn*
	in.	*ppm*	*ppm*	*ppm*	*ppm*	*ppm*
N_0 ..	58.0	192.37	10.42	68.43	10.63	21.20
N_1 ..	65.9	168.89	8.76	60.20	10.67	19.00
N_2 ..	65.6	171.13	8.41	76.62	11.64	18.26
N_3 ..	67.4	167.68	7.96	77.62	10.48	17.70
K_0 ..	63.1	210.00	8.73	71.41	10.98	18.20
K_1 ..	63.8	147.43	8.18	64.59	10.53	21.37
K_2 ..	64.3	169.66	9.48	73.21	10.56	19.33
K_3 ..	65.6	173.00	9.17	77.96	10.59	17.23
Mg_0 ..	64.9	230.18	9.26	84.43	10.46	18.61
Mg_1 ..	63.4	164.96	8.85	67.64	10.15	19.20
Mg_2 ..	64.5	148.71	8.83	65.94	11.03	18.96
Mg_3 ..	64.0	144.38	8.61	68.44	11.03	19.34

In most cases, application of the lower level of the fertilizer appears to have depressed the leaf content of minor elements. Manganese especially seems to be depressed by all the fertilizer applications.

Sampling was repeated in 1965, but this time leaf 17 was sampled. The result of the leaf analysis is shown below. The major element composition has been published in the NIFOR Second Annual Report, pages 89-90.

Trace Element Content of Leaf 17: Expt. 508–1: 1965 Sampling

Treatment	*Weight of Bunches per palm, 1965**	*Trace element content*				
		Mn	*Cu*	*Fe*	*B*	*Zn*
		ppm	*ppm*	*ppm*	*ppm*	*ppm*
N_0 ..	29.4	487.34	9.85	78.97	10.62	19.47
N_1 ..	29.1	498.49	9.35	79.75	9.28	19.61
N_2 ..	31.8	490.85	9.26	85.74	9.57	16.72
N_3 ..	31.1	462.35	8.37	73.30	9.29	16.87
K_0 ..	22.4	572.13	9.00	80.04	10.30	18.15
K_1 ..	30.3	466.43	9.18	81.34	9.13	17.67
K_2 ..	32.9	429.37	9.03	71.04	9.20	17.17
K_3 ..	35.6	454.54	9.18	81.91	9.48	18.42
Mg_0 ..	28.5	507.33	9.24	74.61	9.31	17.36
Mg_1 ..	30.8	492.45	9.22	76.69	9.53	17.95
Mg_2 ..	32.9	465.79	8.83	78.63	9.93	18.59
Mg_3 ..	30.2	470.04	9.14	84.74	10.02	17.82
P_0 ..	29.1	477.33	9.06	77.86	9.66	18.17
P_1 ..	31.5	496.52	9.12	79.30	9.25	17.80

*Part year only.

It is known that the manganese content increases with the leaf age which explains the higher figures for leaf 17 as compared with leaf 1, but otherwise the results are basically similar to those obtained from the previous sampling.

ANALYTICAL METHODS

Sulphur Determination

The gravimetric method for sulphur determination described in the NIFOR First Annual Report, page 85, was modified to a more rapid turbidimetric method. The procedure remains fundamentally the same but the barium sulphate precipitate is held in a colloidal state and measured with a spectrophotometer.

Nitrate Nitrogen Determination

The method used by the Canadian Department of Agriculture (Publication 1064, February 1960) is being adapted for nitrate determination in oil palm leaf samples. The nitrate is extracted with water from dried leaf material. Chlorides and water soluble organic matter are eliminated by precipitation. The nitrate is determined colorimetrically based on the yellow compound formed with phenol sulphuric acid reagent. Work is in progress to assess the effect of the initial weight of sample and analytical reproducibility and the optimum time for water extraction.

Micronutrient Analysis

The methods for trace element determination described in the WAIFOR Twelfth Annual Report, page 81 and in the NIFOR First Annual Report, page 85 have been completely revised. The new procedure adopted is based on the method in use in the Horticultural Research Station, Long Ashton, Bristol (E. G. Bradfield, 1964). The procedure is as follows:

Preparation of samples: About 1 g. of material dried to a constant weight is placed in a 250 ml. conical flask and 10 ml. of re-distilled nitric acid are added. The flask is swirled several times to wet the material, then set aside overnight. The sample is pre-digested with nitric acid at a low temperature on a hot plate until brown fumes of nitric oxide are expelled, then strongly heated until all the organic matter is oxidized, leaving a clear solution. A few more drops of perchloric acid may be added in the course of the digestion to quicken the oxidation of organic matter. The heating is continued to near dryness and until excess perchloric acid is driven off, care being taken to avoid bumping. On cooling, the digest is dissolved by boiling with a mixture of 15 ml. of 0.5 N HCl and 1 ml. of 0.5% sodium nitrite for about five minutes, then filtered through a Whatman No. 42 filter paper into a 20 ml. calibrated borosilicate test-tube. Both the flask and the filter paper are rinsed with de-ionized water and the washings are added to the filtrate. The final volume is adjusted to 20 ml. with de-ionized water and the test-tube is stoppered.

Determination of the Elements: A 2 ml. aliquot of the digest solution is used for the determination of iron, manganese, copper and zinc, and 10 ml. for molybdenum. Iron is determined with o-phenanthroline, manganese with formaldoxime and copper with biscyclohexanone oxalydihydrozone as described by Sandell (1959) and molybdenum by a modified dithiol method of Piper and Beckwith (1948).

The method for boron determination remains as described in the NIFOR First Annual Report, page 86.

H. C. OKOYE
M. J-P. LEYRITZ

REFERENCES

BRADFIELD, E. G. (1964). Leaf analysis as a guide to the nutrition of fruit crops. *J. Sci. Fd. Agric.*, **15**, 469-473.

CHAPMANN, G. W. and GRAY, H. M. (1949). Leaf analysis and the nutrition of the oil palm. *Ann. Bot., Lond.* (*N.S.*), **13** (52), 415-433.

PIPER, C. S. and BECKWITH, R. S. (1948). A new method for determination of small amounts of molybdenum in plants. *J. Soc. Chem. Ind.*, **67**, 374.

SANDELL, E. B. (1959). Colorimetric determination of traces of metals. (3rd Edn.) Interscience Publishers, Inc., New York.

SCHEIDECKER, D. and PREVOT, P. (1954). Nutrition minérale du palmier à huile à Pobé (Dahomey). *Oléagineux*, **9**, 13-19.

PLANT PATHOLOGY DIVISION

STAFF

Mr. K. Rajagopalan, Plant Pathologist, was on leave from August to December 1966. Mr. F. O. Aderungboye, Plant Pathologist, returned from the United Kingdom in September 1966 after post-graduate studies. He was on duty for the rest of the year.

GENERAL PROGRAMME

The main work of the Division during 1966 was the investigation of Brown Germ and Patch Yellows. Trials on the control of Blast disease in the nursery were continued. Screening of progenies for disease resistance to Dry Basal Rot was conducted jointly with the Plant Breeding Division.

CERCOSPORA LEAF SPOT

Regular fortnightly spraying of Main Station nurseries and young palms (1-3 years old) was carried out using Dithane M45, Captan or Cuman. Power sprayers ("Motoblo") were used mostly and a good control of *Cercospora* was achieved.

The results of the three nursery spraying trials carried out during 1964-65 were discussed in the NIFOR Second Annual Report, pages 91 to 93. It was observed that Dithane M45, which has a dithiocarbonate base, gave better control of *Cercospora* than any of the other chemicals in the test. In order to confirm this result on larger plots, the 1966 main season nursery was divided into three sections and the seedlings in each section were sprayed with either Dithane M45 + Tenac, Dithane M45 + Agral 90, or Captan + Tenac. After nearly one year of routine spraying, 500 seedlings were picked at random from each treatment and scored for *Cercospora* lesions using a grading scale of 0 to 10, where "0" represents freedom from attack and "10" the most severe infection. The data are summarized below:

Treatments	*Concentration of Fungicide applied*	*Mean Score per seedling*
Captan + Tenac ..	2 lb./100 gal. Water + ½ pint Tenac ..	2.09
Dithane M45 + Tenac	2 lb./100 gal. Water + ½ pint Tenac ..	0.27
Dithane M45 + Agral 90	2 lb./100 gal. Water + ½ pint Agral 90 ..	0.39

Seedlings which received Dithane M45 had a significantly lower score thus confirming the results of earlier trials. Routine spraying of the Institute's nursery seedlings will be with Dithane M45 and Tenac as sticker.

Field Spraying Experiment: Main Station (Expt. 11–4)

This experiment is a continuation in the field of the nursery spraying trial P.651 described in NIFOR Second Annual Report page 91. The experiment was laid down as a split plot randomized block design. The whole plot treatments included spraying at

two weekly intervals with either Dithane M45, Difoltan 80W or Captan. The control plot was not sprayed with fungicide. Superimposed as split plot treatments were three levels of pruning, *i.e.* no pruning, light pruning and severe pruning at monthly intervals. Light pruning involved removal of fronds which were more than one-third desiccated, while in heavy pruning all leaves affected by *Cercospora* were excised. After treatment for one year the palms were scored for *Cercospora* leaf spot and their heights were measured. The data collected are summarized below:

Treatment	*Whole plot*		*Sub-plot*	
	Mean score per plot	*Mean height per plot in.*	*Treatment*	*Mean score per plot*
Dithane M45 ..	8.4	70.8	No pruning	23.1
Difoltan 80W ..	14.3	70.6	Light pruning	19.6
Captan	24.6	68.2	Severe pruning	17.9
Control	33.4	61.9		
Least Significant Differences:				
P = 0.05 ..	8.2	4.76		2.6
P = 0.01 ..	12.5	7.21		3.6

Analysis of the results showed that all whole plot treatments significantly reduced the incidence of *Cercospora* below that of the unsprayed control and Dithane M45 proved significantly better than Difoltan 80W or Captan. Even though the sub-plot treatments also exhibited significant effects of pruning no importance is as yet being attached to this result because whole plots were scored and a bias was introduced in favour of the palms that were heavily pruned. This bias in the scoring is being corrected. There was no interaction between spraying and pruning.

