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COLLECTION OF OIL PALM (*ELAEIS GUINEENSIS* JACQ.) GENETIC MATERIAL IN NIGERIA

II. PHENOTYPIC VARIATION OF NATURAL POPULATION

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Key words: Oil palm, Nigeria, Phenotypic variation, Natural population.

RINGKASAN

Empat puluh lima populasi kelapa sawit daripada 21 kawasan (areas) yang tersebut di seluruh Nigeria telah dikaji. Purata dan variasi bagi populasi-populasi juga dikaji. Variasi fenotipik bagi pokok kelapa sawit Nigeria menunjukkan terdapat perbezaan pada kedua-dua kedudukan (sites) dan kawasan (areas). Walaubagaimanapun, kebanyakkan variasi lebih disebabkan oleh perbezaan antara pokok kelapa sawit dibandingkan dengan kedudukan dan kawasan.

INTRODUCTION

In Malaysia and elsewhere, the genetic base of material for oil palm breeding is very narrow (JAGOE, 1962; HARDON and THOMAS, 1968; ARASU and RAJANAIDU, 1976; HARTLEY, 1977). Hence, a collection of Nigerian oil palm germplasm was made by MARDI in mid 1973. The methods used in the collection will be described in another paper (OBASOLA *et al.*, in preparation). Although the data pertaining to some of the traits might be influenced by environments and by the methods of collection, some information with respect to variation both between and within populations (sites) of Nigeria can be obtained from the data. Since offspring from these palms will be examined in proper experimental conditions, a comparison will be possible to indicate the validity of palm selection for germplasm collection in the natural environments as is currently used by some research workers (MEUNIER, 1969).

MATERIALS AND METHODS

Data were collected from 45 sites in 21 areas distributed throughout the oil palm growing areas of Nigeria *(Fig. 1)*. Originally it was planned to sample four sites at each area, that is, a total of 84 sites. However, at some areas, fewer sites were sampled due to lack of sufficient number of palms. Similarly, although we planned to sample 20 palms per site, at certain sites we could not get sufficient number of bunches. Hence, we increased or decreased the sample size/site according to the availability of bunches. The areas and sites were chosen at random, objective being, as far as possible, to cover the whole of Nigeria. *Table 1* shows the areas, sites and the sample size of *dura* and *tenera* palms at each site. One bunch was harvested from each of the sampled palms and the fruits from each bunch were kept separate. For the sampled palms, the following data were collected:–

(i)	Bunch weight	(kg)
(ii)	Bunch length	(cm)
(iii)	Bunch breadth	(cm)
(iv)	Bunch depth	(cm)
(v)	Number of spikelets/bunch	