The analysis of the data on height measurements indicated that the palms sprayed with Dithane M45 and Difoltan 80W were highly significantly taller than the Control. There were no significant differences among the sub-plot treatments. However, there were indications that severe pruning depressed growth.

BLAST

The overall incidence of Blast Disease in the main season nursery was low, with losses estimated at 3.2% among Extension Work Seedlings and 7.7% in the Plant Breeding material. The rainfall during the year was above average and was well distributed, particularly in the months of July, August and September.

The Effect of Soil Moisture on the Incidence of Blast Disease (Expt. P.661)

This experiment is being carried out in co-operation with the Soil Chemistry Division, and examines the relationship between soil moisture and the incidence of Blast Disease in the nursery. The treatments, which were in a randomized block design, are as follows:

1 Control—no irrigation.
2 Irrigation from mid-November at 2 in. water per week.
3 Irrigation to field capacity from mid-July.
4 Irrigation from mid-November (2 in. water per week) plus shading from the time of planting to January.
5 Irrigation from mid-November (2 in. water per week) plus shading from July to September.

Seven susceptible progenies were used in the experiment and these were randomized within the plots. The seedlings were planted in June, two months after the recommended planting date, in order to provide more suitable conditions for attack. Soil samples were examined for Pythium population and soil moisture was determined separately for all treatments. The incidence of Blast Disease was recorded weekly up to December and the final count was before planting time in March/April. The data collected are shown opposite in Table 11.

The first appearance of Blast symptoms in the experiment was recorded in early November. Towards the end of November and in December the incidence of the disease was high. Statistical analysis of the data showed no significant correlation between soil moisture and Pythium population during September to November. There was, however, a significant negative correlation in December. The correlation between the average soil moisture and the total Blast incidence for the year was negative but not significant. A comparison of the individual treatments indicated that shading of seedlings from planting till January and irrigation with 2 in. water per week from mid-November had a significant effect in reducing the incidence of Blast Disease. Additional experiments on soil moisture relationships are in progress with the object of obtaining further clarification of the above observations.

Chemical Control of Blast Disease: Main Station (*Expt. P.662*)

The experiment was laid down to examine the efficacy of some chemicals in the control of Blast Disease. The experiment was designed in randomized blocks and included treatments with Dithane A40 (applied by hand watering), Vapam, PCNB (penta-chloro-nitrobenzene) with Captan and control.

Irrigation at a minimum of 2 in. per week was given in accordance with the NIFOR routine nursery procedure from July onwards. The data on Blast incidence collected in March/April 1967 did not give a conclusive result. The experiment is being repeated.

BROWN GERM

The loss of seed due to Brown Germ has been remarkably low during the year. This seems to have been achieved by avoiding surface moisture on germinated seeds. Germinated seeds are set apart at an early stage and stored in polythene bags for further development before planting out. During this period no water is applied. Thus the handling of germinated seed is reduced to a minimum and the risk of accidental injury to the tender growing tissues is reduced. The results have been encouraging and the investigations are being continued.

TABLE 11

SOIL MOISTURE AND PYTHIUM POPULATION IN RELATION TO INCIDENCE OF BLAST DISEASE: MAIN NURSERY 1966
(EXPT. P.661)

Treatment	September		October		November			December			Total Blast for the season
	Moisture	No. of Pythial colonies	Moisture	No. of Pythial colonies	Moisture	No. of Pythial colonies	Blast	Moisture	No. of Pythial colonies	Blast	
	%		%		%		%	%		%	%
1	16.9	4.5	16.6	35.0	15.5	28.2	5.7	10.0	41.0	12.8	13.8
2	16.9	12.7	18.5	24.7	15.6	41.7	7.4	15.8	37.5	16.2	16.9
3	17.7	14.0	16.7	34.0	15.3	29.5	3.7	16.4	32.5	8.8	11.1
4	17.0	7.5	16.6	27.0	18.3	53.0	—	17.9	39.5	—	1.0
5	16.3	16.5	15.8	29.5	14.8	28.7	5.4	14.4	45.0	14.1	15.6

Treatments

	Irrigation	*Shade*
1	nil	nil
2	From mid-November (2 in. per week)	nil
3	From mid-July (to F.C.)	nil
4	From mid-November (2 in. per week)	From planting to January
5	From mid-November (2 in. per week)	July-September

Brown Germ Investigation: Main Station (Expt. P.659)

Three chemicals, Agrosan GN, Aretan 6 and Formalin were tried as seed dressings for the control of Brown Germ (NIFOR Second Annual Report, page 95). The incidence of Brown Germ was too slight for the results to be meaningful. There were indications, however, that the dressing with Agrosan GN after second cooling had beneficial effects.

The experiment has been repeated with slight modifications. The following treatments were applied in four replications using 100 seeds per plot.

Pre-heat treatment:

T_1 Soaking seeds in Aretan 6 (ethoxy-ethyl-mercury chloride) solution for one day followed by six days soaking in water.

T_2 Soaking seeds for six days in water followed by soaking in Aretan 6 solution for one day.

T_3 Soaking seeds in copper sulphate solution for seven days.

Post-heat treatment:

T_4 as in T_1.

T_5 as in T_2.

T_6 as in T_3.

T_7 dressing of seeds with Agrosan GN after seven days soaking.

T_8 Control.

The following data were collected:

Treatments	*Germination after four months* %	*Germination after five months* %	*No. of Brown Germ affected seeds*
T_1	34	39	—
T_2	48	62	—
T_3	26	34	—
T_4	28	32	—
T_5	38	42	—
T_6	26	31	7
T_7	78	85	—
T_8	31	40	10

The percentage germination was highest in seeds dressed with Agrosan GN thus confirming the observation in the first trial. A peak germination of 70% for this treatment was obtained in fifteen days after soaking the seeds and there was no loss of seeds due to Brown Germ. The experiment is being repeated and apart from germination and the incidence of Brown Germ, observation will continue to include the seedlings' development in the raised trays.

PATCH YELLOWS

Pathogenicity tests on E.W.S. seedlings using a *Fusarium* sp. isolated from diseased material were carried out during the year. The inoculation of seedlings was by various methods and for different lengths of time and planting was done in both sterile and non-sterile soils. None of the inoculated seedlings reproduced typical disease symptoms and no root damage was observed even three months after inoculation. Further trials are planned using susceptible progenies and seedlings for the test are being raised.

Disease Surveys

Regular disease surveys were carried out during the year and the results are summarized below:

Experiment	*No. of stands*	*No. of stands affected March 1967*
16–1 and 2 ..	2,480	43
17–1, 2 and 3 ..	5,460	27*
25–1 to 6 ..	6,014	17
30–4 and 6 ..	2,145	4
36–1 to 4 ..	4,712	69

**surveyed in April 1966*

It has been observed that the disease is on the increase in the Main Station, particularly in the progeny trials of Plant Breeding Division, perhaps because susceptible palms have been planted.

DRY BASAL ROT

During the year there was a fresh outbreak of Dry Basal Rot in the Main Station in areas planted in 1962-64. Similar attacks were reported from the out-stations at Kabba and Acharu in the Northern Region and at Odeda in the Western Region. Normally the disease symptoms appear towards the end of dry season and the outbreaks of 1966-67 may be attributed to the prolonged dry season. A survey of the affected fields was carried out and the results are summarized below:

Experiment	*No. of stands*	*Infected palms* %
2–17 (Main Station) ..	70	0.10
6–7 ,, ..	392	0.02
16–1 to 6 ,, ..	4,464	5.88
25–1 to 6 ,, ..	6,014	3.79
30–4 to 6 ,, ..	2,145	0.50
36–1 to 4 ,, ..	4,712	5.85
761–1 (Kabba)	1,064	4.98
761–2 ,, ...	382	5.50
762–1 (Acharu)	800	6.81
762–2 ,, ...	1,140	9.91

Fresh isolations of the fungus responsible for the disease were made from the infected palms and were compared with the cultures which were isolated from earlier outbreaks.

Replanting Experiment: Akwukwu (Expt. 153–1)

This experiment was described in NIFOR Second Annual Report, page 96. Routine fertilizer application was carried out during the year. The maintenance of the plot had been satisfactory throughout the year and the experiment is being kept under observation for disease symptoms and recolonization by the fungus.

Soil Sterilization Experiment: Asaba (Expt. P.622)

General maintenance has been satisfactory in the soil sterilization experiment described in the WAIFOR Eleventh Annual Report, page 80. Some of the palms planted with balls-of-earth have started producing bunches and no disease symptoms have been observed. Soil samples collected from the treated and control plots were examined in the laboratory and species of *Penicillium*, *Trichoderma* and *Absidia* were found to be the predominant fungal population.

Disease Resistance Trial (Expt. P.664)

This experiment was set up in co-operation with the Plant Breeding Division. Twenty-three progenies were tested for susceptibility to Dry Basal Rot by a simple root-dip inoculation method. Both leaves and roots were scored for degrees of infection one month after the inoculation. The data collected are being analysed by the Plant Breeding Division. The results continue to indicate that there are definite lines of resistance and susceptibility and that resistance is governed by a single gene.

EFFECT OF METHYL BROMIDE ON THE VIABILITY OF OIL PALM SEEDS

The experiment was designed to examine the effect of methyl bromide on the viability of seeds. Seeds which had been in storage for different periods were treated with methyl bromide at a rate of 20 ml. to 250 cu. ft. After treatment the seeds were divided into two lots; one batch was set to germinate immediately after the treatment and the second batch was stored for a further five months before germination. The counts taken for three months showed no germination for treated seeds and 90% for the untreated control. This suggests that methyl bromide at the applied dosage had a deleterious effect on the viability of the oil palm seed.