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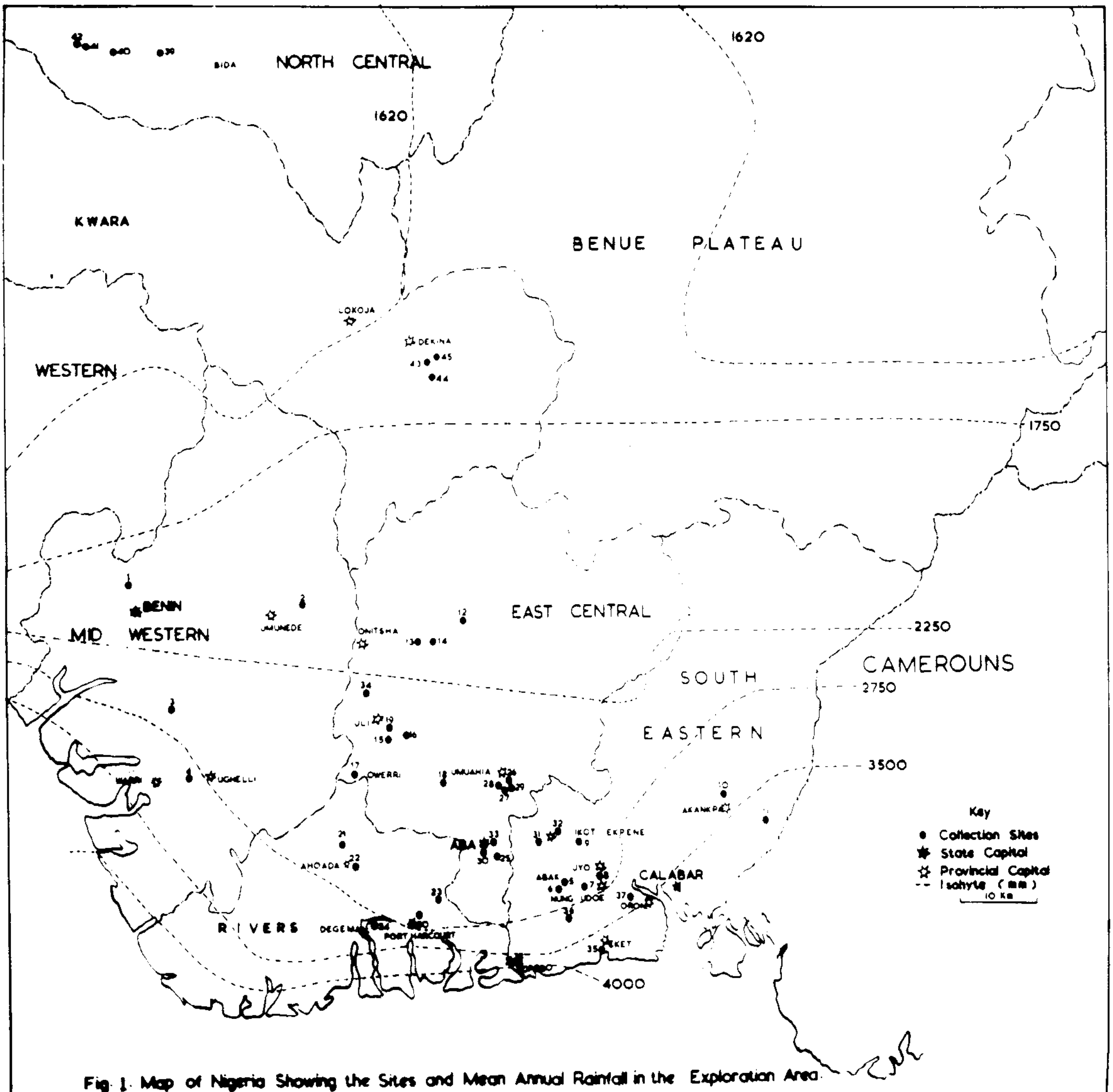


Fig. 1. Map of Nigeria Showing the Sites and Mean Annual Rainfall in the Exploration Area

TABLE 1. LIST OF SITES AND SAMPLE SIZES

State	Area	Site		Sample size, n.	
				Dura	Tenera
Midwest	1. Benin	Iyowa	(01)	4	–
	2. Asaba	Umende	(02)	8	2
	3. Sapele	Amukpe	(03)	8	0
	4. Ughelli	Ogubi	(04)	8	5
South-Eastern	5. Abak	Ikot Okpong	(05)	13	9
		Ikot Okora	(06)	21	7
		Ikot Ikan	(07)	12	10
		Nung Udoe	(08)	18	8
	6. Ikot Ekpene	Ebok Ndiya	(09)	15	17
		Ikot Inemme	(31)	17	7
		Ikot Anwana	(32)	11	11
	7. Calabar	Akampa	(10)	13	11
		Kwa Falls	(11)	16	6
	8. Eket	Ibono	(35)	10	10
		Ikot Okudom	(36)	15	6
	9. Oron	Ebighi Anwa	(37)	13	9
	10. Opobo	Obong	(38)	10	13
East-Central	11. Udi	Umuabi	(12)	4	7
	12. Akwa	Ugwuoba	(13)	5	9
		Ufuma	(14)	8	15
	13. Uli-Ihiala	Umuaku	(15)	11	12
		Ndinyineji	(16)	12	17
		Eziama	(19)	5	18
		Iseke	(34)	10	12
	14. Owerri	Egbema	(17)	13	11
		Aboh-Mbiase	(18)	15	9
	15. Aba	Abala	(25)	18	3
		Ovo-Ahiafor	(30)	13	11
		Ovorn	(33)	11	11
	16. Umahia	Okwe	(26)	21	2

TABLE 1. LIST OF SITES AND SAMPLE SIZES

State	Area		Site		Sample size, n.	
					Dura	Tenera
			Ahaba	(27)	13	8
			Oloko	(28)	14	7
			Mbarrabo	(29)	13	9
Rivers	17.	Port Harcourt	Umuchrughe	(20)	17	7
			Iriebe	(23)	16	5
	18.	Degema	Degema	(24)	0	2
	19.	Ahoada	Abarigbo	(21)	19	3
			Elele-Alimini	(22)	12	2
North-West	20.	Bida	Batati	(39)	17	3
			Vabiti	(40)	20	1
			Labozhi	(41)	20	–
			Takuma	(42)	21	–
Kwara	21.	Ayangba	Ayangba	(43)	18	3
			Ogbaloto	(44)	18	2
			Olobga	(45)	19	4

(vi)	Fruits/spikelet	
(vii)	Fruit diameter	(cm)
(viii)	Fruit length	(cm)
(ix)	Nut diameter	(cm)
(x)	Kernel diameter	(cm)
(xi)	Percentage mesocarp per fruit	
(xii)	Shell thickness	(cm)
(xiii)	Single fruit weight	(g)
(xiv)	Single nut weight	(g)

Measurements on the frond, e.g. rachis length, rachis base area, number of leaflets, length of leaflets, width of leaflets were also made on sampled palms wherever possible but there were too many missing values for reliable statistical analysis.

RESULTS AND DISCUSSION

In oil palm, there are three fruit forms based on their shell thickness. They are the homozygous, dominant, thick shelled *dura* (Sh^+Sh^+), homozygous shell-less, recessive, *pisifera*

(Sh^-Sh^-) and the intermediate shelled heterozygous *tenera* (Sh^+Sh^-). *Table 2* shows the frequencies of *dura, tenera* and *pisifera* fruit forms. The frequencies were based on rather large samples of palms observed at each site. Since fruit form is controlled by a single gene, the frequencies of fruit types reflect the actual gene frequencies except for sampling error. The *pisifera* suffers from a defect in that it does not produce seeds. OOI (pers. communication) has pointed out that, given this difference in fitness value, the *pisifera* would be completely eliminated from the population unless it is maintained by the heterozygote advantage of the *teneras. Table 2* shows that the *pisifera* is virtually absent in all the populations. However, the *tenera* frequencies show high variation from population to population. ZEVEN (1967) has indicated that there is some preference for *teneras* with their higher mesocarp and oil yield. It was observed, in the course of prospection, that farmers tend to keep the *tenera* bunches for home consumption and to send the heavier *dura* material for processing and sale because they are paid by bunch weight by the mills. This could be a relatively modern practice but might reflect a long standing preference. Such a preference for *tenera* fruits could have led to Man playing an unconscious role in influencing the frequencies of the *tenera* in the local populations by aiding in the chance establishment of seedlings. Further, when occasion arose for felling palms, it is likely that *teneras* could have been selectively avoided. Man's role in selectively thinning groves is also an important factor in greatly reducing the *pisiferas* in the population. The frequency of *pisifera* observed was close to zero even at sites where more than 50% of observed palms were *teneras.* Even allowing for difficulties in positively identifying *pisifera* under palm grove conditions, it is difficult to explain satisfactorily in any other way the extremely low observed frequencies of *pisifera* except by alluding to Man's interference. The sites in drier northern states, that is, North Central, Kwara, Western and Midwestern states showed high proportion of *duras* and it has been suggested by HARTLEY (1977, loc. cit.) that *tenera* seeds, because of their thinner shell, do not survive well under drier conditions when compared to the wetter southern states. However, so far, there is no conclusive evidence to support this suggestion. However, there is evidence to show that *duras* are predominant at sites where the human population density is low and conversely *teneras* are comparatively more abundant in the south where the human population density is high. Thus, human could be one of the main contributing factors in influencing the fruit forms in the Nigerian oil palm populations. TOOVEY (1947) described the unusual frequencies of fruit forms observed in a grove at Ufuma and found that, of the identified palms, 53% were *dura,* 43% *tenera* and 4% *pisifera*. During the prospection, sites 12, 13 and 14 corresponding to Ufuma, too, had shown high proportion of *teneras.* However, other sites in those areas constitute only about 20% *tenera.* This is believed to indicate deliberate planting of *teneras* in the past in this region (HARTLEY, 1977, loc. cit.) A NIFOR trial, 18–1, covering 100 acres of palm grove near Benin, (corresponding to site 1) indicated that 96% of the palms are poor *duras* and only 4% were *teneras.* This shows that little or no selection was exercised by Man in this area (ZEVEN, 1967, loc. cit.).