PHYTOSANITARY INSPECTION

Fifty-two samples of plant material, mainly oil palm seeds and pollen grains, were examined for phytosanitary certificates.

K. RAJAGOPALAN

PLANT PHYSIOLOGY DIVISION

STAFF

There was no Plant Physiologist on duty. Work carried out by the Acting Senior Plant Breeder on seed dormancy, the storage of oil palm seed and the relationship between assimilation and yield is reported below. Mr. M. O. Otedoh, Research Officer-in-Training, was engaged in experiments connected with seed storage from June 1966 to the end of the year.

GERMINATION

The Genetic Basis for Period of Seed Dormancy (Expt. B.6611)

Investigations into the causes of the variable germination obtained after seed dormancy had been broken by shock heat treatment at 60°C revealed that seeds from different origins may have different periods of dormancy. Two Deli palms growing at the NIFOR Main Station are known to produce selfed seed that germinates well during storage under moist conditions at 72°. A programme of crosses has been started between these palms and also back-crosses with palms obtained from the selfing of one of the parents. The distribution of the dormancy period in this selfing has been examined. While no evidence of segregation into different dormancy levels has been detected within this selfing, it has been found that it has a different heat treatment requirement for germination (30-40 days) to that of the African *dura* or *tenera* seed on which the NIFOR practice of 80 days heat treatment was based. The opinion that the Deli seed has a different germination requirement is thus confirmed. Shorter periods of heat treatment are normally practised in Malaya. A comparison between the percentage germination of seed heated for different periods in the earlier WAIFOR experiments and the current investigation is given below.

Percentage Germination of Dura and Tenera Seed within 90 Days from Cooling

	Days at 40°C							
	10	*20*	*30*	*40*	*50*	*60*	*70*	*80*
Dura	1	1	12	32	67	78	83	87
Tenera	0	3	23	43	66	65	83	79
Deli *dura* (Expt. B.6611) ..	32	47	82	93	95	92	98	98

Chemical Tests of Seed Viability (Expt. H.672)

In 1951 an investigation into the use of 2,3,5-triphenyl-tetrazolium bromide for making quick estimates of the viability of oil palm seed was started at the Institute, but the investigation was discontinued. Tetrazolium salts have more recently been used in the Ivory Coast and in Malaya for routine tests of seed viability. The use of tetrazolium chloride for assessing the viability of pollen grains is under investigation at NIFOR, and has been described on page 73 of this report. The same salt is being tested for determining the viability of oil palm seed. Monthly samples of material from the seed storage experiment, described below, have been used for the chemical tests and they are being compared with the results of actual germination obtained in that experiment.

SEED STORAGE

The Effect of Drying out during Storage at 72°F (Expt. H.671)

Earlier experiments reported on page 91 of the NIFOR First Annual Report indicate that oil palm seed of normal moisture content is best stored under conditions of low temperature. This method of storage has been used for the small lots of seed from the breeding programme crosses since early 1960. Up to 1965, routine storage of Extension Work Seed had been at ambient temperature, the seed being dried briefly in the shade before storage. This method had given good results for short periods of storage (WAIFOR Twelfth Annual Report, pages 84-5). More recently, bulk storage of seed for up to one year has been carried out in open trays kept in an air conditioned store, but temperature fluctations between 17°C and 27°C have been observed. The extremes occur during cool Harmattan nights and the dry season mid-day heat. The mean temperature of the store is 22°C while the relative humidity varies from 51% to 62%. This causes a drop in seed moisture to a minimum of just under 10% after six months storage. Although normally good germination has been obtained from seed stored for up to a year under these conditions, it was considered advisable to examine this effect of drying during storage.

The experiment was started in September 1966 using open-pollinated *dura* seed derived from Aba and Ufuma palms (Expt. 15–1), and it examines the effect of three possible methods of reducing the rate of drying. Treatments include storage in polythene bags varying in thickness from 115 to 500 gauge, covering the storage trays at the top and bottom with polythene sheets of various thickness and hand watering at daily to monthly intervals. The treatments are compared with seed which are kept at normal ambient conditions or are maintained at the "optimum" moisture content of about 22%. Moisture content, percentage germination, production of transplantable seedlings and reaction to tetrazolium chloride have been measured in monthly samples.

THE STUDY OF DIFFERENCES IN YIELD

The purpose of this investigation was mentioned on page 92 of the NIFOR First Annual Report. The sampling methods developed for assessing the reducing sugar content of oil palm leaflets were described on page 98 of the NIFOR Second Annual Report.

During the year measurements were taken of the accumulation of reducing sugars in leaflets from the ninth frond of palms planted in 1959 and 1961. The palms planted in 1961 were subdivided into the thirty high and thirty low yielders during their fourth year in the field. Since it was not possible to sample more than twenty palms on any one day, ten palms were taken from each of the groups for the tests. Hourly total solar insolation was recorded by a Kipp solarimeter during the period of active photosynthesis (7.30 a.m. to 1.30 p.m.) and supplemented by hourly readings from a selenium cell. The analysis of accumulated reducing sugar has given very variable results and the correlation between samples taken from the same palms on different occasions is poor. There has, however, been a consistent trend ($P = 0.03$) suggesting that less reducing sugar remains in the leaflets at mid-day in those palms classified as high yielders. Examination of this group of sixty palms is being continued both for day-time accumulation and night-time depletion of sugar in the leaves.

In the field, measurements for estimating leaf area indices, vigour and bulk have been completed for the experimental palms. Fifteen leaves from different palms have been measured in detail and the true areas of the leaflets has been calculated. Derivation of a simple method for measuring leaf area in the field is in progress.

T. MENENDEZ

RESEARCH ENGINEERING DIVISION

STAFF

The Director, Mr. S. C. Nwanze, supervised the work of the Division, the post of the Research Engineer being vacant.

GENERAL PROGRAMME

Three new experiments were started during the year: (*a*) an experiment to compare the quality of the liquid and the semi-liquid components of palm oil, (*b*) an experiment to study the resistance of certain steels to the corrosive action of palm oil and (*c*) an experiment to examine oil storage in polythene lined steel drums. A preliminary study of the action of the fungus *Neurospora* on palm oil was made in January 1967. Subsequently it was decided that the study should include other species of fungi normally found associated with bunches, and arrangements were made with the Plant Pathologist to provide pure cultures of such fungi.

PALM OIL INVESTIGATIONS

Liquid and Semi-Liquid Components of Palm Oil (Expt. E.661)

At the ambient temperature in the tropics (23-25°C), palm oil on standing settles in two separate layers, an upper deep red liquid layer and a lower light yellow waxy fraction. In order to assess the bleaching characteristics of the two constituents, settled samples of palm oil were chilled to about 10°C and pressure was applied to the two congealed fractions to extract samples of liquid oil. The two samples were bleached and their residual colour determined. The carotene content was determined prior to bleaching. Results obtained are given below:

Liquid at low temperature		*Waxy at low temperature*	
Carotene	*Lovibond*	*Carotene*	*Lovibond*
p.p.m.	*10 (R + Y)*	*p.p.m.*	*10 (R + Y)*
—	3.4	—	1.8
—	12.8	—	10.5
—	4.1	—	2.0
—	6.1	—	4.0
—	2.1	—	0.3
1,005	1.9	736	0.1
1,184	3.9	730	0.6
978	0.4	717	0.3
1,106	1.9	566	0.3
1,007	0.5	768	0.2
940	0.4	718	0.2
1,040	1.6	577	0.4

The results showed that the carotene content of the liquid portion of the oil was greater than that of the semi-liquid part and that the semi-liquid fraction bleached very well.

The experiment was suspended when chilling facilities were no longer available.

Corrosion Resistance Experiment (*Expt. E.662*)

Previous experiments showed that iron contamination is one of the major factors affecting the quality of palm oil. This is caused by corrosion of drums, used for oil storage and transportation. It was arranged with the Gebr. Stork, Amsterdam, to provide test pieces of stainless steel for corrosion tests. Thirteen formulations comprising 42 stainless steel pieces were obtained. The experiment was designed (*a*) to study the effect of palm oil on the steel surfaces, (*b*) to examine the rate of corrosion with the steel pieces suspended in palm oil at the different stages of the oil's extraction in the mill and (*c*) to find the effect of the various steel pieces on palm oil in the laboratory.

Observations on the test pieces were made weekly and the data for the sixteenth week are summarized in Table 12. Steel 73118/285 V14 proved particularly susceptible to corrosion, losing 41.47% of its original weight in hot oil. Corrosion took the form of a black crust which cracked away exposing fresh surfaces for attack. For most of the test pieces the rate of corrosion appeared to be largely dependent on the temperature of the oil.

The investigation into the effect of the steel samples on palm oil showed that there was little or no change in the peroxide value or free fatty acid content in the sixteen weeks, but the iron content increased considerably in the oil in contact with steel formulation 73118/285 V10 and rather less so with formulations 73118/285 V4 and V12.

Drum Lining Experiment (*Expt. E.663*)

This experiment, like Experiment E.662, described above, aims at finding a solution to the problems of oil storage in steel drums. This experiment investigates storage in both resin and polythene lined drums, with linings of different gauges. The objects of the experiment are (*a*) to determine the effect of the linings on the stored oil, (*b*) to find the optimum thickness of lining required for satisfactory oil storage. Treatments were as follows.

A. Resin lined, lining thickness 16BG.
B. Resin lined, lining thickness 18BG.
C. Polythene lined, lining thickness 16BG.
D. Polythene lined, lining thickness 18BG.
E. Polythene lined, lining thickness 20BG.
F. Control—standard drums (Nigerian Marketing Board).

The experiment was replicated three times. The drums were filled with oil from the same stock, which was sampled for analysis beforehand. Subsequent samples were taken from the drums at weekly intervals and analysed for peroxide value, free fatty acid, moisture, iodine value, carotene and iron content. A portion of each sample was bleached and the residual colour examined.