Man's role in influencing the frequency distribution of fruit types can also be seen in other areas; the incidence of *virescens* palms. The exocarp colour is controlled by a single gene and the *virescens* (green fruits) is dominant over the recessive *nigrescens* (purplish fruits) (HARTLEY, 1977, loc. cit.). In the natural population, the recessive *nigrescens* are predominant over the *virescens.* It is difficult to explain this phenomenon because normally the dominant characters would be abundant in the natural population. At certain sites (12, 14), the proportion of *virescens* could be as high as 18%. ZEVEN (1967, loc. cit.) attributed that the high concentration of *virescens* palms occurred on some old compounds which were formerly used for ceremonial purpose. It has been noticed that local people attached religious significance to *virescens* palms and they were held in such a high regard that in several instances, it was difficult to get permission to harvest these bunches. Thus, the influence of Man in the frequencies of certain types of palms is very obvious. Observations were also made regarding other aspects of variation; for instance, only one mantled *(poissoni)* palm was encountered (at site 10) and no albescens was seen throughout the survey. However, mantled palms have

TABLE 2. DISTRIBUTION OF FRUIT FORMS AND EXOCARP PIGMENTATION (%)

Site	No.	Fruit Form			Pigmentation	
		D	T	P	N	V
1	24	100.0	–	–	100.0	–
2	17	93.0	7.0	–	100.0	–
3	25	80.0	20.0	–	100.0	–
4	40	80.0	20.0	–	100.0	–
5	132	92.0	8.0	–	92.0	8.0
6	76	87.0	12.0	–	100.0	–
7	47	78.0	22.0	–	100.0	–
8	41	76.0	24.0	–	100.0	–
9	139	83.0	17.0	–	99.3	0.7
10	48	77.0	23.0	–	100.0	–
11	36	83.0	17.0	–	100.0	–
12	11	36.0	64.0	–	82.0	18.0
13	14	36.0	64.0	–	100.0	–
14	67	69.0	31.0	–	89.6	10.4
15	44	52.0	48.0	–	100.0	–
16	67	61.0	39.0	–	100.0	–
17	45	53.0	47.0	–	95.5	4.5
18	24	63.0	37.0	–	95.8	4.2
19	60	38.0	62.0	–	100.0	–
20	37	76.0	24.0	–	100.0	–
21	22	86.0	14.0	–	100.0	–
22	14	86.0	14.0	–	100.0	–
23	59	86.0	14.0	–	98.3	1.7
24	6	67.0	33.0	–	100.0	–
25	120	96.0	4.0	–	98.3	1.7
26	36	94.0	6.0	–	91.7	8.3
27	21	88.0	12.0	–	100.0	–
28	21	89.0	11.0	–	98.7	1.3
29	22	79.0	21.0	–	98.4	1.6
30	90	86.0	14.0	–	100.0	–
31	51	80.0	20.0	–	100.0	–
32	56	82.0	18.0	–	95.4	4.6
33	68	74.0	26.0	–	97.1	2.9
34	22	44.0	52.0	4.0	100.0	–
35	35	71.0	29.0	–	100.0	–
36	26	88.0	12.0	–	100.0	–

TABLE 2. DISTRIBUTION OF FRUIT FORMS AND EXOCARP PIGMENTATION (%)

Site	No.	Fruit Form			Pigmentation	
		D	T	P	N	V
37	29	68.0	31.0	—	100.0	—
38	54	63.0	37.0	—	100.0	—
39	35	91.0	9.0	—	100.0	—
40	34	97.0	3.0	—	100.0	—
41	96	100.0	—	—	100.0	
42	54	100.0	—	—	100.0	—
43	48	94.0	6.0	—	100.0	—
44	51	96.0	4.0	—	100.0	—
45	48	92.0	8.0	—	100.0	—

Key:
D = *Dura*
T = *Tenera*
P = *Pisifera*
N = *Nigrescens*
V = *Virescens*
No. = Number of palm observed per site

occupied a prominent position in the early oil palm breeding programme in Nigeria, assuming that the fleshy extra carpels would produce extra oils. According to HARTLEY (1977, loc. cit.), mantled fruits are rare and in one area of Nigeria, only 33 mantled bunches were found from 20,291 bunches harvested from the grove plots over a four-year period. ZEVEN (1967, loc. cit.) estimated a frequency of 0.05% in a grove at Asuntan Ekpe. In Angola, the frequency was found to be 9 palms in 10,000. Our results, therefore, are consistent with those of others.