TABLE 12

CORROSION OF STEEL IN PALM OIL (EXPT. E.662)

Data after the sixteenth weekly immersion

Steel Code No.		Immersed in oil boiler (96°C)			Immersed in crude oil (75°C)			Immersed in clean oil (29°C)		
		Loss of wt.	Loss in thickness	Appearance	Loss of wt.	Loss in thickness	Appearance	Loss of wt.	Loss in thickness	Appearance
		%	*in.*		%	*in.*		%	*in.*	
73118/285	3 × 5 × 1	0.07	0.0006	purple blue	0.01	0.0007	purple blue	0.01	0.0006	tarnished
73118/285	3 × 6 × 1	0.04	0.0002	light blue	—	—	original	—	0.0001	original
73118/285	3 × 7 × 1	0.03	0.0002	original	—	0.0002	original	—	0.0160	original
73118/285	V2	6.21	0.0048	brown, rusty	1.39	0.0016	grey, rusty	—	0.0030	tarnished
73118/285	V3	3.79	0.0038	black	1.86	0.0017	black	0.04	0.0007	tarnished
73118/285	V4	4.99	0.0074	black	1.75	0.0015	dark grey	0.27	0.0009	rusty, pitted
73118/285	V1	9.40	0.0111	brown, rusty	2.62	0.0026	grey, rusty	0.01	—	tarnished
73118/285	V8	0.05	0.0002	original	0.01	0.0012	original	0.01	0.0007	original
73118/285	V9	7.02	0.0041	black	4.01	0.0017	black	0.03	0.0004	tarnished
73118/285	V10	13.19	0.0107	brown, rusty	3.86	0.0025	brown, rusty	0.94	0.0007	brown, rusty
73118/285	V12	12.55	0.0068	black	2.33	0.0020	black	0.05	0.0006	rusty
73118/285	V13	4.02	0.0034	black, pitted	2.80	0.0012	black	0.01	0.0008	tarnished
73118/285	V14	41.47	0.0037	black, pitted	8.97	0.0039	grey, pitted	0.02	0.0008	tarnished

After one week the peroxide value of the oil sampled from the control rose sharply. No peroxide formation was detected in the other samples up to the twenty-fifth week of the experiment.

Fungus Inoculation Experiment (Expt. E.671)

The common occurrence of certain fungi, particularly *Neurospora* sp., on bunch refuse near the oil mill stimulated speculation as to their influence on the quality of palm oil. A preliminary experiment was set up to study the effect of *Neurospora* sp. on the F.F.A. content of palm oil. The experiment was arranged with two treatments and a control, all replicated five times.

Treatment A: Oil inoculated with *Neurospora* and kept in a closed bottle.

Treatment B: Oil inoculated with *Neurospora* and left open in a bottle.

Treatment C: Control no inoculation.

The inoculum for each replication consisted of 2 gm. of a mixture of raw *Neurospora* mycelium and spores taken from bunch refuse. Samples of oil were taken from the bottle fortnightly and analysed:

Treatment	*Free fatty acid (mean of five replications)*			
	Start	*Two weeks*	*Four weeks*	*Six weeks*
	%	%	%	%
A. Inoculated and sealed ..	1.98	4.52	5.06	5.37
B. Inoculated, left open ..	1.98	5.07	6.02	6.04
C. Control	1.98	2.09	2.04	2.03

The data indicate that within the six week period, the free fatty acid content of the treatment samples rose rapidly, while it remained constant in the control samples. This may be attributed to the *Neurospora* alone, or to its contaminants, as the culture was not a pure one. Further experiments are planned with pure cultures, which are being prepared by the Pathology Division.

Fruit from Corozo oleifera and hybrids

The investigation of the characteristics of oil from *Corozo oleifera* and its hybrids with *Elaeis guineensis* started in July 1965. First results of analyses of oil from two hybrid palms were published in the NIFOR Second Annual Report, page 106. Further analyses of oil have now been made.

Mean data for oil from Corozo oleifera hybrids

Palm	*No. of analyses performed*	*F.F.A.* %	*Moisture* %	*Iodine Value*	*Carotene p.p.m.*
1.2469	11	0.582	0.324	87.52	784
1.2464	12	0.494	0.276	90.04	854

Fruit analyses have also been carried out on bunches from *Corozo oleifera* hybrids. The average percentage of oil to fruit is higher than in the previous year (see NIFOR Second Annual Report, pages 106-7).

Analysis of hybrid Corozo oleifera fruits

Mesocarp to fruit	*Nuts to fruit*	*Oil to Mesocarp*	*Oil to fruit*	*S.G. of oil*	*Unsaponifiable matter*	*Saponification value of oil**
%	%	%	%	%	%	%
72.8	27.2	58.0	42.2	0.912	0.96	201.8
62.5	37.5	49.0	30.6	0.906	1.03	207.2
73.0	27.0	48.4	35.3	0.901	1.29	198.9
63.6	37.3	44.4	28.2	0.903	1.04	205.0
63.1	36.8	34.0	21.4	0.900	1.02	201.2
59.2	40.7	48.0	28.4	0.902	0.86	207.8
49.2	50.3	46.0	22.6	0.906	0.98	203.1
57.7	42.3	50.0	28.8	0.910	1.02	208.3
21.3	28.7	55.6	39.7	0.905	0.75	201.6
66.4	33.6	42.0	27.8	0.901	1.05	204.1
46.0	54.0	45.5	20.9	0.908	1.01	206.3
60.0	40.0	58.9	35.3	0.902	0.64	203.4
49.4	50.6	44.0	21.2	0.903	0.97	199.3
77.4	22.5	59.0	45.6	0.907	1.02	208.9
70.7	29.2	47.7	33.7	0.902	0.86	204.2
55.4	44.5	27.6	15.3	0.913	1.05	213.1
57.8	42.2	62.3	36.0	0.906	0.98	207.6
54.5	45.5	57.6	31.3	0.903	1.01	201.6
Av. 51.27	33.73	48.78	30.29	0.905	0.974	204.65

**Expressed as milli-equivalents potassium hydroxide*

MILLING INVESTIGATIONS

Fruit Quality Determination (Expt. E.645)

The objects of the experiment were described in the NIFOR First Annual Report, page 93, together with the first results. More results were published in the NIFOR Second Annual Report, page 99. Further observations showed that the thickness of the mesocarp gave a less accurate indication of the oil content of the fruit than of percentage mesocarp in the fruit, because of the variations in shell thickness and the percentage oil content of the mesocarp.

Fruit-to-bunch Ratio

In March 1967, a modified method of calculating the fruit to bunch ratio was introduced. This is necessitated by the increased quantity of *tenera* fruit reaching the mill. The new method takes into account the loss of weight during milling processes and is much more satisfactory.

AID TO OTHER DEPARTMENTS

The programme of laboratory tests on samples of palm oil and kernels from the Produce Inspection Division of the Ministry of Commerce and Industry, Midwest Region was completed in December 1966. The samples originated from Benin City, Sapele and Warri.

Oil from Benin was found to have a range of free fatty acid content from 1.50% to 3.30%, while that from Warri ranged from 18.46% to 40.30%. Sapele oil was intermediate in quality.

S. C. NWANZE

SOIL CHEMISTRY DIVISION

STAFF

Mr. St. C. M. Forde, Soil Chemist, was on duty until proceeding on leave in March 1967. Mr. P. I. Eapen, Analytical Chemist, returned from leave in August 1966.

GENERAL PROGRAMME

Investigations continued to centre upon soil potassium in relation to the nutrition of the oil palm. Previous work on the relationship between soil and leaf analysis data and the yield of the oil palm was greatly extended. Studies on soil moisture stress continued.

PHOSPHORUS STUDIES

Phosphorus Supplying Power of Soils (Expt. C.652)

Results from pot experiments and laboratory studies on the mobilization of phosphate in soils have indicated that yield responses to phosphorus by the oil palm could be expected on some Nigerian soils. In a pot experiment designed to assess the relative phosphorus supplying power of soils, samples from fourteen sites in Nigeria were compared with one from Aiyinasi, Western Ghana, where a large response to phosphate fertilizer had been obtained.

Experimental details were given on page 109 of the NIFOR Second Annual Report. Chemical tests for "available" phosphorus were carried out on the soils. These included Truog's extraction with 0.002 N H_2SO_4; Olsen's 0.5 N Na_2CO_3; Saunder's 0.1 N NaOH and the Bray and Kurtz's No. 1 method using 0.03 N NH_4F in 0.025 N HCl. The logarithm of the percentage increase in dry matter production of the phosphate fertilized pots over the unfertilized was significantly related to the soil test values for phosphorus. The increase in phosphorus uptake in the leaves of phosphate treated seedlings over the untreated also correlated significantly with the available soil phosphorus.

Soil Test	*Correlation coefficients*	
	Log % increase in dry matter	*Increase in P-uptake*
Truog	−0.607*	−0.471
Saunders	−0.621**	−0.615*
Olsen..	−0.526*	−0.577*
Bray and Kurtz No. 1	−0.735**	−0.557*

*P = 0.05 **P = 0.01

POTASSIUM STUDIES

Potassium Supplying Power of Soils: Laboratory Method II (Expt. C.656)

On page 110 of the NIFOR Second Annual Report a method (I) was described for determining the potassium supplying power of soils by continuous extraction with 0.005 N $CaCl_2$. A qualitative comparison of the potassium reserves in the seventeen soils examined was made from the graphs obtained by plotting the cumulative potassium removed against the number of extractions. The shape of the curves indicated that most of the potassium present in the soils was represented by the soluble and easily replaceable forms of the element.

In this method (II) the exchangeable potassium was first extracted with N NH_4OAc at pH7 and the soils incubated at room temperature. After specific intervals, the soils were leached with N NH_4OAc and potassium determined. Complete removal of the exchangeable potassium was attained by the fifth leaching. From the data tabulated below it can be seen that the release of non-exchangeable potassium from typical "Acid Sands" was negligible. Even on Basement Complex Soils non-exchangeable potassium was not readily available to the palms and hence the potassium supply in Nigerian soils is dependent on the exchangeable form of this element. Various parameters for the selected soils expressed as lb. K per 2×10^6 lb. soil were:

Site	*Method I*			*Method II*					
				K_e released after following period (weeks)					
	K_e	*K_{HNO_3}*	*K_{CaCl_2}*	*Start*	*1*	*4*	*8*	*12*	*16*
Abak 508–1 ..	67	97	64	65	4	4	4	4	2
Imuabi	35	51	41	34	2	4	1	1	2
Calaro (mica) ..	185	357	95	168	4	4	1	1	2
Calaro (granite) ..	205	1,049	126	198	5	0	1	2	2
NIFOR 34–2 ..	95	113	83	79	6	3	3	3	3
NIFOR 2–15 ..	37	58	59	48	4	7	1	3	2
Abak 506–3 ..	50	64	50	43	5	1	4	1	4
Umudike	50	67	36	48	5	1	0	4	2
Itu	27	42	31	21	5	1	1	2	3
Mbawsi	48	67	52	46	5	4	1	2	3
Ogba	55	73	63	70	4	3	4	2	2
Elele	110	123	96	109	6	2	2	2	2
Kwa Falls ..	70	134	77	67	4	4	5	1	3
Jema'a	55	243	51	51	5	4	1	2	2
Kabba	230	399	107	198	7	4	4	2	3
Njala (S.L.) ..	305	407	138	262	13	4	2	3	2
Aiyinasi (Ghana)	33	48	36	43	4	3	1	3	2

Potassium Supplying Power of Soils: Cropping Method (Expt. C.663)

In this experiment a cropping method was used to estimate the available potassium reserves in soils and the results were related to the yield of bunches of the palms. Italian Rye Grass was grown in polythene pots, each containing soil sampled from the rooting zone of one of fifteen selected *dura* palms in Expt. 1–6. Basic dressings of major and minor elements were made, omitting potassium. The leachate from each pot was re-cycled. Three replicate pots of each soil sample were set up. The grass grew well and the first cutting was made after five weeks.

The dried weight of the cuttings was recorded and the potassium content determined. No significant relationship was found between the yield of the palms and the mean weight of dry matter produced. There was, however, a very highly significant correlation between yield and the total amount of potassium removed by the grass, although the correlation between yield and the exchangeable potassium was slightly better. Most of the exchangeable potassium in the soils was removed at the first cropping, after which poor growth or even death occurred. It appeared that very little potassium was available for growth from non-exchangeable sources and further cropping ceased. The soils will be analysed for exchangeable potassium.

Correlation coefficients were calculated between yield and the amount of potassium originally present in the soil as well as parameters derived from the cropping results. These are shown below:

Palm No.	*Yield of bunches** *lb.*	K_e *mg./pot*	K_e *removed by cropping mg./pot*	K_e *removed by cropping % of original*
1	239	29.5	19.8	67
2	340	32.3	21.9	68
3	247	19.2	15.6	81
4	143	19.6	14.9	76
5	102	13.3	10.5	79
6	66	9.0	8.5	94
7	56	9.0	8.8	98
8	191	17.0	12.3	72
9	130	13.3	11.3	85
10	73	7.2	7.9	110
11	102	11.2	9.2	82
12	133	15.4	13.3	86
13	226	17.8	12.3	69
14	140	15.4	12.3	80
Correlation coefficients	—	0.9136***	0.8988***	0.7851***

*January-June 1966 ***P = 0.001

Relationship between Soil and Leaf Analysis (Expt. C.641)

Soil samples taken from fertilizer Experiments 508–1 at Abak and 552–2 at Mbawsi were analysed. The potassium status of the soil was examined in relation to bunch yield and the leaf content of this element. Regression analyses carried out on the data showed that at Abak there was a highly significant relationship between K_e and yield. The level of potassium at Mbawsi was very low and, as expected, there was a highly significant response to potassium in the yield of bunches. The relationship between soil potassium and yield did not attain significance. The results for these two experiments were as follows:

Correlation Coefficients for Soil-K, Leaf-K and Yield Data from Experiments 508–1 (Abak) and 652–2 (Mbawsi)

	1965 data	
	Abak K_e	*Mbawsi* K_e
Yield (weight of bunches)	0.4788	0.2345
Yield (number of bunches)	0.3644	0.2621
Leaf-K	0.1593	
Significance level		
P = 0.05	0.1730	0.2442
P = 0.01	0.2261	0.3174
P = 0.001	0.2864	0.3988

Mean Treatment Effect of Potassium on Soil-K, Leaf-K and Yield per plot

	Expt. 508–1, Abak				*Expt. 652–2, Mbawsi*		
K-level	K_e *	*Leaf-K* %	*Yield* *No.*	*lb.*	K_e *	*Yield* *No.*	*lb.*
0	0.101	0.75	52	210	0.036	30	759
1	0.123	1.13	68	274	0.040	40	1,569
2	0.139	1.35	68	293			
3	0.132	1.41	70	320			

*m.eq./100 g. soil

In addition to the two experiments referred to above, similar data from Experiment 556–2 at Calaro Estate and the 1965 and 1966 samples from Experiment 1–6 on the Main Station have been prepared for statistical analysis by computer. The results will be reported more fully when the analyses are completed.

Potassium Fixation in Soils (Expt. C.661)

Experimental details were given on page 115 of the NIFOR Second Annual Report for the determination of potassium fixation in soils by two methods (wet and dry). The effect of temperature on fixation was studied in two soil samples from the Main Station. By the dry method, the quantity of potassium fixed was estimated after three

wetting and drying cycles at 40°C. The quantity of potassium fixed increased with increasing amounts of KCl added. The clay content of the samples did not have any effect on the amount of potassium fixed, but with a rise in temperature from 40°C to 70°C, fixation increased from about 15 mg. to 35 mg. K/100 g. soil at the highest rate of application of KCl. Results are shown below:

Potassium fixation in mg. K/100 g. soil

Sample No.	*Depth*	*Temp.*	*Mechanical Analysis*			*Amount of K supplied in mg./100 g. soil*						
			Clay	*Silt*	*Sand*							
	ft.	*°C*	*%*	*%*	*%*	*10*	*25*	*50*	*100*	*125*	*250*	*500*
DBR 428	0-2	40	25.9	2.4	71.7	2.5	1.1	5.0	11.2	7.5	21.2	14.4
DBR 428	0-2	70	25.9	2.4	71.7	2.5	6.9	11.2	16.2	18.7	21.2	35.0
DBR 445	14-16	40	38.6	1.4	60.0	5.0	5.0	3.7	7.5	11.2	5.0	20.0
DBR 445	14-16	70	38.6	1.4	60.0	2.5	5.0	8.7	15.6	23.7	15.0	35.0

In another experiment, two soils were saturated with various cations and the effect on potassium fixation investigated by the dry method at 40°C. The cations used were H^+, NH_4^+, Ca^{++}, Mg^{++}, Al^{+++}, Ba^{++} and Na^{++}. The results were not entirely consistent and further work is needed. It appears that NH_4^+ and Na^+ increase the percentage fixation as can be seen below:

Effect of cations on Potassium Fixation at 40°C

Soil	*Depth*	*Mechanical Analysis*			*K-fixed as a percentage of amount added*							
		Clay	*Silt*	*Sand*	*Un-treated*	*Al*	*Ba*	*Ca*	*Mg*	*NH_4*	*H*	*Na*
	ft.	*%*	*%*	*%*								
DBR 438	0-2	30.1	2.9	67	11	9	17	13	13	21	10	19
DBR 447	18-20	36.6	1.4	62	15	9	6	15	12	14	12	23

Factors Affecting the Determination of Exchangeable Potassium in Soils (Expt. C.662)

It has been found that the best index of soil potassium in relation to the yield of the oil palm is the exchangeable potassium extracted with N NH_4OAc at pH7. Several factors affect this determination, particularly the stage of drying of the soil sample. In this laboratory samples collected from the field are air-dried and analyses carried out subsequently. This experiment was designed to investigate the influence of the stage of drying on the exchangeable potassium estimated by this method.

Samples were taken from Experiment 1–6 in June 1966 and the exchangeable potassium measured on the fresh soil samples. Moisture determinations were made and the results calculated on a dry weight basis. The air-dried and oven-dried (105°C) samples were also analysed for potassium. The results showed that the exchangeable potassium increased with drying, thus:

$$K_{\text{moist soil}} < K_{\text{air-dried soil}} < K_{\text{oven-dried soil}}$$

In order to establish whether this affected the correlation with yield data, fifteen samples representing *dura* palms were selected and correlation coefficients calculated. It was found that using results based on the analysis of fresh soil samples lowered the correlation between soil potassium and yield, but no particular benefit was derived by

oven drying the samples. Correlation coefficients between values of exchangeable potassium and yield data (January-June 1966) are presented below:

Moist soil	0.8825***
Air-dried soil	0.9136***
Oven-dried soil	0.9387***

The Distribution of Potassium in Soils (Expt. C.664)

It has been assumed that it is the large rooting volume available to the oil palm in "Acid Sands" that furnishes a sufficient source of potassium for plant growth. Analyses were carried out to examine the distribution of the forms of potassium in profiles of Acid Sands soils. It was found that while the total potassium (HCl soluble) remained relatively constant throughout the profile, the exchangeable potassium was always highest in the surface of the soil. The amount of exchangeable potassium found below the surface was very low. Under conditions where potassium fertilizers were not applied, quantities of the element present would lead to deficiency conditions and a reduction in yield of the palms. A typical profile analysis for various forms of potassium is given below:

Distribution of Potassium in a Soil Profile from Expt. 7–1

Depth	K_e	K_f[1]	K_h[2]	K_e	K_f	K_h
ft.	*m.eq.K/100 g. soil*			%[3]	%[3]	%[3]
0-2	0.058	0.046	0.003	54	43	3
2-4	0.035	0.025	0.032	38	27	35
4-6	0.035	0.017	0.048	35	17	48
6-8	0.029	0.023	0.040	31	25	44
8-10	0.022	0.029	0.056	20	27	53
10-12	0.032	0.026	0.049	30	24	46
12-14	0.032	0.019	0.056	30	18	52
14-16	0.024	0.016	0.057	25	16	59
16-18	0.027	0.014	0.051	29	15	56
18-20	0.022	0.008	0.062	24	9	67

[1] K extracted by boiling N HNO_3

[2] K extracted by boiling HCl

[3] Percentage of total of the three values

Effects of Different Sources of Potassium Supply on the Nutrition of Oil Palm Seedlings (Expt. C.665)

In Nigeria, the potassium fertilizer most usually applied to palms is potassium sulphate. In other countries potassium chloride is preferred. It has been suggested that when potassium is supplied in the sulphate form, the oil content of the crop is increased (Venema, 1959). The aim of this experiment is not to examine this effect, but to obtain information as to whether equivalent amounts of potassium supplied in either the sulphate or chloride forms have the same result on dry matter production and the uptake of nutrients.

The pot trial consists of five treatments in eight randomized blocks. They compare:

(*a*) the effects of potassium in the absence of sulphate or chloride anions with an equivalent quantity of the element in the presence of either one of these anions;

(*b*) the effects of potassium sulphate and those of potassium chloride when similar amounts of either chloride or sulphate are present.

Four seedlings were established in each pot, containing 15 kg. soil to which a basal dressing of major and minor elements was added. The treatments were as follows:

1. Potassium carbonate and sodium acetate.
2. Potassium carbonate and sodium chloride.
3. Potassium carbonate and sodium sulphate.
4. Potassium chloride and sodium sulphate.
5. Potassium sulphate and sodium chloride.

MICRONUTRIENTS

Toxicity Effects of Microelements (*Expt. C.666*)

With the exception of copper, which was known to produce leaf scorch at a concentration of 2,500 p.p.m., no information was available about the maximum concentration at which micronutrients could be applied to palms without producing harmful effects on the leaf tissue. This study was designed to furnish this data and provide a better basis for selecting the concentration of nutrients being used in Experiment 9–2.

A number of polythene pots, each containing two nine-month-old seedlings, were used. The trace elements studied were copper, zinc and molybdenum which were applied at rates ranging from 0 to 100,000 p.p.m. Within two days of application of the treatments, toxicity symptoms appeared at certain concentrations of each element. The symptoms took the form of a chlorosis of the tissue, which later became necrotic and gave the appearance of the leaves having been scorched. The younger leaves were most seriously affected. The necrosis finally resulted in complete desiccation of the leaves. The minimum concentrations at which toxicity effects were observed were:

Element	*Concentration*
	p.p.m.
Copper	1,500
Molybdenum	2,500
Zinc	5,000

Trace Elements in Soils (*Expt. C.653*)

On page 118 of the NIFOR Second Annual Report, preliminary results were reported for the distribution of copper in Nigerian soils. Analytical procedures were also developed for the determination of iron and manganese. Using air-dried soil samples, exchangeable ferrous, ferric and dilute acid soluble iron were extracted with N NH_4OAc at pH3. The iron in the extract was determined colorimetrically by the orthophenanthroline method at 490 mμ. Tests showed that up to 95% of the iron added to the soil (before extraction) could be recovered.

The soluble, exchangeable and easily reducible manganese were estimated on soils following extraction with N NH_4OAc at pH7, to which hydroquinone was added. The manganese in the solutions was oxidized to $HMnO_4$ by means of para-periodate and the optical density read at 540 mμ. The recovery of added manganese was 90%.

The distribution of manganese, copper and iron in certain soils is shown below:

Location/Expt.	*Depth in.*	*Manganese p.p.m.*	*Copper p.p.m.*	*Iron p.p.m.*
Umuabi	0-6	2	9	14
Mbawsi	0-6	36	9	27
	6-12	27	11	38
Umudike	0-6	22	4	31
	6-12	18	9	44
Kwa Falls	0-6	65	10	31
	6-12	48	12	34
C.O.P.E.	0-6	3	3	79
	6-12	2	8	67
Abak 508–1	6-12	38	7	69
Abak 506–2	0-6	10	5	61
Calaro (F85)	0-6	20	6	41
	6-12	10	12	48
NIFOR 5–5	0-6	130	9	30
NIFOR 2–15	0-6	135	9	11
	0-12	133	9	12
NIFOR 34–2	0-6	91	8	65
NIFOR 1–6	0-6	150	7	3
	0-12	131	8	7
Cowan I-III	0-6	24	8	58
Cowan IV	0-6	62	9	50
Aiyinasi (Ghana) ..	0-6	16	4	43
Mange (Sierra Leone)..	0-12	117	17	40

SOIL MOISTURE STUDIES

Soil Moisture Studies 1: Determination of Field Capacity (Expt. C.654)

An attempt to derive a laboratory method for estimating the field capacity of soils was described previously (see page 119, NIFOR Second Annual Report). In further work, soil moisture constants based on the use of the pressure pot apparatus were introduced. Measurements of field capacity were carried out on a typical Acid Sands profile on the NIFOR Main Station as follows:

(*a*) *Direct method.* The soil was brought to field capacity by irrigation and then covered with polythene sheeting to prevent evaporation. After three days drainage, samples were taken and the moisture content determined gravimetrically by drying to constant weight at 105°C.

(*b*) *$\frac{1}{10}$-atmosphere percentage.* Duplicate samples were saturated and placed in a pressure pot extractor at a suction of $\frac{1}{10}$-atmosphere according to the procedure outlined in Agriculture Handbook No. 60 of the U.S.D.A. After hydraulic equilibrium was achieved, the moisture content of the samples was assessed gravimetrically by oven-drying at 105°C.

(*c*) *$\frac{1}{3}$-atmosphere percentage.* The method was similar to (*b*) except that the applied suction was $\frac{1}{3}$-atmosphere.

(*d*) *Moisture Equivalent.* This determination was made by the method of Briggs and McLane in a soil moisture centrifuge at 2,200 r.p.m.

The null hypothesis that the expectation of $b = \beta = 1$ in the comparisons of the direct method with each of the indirect methods was tested, and correlation coefficients calculated for each comparison. The procedures (*b*), (*c*) and (*d*) were all highly correlated with the true value of the field capacity. The null hypothesis was valid in the comparison between the $\frac{1}{3}$-atmosphere and the field capacity, but the moisture equivalent and the $\frac{1}{10}$-atmosphere differed significantly from the true value ($P = 0.05$ and $P = 0.01$ respectively). By use of the moisture equivalent, field capacity was under-estimated, while it was over-estimated using the $\frac{1}{10}$-atmosphere percentage. The data below shows that for the $\frac{1}{10}$-atmosphere the ratio b (regression coefficient) of the measured value to the true value was 1.1847 and 0.9096 for the moisture equivalent. Thus, the $\frac{1}{10}$-atmosphere produced values that were high by about 18% and the moisture equivalent yielded values that were low by about 9%.

Comparison of Indirect Methods with the Direct Method of estimating Field Capacity

Method	*Coefficient of Variation* %	*Correlation Coefficient*	*Regression Coefficient* (*b*)	*S.e. of b*
Moisture equivalent ..	8.91	0.94***	0.9096	±0.0151
$\frac{1}{10}$-atmosphere	12.83	0.85***	1.1847	±0.0319
$\frac{1}{3}$-atmosphere	9.31	0.92***	0.9667	±0.0193

Using Bartlett's test of homogeneity to examine the variations in the populations generated by the three methods, it was found that the population generated by the $\frac{1}{10}$-atmosphere procedure was quite different from those of the other two methods.

Rooting Studies using Radioactive Tracer Methods (Expt. C.649)

Earlier studies on adult palms have been reported previously. Considerable dilution of the P^{32} occurred due to the bulk of such palms and low activities were recorded. A further study was carried out in an area of younger palms in Experiment 13–1, planted in 1965. The trial consisted of three treatments in 12 randomized blocks. Experimental details were as follows:

Treatment (*a*) No irrigation.

(*b*) 2.2 inches of water per palm just prior to the application of the P^{32}.

(*c*) 2.2 inches of water per palm applied weekly throughout the dry season.

Irrigation began on the 15th November 1966 and the P^{32} was applied in carrier solution during the first week of February 1967. Samples were taken from leaf 3 one week afterwards. The oven-dried ground leaf material was ashed at 500°C, extracted with 1 : 1 HCl and the phosphate precipitated as ammonium phospho-molybdate in nitric acid medium. The precipitate was dissolved in ammonia. The P^{32} in solution was determined by a liquid Geiger-Muller counter and the total phosphate in the same solution estimated colorimetrically using the vanado-molybdate method at 470 mμ. The results showed that the uptake of P^{32} was significantly higher in the irrigated palms than in the un-irrigated.

	Mean Specific Activity	
	Time after application of P^{32}	
Treatment	*One week*	*Two weeks*
(*a*)	0.138	1.032
(*b*)	0.251	1.744
(*c*)	2.432	5.337
Least Significant Differences:		
P = 0.05	0.9	1.9
P = 0.01	1.3	2.6

Effects of Irrigation on Mid-day Stomatal Closure of Oil Palms (Expt. C.667)

In Experiment 1–21 the effect of irrigation on the growth and development of the oil palm is being investigated. For the present study 36 palms were selected and the percentage stomatal opening at mid-day was estimated by Moliche's method (infiltration of water and isopropanol mixtures). The tip of leaf 3 was used for these measurements, as considerable variation was found from both leaf to leaf and between leaflets on each leaf. A summary of results obtained during the dry season is presented below:

	Mean per cent stomata open at mid-day		*Mean per cent soil moisture by weight*	
	Un-irrigated	*Irrigated*	*Un-irrigated*	*Irrigated*
Fertilizer Application	%	%	%	%
None	12	42	1.6	14.3
April	12	44	2.4	14.5
April and October	14	50	2.0	13.4
Mean ..	13	45	2.0	14.1

Determination of Soil Moisture and Density by Neutron Hygrometry and Gamma-ray Densitometry

Calibration of probes for the determination of soil moisture and density by neutron moderation and the gamma-ray method was begun. The density probe functioned satisfactorily, but due to the failure of certain components in the pre-amplifier of the moisture probe, this work had to be stopped until the fault was corrected. Testing of the equipment will continue and a programme of work planned for this equipment will soon start.

ST. C. M. FORDE

REFERENCE

VENEMA, K. C. W. (1959). Influence de l'anion sulfate lors de la fumure du palmier à huile (*Elaeis guineensis*). *Pot. Rev.*, Février 1959, Sect. 27, 27^{e} suite, 9 p.

STATISTICS DIVISION

STAFF

Mr. B. O. Mgbolu, Statistician, was on study leave in the U.K. from 16th May to 30th June 1966, and was appointed head of the Division in December 1967. He also took three weeks vacation leave in January 1967. Earlier the Division had been under the supervision of Mr. R. D. Sheldrick, Acting Senior Agronomist, except for the period he was on leave when Mr. T. Menendez, Acting Senior Plant Breeder took over his duties. Mr. S. E. Nnabuchi, Technical Officer, was appointed Acting Higher Technical Officer in August 1966. He was on duty throughout the year except for a brief absence on leave in August and September 1966.

DESIGN AND ANALYSIS

The Division was busy reviewing past work after more than two years absence of a Statistician. Certain corrections were made both in design and analysis of some experiments. Assistance was given to other Divisions with designs of field and laboratory experiments. The major problem at present is the lack of satisfactory computer facilities in the country to relieve the pressure of routine computation.

BIOMETRIC STUDIES

Work on the relationship between soil and leaf analysis and the bunch yield of the oil palm is in progress. It is hoped to incorporate meteorological records into this study and to extend the whole investigation to include growth parameters of the palm. This work is being done in conjunction with the Soil Chemistry and Plant Breeding Division, work on the relationship between nursery measurements and bunch analysis has been started.

FIELD EXPERIMENTS

Calibration Trial: Main Station (Expt. 8–1)

The objects of this experiment were first discussed in the WAIFOR Fifth Annual Report, page 115. The eighth and final year's planting was carried out in May 1966. Vacancies in the 1965 plantings were supplied at the same time. Some palms in the 1963 plantings have been observed to be suffering from Dry Basal Rot and surveys are now being carried out by the Pathology Division.

Routine harvesting, leaf and flowering observations and height measurements in immature areas continued.

A preliminary study of the available yield data is given in Table 13. The data have not been fully examined, but it can be observed that no consistent trend exists in the behaviour of either the progenies planted in the same year or the same progenies planted in different years. The yield during 1966 was generally poor.

Seedling Selection Experiment: Main Station (Expt. 33–13)

Details of this experiment, formerly Experiment A.653, were given in the NIFOR First Annual Report, pages 28-9. Monthly height measurements and leaf counts were continued on the nursery seedlings until May 1966, when they were planted out in the field. The selection of the transplanted seedlings was made by a stratified sampling method with optimum allocation based on height variation within plots which form the strata.

The area will be mechanically maintained. Monthly height measurements and leaf counts continued to be taken. Records of the leaf that subtends the first inflorescence are being made.

YIELD RECORDING

Table 14 shows the number and location of palms yield-recorded in 1967. The total of 167,639 palms shows an increase of 6,176 over the previous year. This is made up of 104,581 palms situated at the Main Station, 43,271 elsewhere in Nigeria, 10,618 in Ghana and 9,169 in Sierra Leone.

The use of the punched card machinery to record and store oil palm data continued satisfactorily. All the 1966 by-palm listings and plot and treatment tabulations have been completed. Plot and treatment codes for twenty-four new field experiments have been devised. Entries of the 1965 yields into the annual yield books have been completed.

METEOROLOGY

The meteorological report for 1966 appears as Appendix I. All records except those of soil temperature and diffuse short wave radiation are being kept satisfactorily. The nickel resistance units for recording soil temperatures and the Beckman and Whitley radiometers for recording short wave radiation are still faulty. Monthly returns continued to be sent to the Meteorological Services Headquarters, Lagos and radiation data to Leningrad.

TABLE 13

CALIBRATION TRIAL: MAIN STATION (EXPT. 8–1)

Mean number and weight of fruit bunches per palm (1959–62 plantings only)

Year of Yield	Year planted	Progeny													
		1		2		3		4		5		6		7		8	
		No.	Wt. *lb.*	No.	Wt. *lb.*	No.	Wt. *lb.*	No.	Wt. *lb.*	No.	Wt. *lb.*	No.	Wt. *lb.*	No.	Wt. *lb.*	No.	Wt. *lb.*
1963	1959	10	49	11	57	10	56	9	47	8	41	9	55	6	42	10	54
1964	1959	11	67	10	73	10	74	11	76	10	63	7	60	8	72	10	75
	1960	15	75	13	75	10	59	11	72	11	70	13	78	11	74	13	74
1965	1959	13	116	15	153	12	130	14	154	13	147	11	136	8	120	11	130
	1960	15	124	15	132	13	121	11	112	12	126	13	135	11	123	14	133
	1961	14	73	14	89	10	72	10	76	13	72	12	90	10	70	15	95
1966	1959	5	45	6	85	6	72	8	96	5	57	5	66	3	44	5	65
	1960	7	64	11	98	9	88	7	89	7	79	10	103	6	81	8	79
	1961	10	67	11	98	18	72	6	59	10	76	10	92	7	76	9	79
	1962	12	66	10	52	10	59	13	84	11	67	11	69	10	64	12	71

TABLE 14

Number of NIFOR Palms Yield Recorded in 1967

Main Station		
Field	1	2,522
	2	2,705
	3	4,278
	4	5,890
	5	5,120
	6	3,293
	7	3,870
	8	3,780
	11	3,760
	14	5,573
	16	2,096
	15	5,766
	17	5,460
	20	4,604
	21	2,184
	22	5,270
	24	4,886
	25	3,906
	30	5,952
	31	5,704
	32	4,007
	33	3,724
	35	4,714
	36	4,712
	39	805
Total		104,581
Ogba (Near Benin)		
Field	104	286
Ghana		
Field	801	858
	802	572
	803	1,704
	804	198
	809	600
	810	825
	811	572
	812	660
	813	90
	821	608
	822	572
	830	572
	831	1,191
	832	1,596
Total		10,618
Sub-Station, Abak		
Field	501	9,460
	502	2,747
	505	998
	506	2,296
	507	1,635
	508	1,845
	509	1,755
Total		20,736
Calabar and Uyo Provinces		
Field	554	2,009
	555	459
	556	6,976
	560	3,838
Total		13,282
Rivers Province		
Field	654	1,452
Onitsha Province		
Field	756	1,032
Northern Provinces		
Field	761 (Kabba)	1,064
	762 (Acharu)	4,353
	766 (Jema'a)	1,066
Total		6,483
Sierra Leone		
Field	901	510
	902	510
	904	2,530
	906	890
	907	266
	908	448
	910	552
	911	1,862
	916	1,349
	917	252
Total		9,169
Total All Areas:		167,639

PAY-ROLL

The use of the punch-card machinery to prepare the staff and labour pay-roll, labour costings, and calculations of PAYE, Income Tax and N.P.F. continued. In February, Mr. B. Harkin, Systems Adviser of I.C.T. Ltd., visited the Institute to re-appraise the work of the punch-card unit.

B. O. MGBOLU
R. D. SHELDRICK

PART III. PLANT PRODUCTION

STAFF

Mr. I. Osayi, Plant Production Officer, was on leave from 14th November to 25th December 1966.

GERMINATION

Germination of seeds at the Main Station continued to be satisfactory. The germination of dry heat-treated seed was 82.93% for Extension Work Seed (E.W.S.) issued in August 1966. A total of 32,600 E.W.S. and 43,404 Breeding Programme Seed (B.P.S.) were sown.

PRE-NURSERIES

Pre-nursery seedlings continued to receive the treatments recommended in the Institute's Advisory Sheets and their growth was very satisfactory. Two pre-nurseries were raised, one from May 1966 to October 1966 for the dry season nursery planted in October 1966 and the second from December 1966 to March 1967 for the main nursery planted in April 1967. In the former a total of 2,866 germinated E.W.S. and B.P.S. were planted. Losses were 16.5% among the E.W.S. and 14.88% among the B.P.S. Of the remainder, 91.23% E.W.S. and 82.56% B.P.S. were transplantable in October 1966. In the second pre-nursery, 25,495 E.W.S. were planted in addition to the B.P.S. Losses were 10.10% E.W.S. and 19.10% B.P.S. Of these, 94.72% E.W.S. and 86.50% B.P.S. were transplanted into the Main Nursery in April 1967.

NURSERIES

1966 Main Nursery

A nursery of 2.41 acres was planted in April 1966. Growth of seedlings was very satisfactory. Losses from Blast Disease were 3.23% for E.W.S. and 7.77% for B.P.S. as against 17.83% and 18.45% for E.W.S. and B.P.S. respectively in 1965. 90.50% E.W.S. and 84.20% B.P.S. were transplantable one year later. The total number of seedlings planted was 3,715 E.W.S., 6,563 B.P.S. and 96 ornamentals.

1966 Dry Season Nursery

The 1966 dry season nursery, covering 1.25 acres was planted in October 1966 with 3,939 Special Grade E.W.S. and 6,903 B.P.S. Shading lasted for three and a half months until the end of January 1967. Losses were 0.90% E.W.S. and 1.56% B.P.S. Transplantable seedlings totalled 72% of the E.W.S. and 70% of the B.P.S. Irrigation was stopped at the end of March 1967.

Seed Production: 1966-67

Station	*Grade*	*January-July*	*August-December*	*Total*
Main Station	Special ..	283,653	414,904	698,557
	E.W.S. ..	3.597,324	3,208,232	6,805,556
Ogba	E.W.S. ..	694,160	163,895	858,055
Nkwelle	E.W.S. ..	294,867	116,435	411,302
		4,870,004	3,903,466	8,773,470

During 1966 further pollinations were stopped at the Onitsha Provincial Farm, Nkwelle and the last seeds were produced in January 1967. Seed production has now started at the Sub-Station, Abak.

Seed Distribution: 1966-67

	August 1966	*January 1967*	*Whole Seed Year*
Nigeria			
Western Region	500,000	500,000	1,000,000
Mid-Western Region ..	200,000	—	200,000
Eastern Region	5,821,034	—	5,821,034
Northern Region	200,000	—	200,000
Other West African Countries		—	
The Gambia	10,000	—	10,000
	6,731,034	500,000	7,231,034

The total seed production of 8,773,470 during 1966 was in excess of Nigeria's requirement for the year.

I. Osayi

APPENDIX I

METEOROLOGICAL DATA 1966

In Table 15, rainfall figures for 1966 and averages based on previous years' data are shown for the Main Station, Sub-Station, four Out-Stations in Nigeria and Njala, Sierra Leone. In Table 16 are shown monthly atmospheric maximum and minimum temperatures, relative humidity, sunshine hours, total sun and sky radiation and open pan evaporation.

Rainfall

The total rainfall recorded in the main meteorological compound was 91.29 inches while the other rain gauges distributed over the Main Station gave annual totals varying between 84.37 inches and 91.38 inches. There were 166 wet days in the year. The heaviest rainfall recorded on a single day in the main meteorological enclosure was 4.83 inches on 22nd July 1966.

Atmospheric Humidity

Relative humidity estimated from dry and wet bulb thermometers in a Stevenson's Screen varied between 82.8% and 89.9% at 0900 hours G.M.T. and 48.8% and 83.1% at 1500 hours G.M.T. There were periods of harmattan in January, February, March and December.

Atmospheric Temperatures

Monthly mean maximum temperatures varied between 82.5°F for August and 93.4°F for March, and the minimum temperatures between 69.8°F for December and 73.8°F for March. The highest daily maximum of 96°F for the year was recorded on both 19th and 25th February and the lowest minimum of 58°F on 31st December, during harmattan conditions.

Radiation and Evaporation

Monthly averages of hours of sunshine per day measured by means of a Campbell Stokes recorder varied between 2.5 hours in August and 7.1 hours in February. The total sunshine hours for the year was 1,979.8.

The Kipp Solarimeter was not in service during January and February 1966. For the remaining ten months, the average monthly total sun and sky radiation in calories $cm.^{-2}\ day^{-1}$ varied between 318 for August and 436 for April. The average daily radiation over the ten months of the year for which figures were available was 391.0 calories $cm.^{-2}\ day^{-1}$.

Daily evaporation from the Class A cylindrical evaporation tank varied from 0.12 inches in August to 0.19 inches in March, from the rectangular raised tank from 0.10 inches in August to 0.17 inches in February and March, and from the sunken tank from 0.10 inches in August to 0.19 inches in March. The estimated total evaporation for the year was 43.6, 40.2 and 37.3 inches respectively from Class A, raised and sunken tanks.

TABLE 15

RAINFALL IN INCHES IN NIGERIA AND SIERRA LEONE

Month	NIFOR Main Station		Abak Sub-Station		Njala Sierra Leone		Calabar		Nkwelle (Onitsha Province)		Elele (Ahoada Province)		Wukari (Kabba Province)	
	1940–65	1966	1949–65	1966	1926–65	1966	1906–65	1966	1931–65	1966	1961–65	1966	1961–64	1966
	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.	in.
January ..	0.41	1.22	1.22	0.10	0.45	0.00	1.58	4.63	0.56	0.60	1.32	0.55	0.09	0.00
February ..	1.03	1.89	1.91	0.58	0.78	0.42	2.82	0.15	0.96	0.00	1.61	0.44	0.00	0.00
March ..	3.71	2.49	4.87	8.61	2.96	3.82	6.25	3.01	2.65	1.28	4.88	3.16	1.12	2.09
April ..	6.46	7.08	7.19	12.87	4.93	2.45	8.65	12.68	5.71	6.60	6.63	7.88	3.83	3.76
May ..	7.84	7.53	9.48	6.63	9.90	5.78	12.07	7.41	7.85	5.96	7.25	11.40	5.34	11.63
June ..	10.02	8.67	12.03	14.77	14.41	17.46	15.92	13.78	9.55	13.47	13.31	8.57	9.13	6.55
July ..	12.88	22.55	14.26	9.54	16.47	21.83	17.54	14.87	10.95	5.72	17.48	12.01	6.54	2.84
August ..	8.23	16.26	11.92	18.11	20.32	34.89	15.62	16.27	8.11	8.68	10.59	23.84	4.58	6.00
September ..	11.61	13.18	15.33	10.83	17.35	19.79	16.86	9.84	12.13	5.55	19.80	8.42	13.08	9.96
October ..	8.86	9.31	12.08	11.30	13.26	13.62	12.89	10.37	9.74	7.67	11.73	9.63	7.87	10.97
November ..	2.59	1.10	5.19	9.79	7.01	7.03	7.26	10.94	2.17	2.08	2.79	0.27	0.36	0.00
December ..	0.38	0.01	1.00	0.00	1.84	1.61	1.93	1.37	0.49	1.43	0.50	0.28	0.00	0.00
Totals ..	74.02	91.29	96.48	103.13	109.68	128.70	119.39	105.32	70.87	59.04	97.89	86.45	51.94	53.80

Month	
January ..	
February ..	
March ..	
April	
May	
June	
July	
August ..	
September ..	
October ..	
November ..	
December ..	

APPENDIX II

THE INSTITUTE'S ACCOUNTS FOR 1966-67

TABLE 17. BALANCE SHEET AS AT 31ST MARCH, 1967

	£	£
ENDOWMENT FUND		566,234
REVENUE SURPLUS—Available for Expenditure		324,470
Surplus at 31st March, 1966	294,759	
Add Surplus to 31st March, 1967	29,711	
	324,470	
Accumulated Fund		890,704
Represented by		
Assets		
INVESTMENTS—At Cost		525,280
CURRENT ASSETS		
Unallocated Stores	1,409	
Sundry Debtors and Prepayments	51,137	
Cash at Bank and in Hand	82,284	
Deposits: S.B.W.A.	262,000	
Crown Agents (J.M.F.)	21,900	
		418,730
		944,010
Liabilities		
Sundry Creditors and Expenses Accrued Due		53,306
NETT ASSETS		£890,704

The Accounts are presented for completeness but have not been audited.

TABLE 18. INCOME AND EXPENDITURE ACCOUNT FOR THE YEAR ENDED 31ST MARCH, 1967

	£	£
INCOME		
Contributions to Current Expenditure		
Nigeria: Federal Government	56,000	
Eastern Region	132,000	
Western Region	56,000	
Mid-Western Region	28,000	
Northern Region	8,500	
		280,500
Sundry Revenue		106,034
Investment Interest		36,718
Deposit Interest:		
Crown Agents	944	
S.B.W.A.	12,478	
		13,422
		436,674
EXPENDITURE		
Recurrent	370,038	
Special	36,925	
		406,963
Surplus for the Year		£29,711

TABLE 19. INVESTMENTS HELD 31ST MARCH, 1967

Description of Security Held			Nominal Value £	Cost Price £	Market Value £
Federation of Nigeria Third Development Stock	6%	1986 ..	458,750	458,750	458,750
Federation of Nigeria Fourth Development Stock	5½%	1987 ..	66,530	66,530	66,530
			525,280	525,280	525,280

TABLE 20

Schedule of Expenditure for the Year Ended 31st March, 1967

Head	Nature of Expenditure	Approved Estimate		Revised Estimate		Actual Expenditure	
		£	£	£	£	£	£
1.	Personal Emoluments	136,500	136,500	136,500	136,500	130,828	130,828
	Administration						
2.	Local Transport Allowance and Travelling ..	21,720		21,020		17,903	
3.	Office and General Charges	7,880		8,180		8,144	
4.	Institute Charges	4,140		4,540		4,441	
5.	Visitors	250		250		78	
6.	Rents Payable	285		285		270	
			34,275		34,275		30,836
	Research						
7.	Equipment and Materials	13,415		13,415		12,387	
8.	Labour for Research Divisions	28,110		28,110		26,868	
9.	Oil Palm Survey	1,300		1,300		1,061	
			42,825		42,825		40,316
	Plantations						
10.	Labour	93,300		92,500		82,964	
11.	Equipment and Materials	8,160		8,960		8,888	
12.	Motor Vehicles Running Costs	16,200		16,200		15,758	
13.	Operation of Oil Mill	11,860		11,860		10,945	
			129,520		129,520		118,555
	Internal Services						
14.	Water, Gas and Electricity	20,400		20,800		20,735	
15.	Maintenance of Permanent Buildings	11,400		11,400		10,823	
16.	Maintenance of Temporary Buildings	80		80		59	
17.	Workshop Running Costs	8,540		9,140		9,068	
			40,420		41,420		40,685
	Miscellaneous						
18.	Uniforms and Recreational Facilities	1,100		1,100		1,067	
19.	Training Courses	5,200		5,200		4,485	
			6,300		6,300		5,552
20.	Contingencies	5,415		4,415		3,266	
			5,415		4,415		3,266

continued overleaf

TABLE 20—*continued*

SCHEDULE OF EXPENDITURE FOR THE YEAR ENDED 31ST MARCH, 1967

	Special Expenditure										
21.	Minor Works	..	..	..	..	..	1,000		1,000		905	
22.	Capital Equipment	..	..	..	..	..	13,445		13,445		12,216	
23.	Permanent Buildings	..	..	..	..	..	22,800		22,800		22,709	
24	Clearing and Layout	..	..	..	..	..	1,200		1,200		1,095	
	Factories Ordinance—1955	..	..	..	..	..	100		100		—	
								38,545		38,545		36,925
								433,800		433,800		406,963