In the oil palm bunch, spikelets are borne in a spiral round the bunch stalk. Each spikelet bears several fruits each subtended by a bract. The axis of the spikelet extends to varying lengths beyond the fruits as spines. The bracts subtending the fruits are also often elongated and toughened to different degrees and look like spines. The combination of these two leads to considerable variation in the spininess of the bunches. The spines vary in length, thickness and colour. The *deli dura* material is often associated with few short spines and African material used in breeding programmes are often characterised by profuse and long spines. In the Nigerian groves, we have encountered palms with bunches having spines as sparse and as short as in *deli dura.*

The overall variation of the different characters of *dura* and *tenera* individuals is given separately in *Table 3.* Their mean, standard deviation, sample size, maximum and minimum values and coefficient of variation are given. Except for shell thickness, single net weight and % mesocarp, there is not much difference in the mean and coefficient variation between the *dura* and *tenera* samples of the population. At present *tenera* in distinguished from *dura* by the presence of thin shell and fibre ring around the shell. We have encountered in the natural population, *duras* with shell (macrocarya) with distinct fibre around the shell. When a frequency diagram was drawn for percentage mesocarp of *dura* and *tenera* palms, it was noticed that at 60% mesocarp level, only about 5% *duras* exceeded the 60% level and at the same time, only

TABLE 3. VARIATION OF THE CHARACTERS OF NIGERIAN PALMS

Fruit form	Statistics	Bunch weight	Bunch length	Bunch breadth	Bunch depth	No. of spikelets	Fruit length	Fruit dia-meter	Nut dia-meter	Kernel dia-meter	Shell thickness	Fruit spk.	Single fruit weight	Single nut weight	Mesocarp (%)
	$\bar{x}$	11.82	41.25	32.18	23.90	186.53	3.44	2.11	1.60	1.10	0.25	8.02	7.98	4.17	47.31
	S.D.	6.13	6.35	5.19	4.18	53.52	0.53	0.36	0.31	0.22	0.09	2.38	2.74	1.52	7.75
Dura	n	595	595	594	594	449	595	595	595	595	595	436	591	591	591
	Max	41.36	60.0	51.0	390	360	5.70	3.70	3.10	2.00	0.70	20.40	23.0	11.70	79.00
	Min	2.27	19.00	17.0	13.0	27	2.30	1.10	0.90	0.60	0.05	2.8	2.0	1.00	15.00
	CV	51.86	15.39	16.13	17.49	28.69	15.41	17.06	19.38	20.00	36.00	29.68	34.34	36.45	16.38
	$\bar{x}$	10.91	40.31	31.83	23.90	189.51	3.43	2.06	1.26	1.01	0.12	8.43	6.50	1.87	70.96
	S.D.	5.14	6.58	5.20	3.65	57.37	0.46	0.35	0.22	0.19	0.06	2.55	1.95	0.95	9.78
Tenera	n	322	319	319	319	258	324	324	324	324	324	243	320	320	320
	Max	28.64	65.0	47.0	36.0	340	4.60	5.80	2.10	1.70	0.40	19.40	15.40	11.90	97.00
	Min	1.82	21.0	19.0	12.0	42.0	2.00	1.20	0.60	0.40	0.04	3.30	1.20	0.50	16.00
	CV	47.09	16.32	16.34	15.27	30.27	13.41	16.99	17.46	18.81	50.0	30.25	30.00	50.80	13.78

Key:
$\bar{x}$ = Mean
S.D. = Standard deviation
n = Sample size
Max = Maximum
Min = Minimum
CV = Percentage coefficient of variation

5% of *teneras* had mesocarp below 60%. In addition to shell thickness and fibre ring, % mesocarp can be used to differentiate *duras* and *teneras* when the situation is ambiguous *(Fig. 2)*.

A comparison of the means of extreme populations in Ivory Coast and Nigeria with respect to bunch weight, % mesocarp and single fruit weight is given in *Table 4*. It is interesting to note that Nigerian material has higher mean values for the characters mentioned. However, the magnitude of variation seems to be the same in both areas. This study was made to find the level of variation of the characters at these areas and pin point, if possible, the likely centre of diversity of oil palm in Africa. However, the populations at Ivory Coast and Nigeria seem to show similar level of variation.

Hierarchical analyses (SNEDECOR and COCHRAN, 1972) of unequal sizes were carried out separately for the *dura (Table 5)* and *tenera (Table 6)* materials. For most traits, the variation between sites was highly or very highly significant, whereas variation due to areas was of relatively low significant or non-significance.

However, it is important to note that the test for areas in the analysis of variance is more powerful than that for sites simply because the coefficient of σ_2^2 is greater than that of σ_1^2 for all the characters analysed. The percentage of the total variance for each trait contributed by the three components, that is, area, site and palms, are summarised in *Table 7*. It can be seen that the largest component of variance was between palms within sites, $\sigma^2{}_0$, accounting for about 80% of the total variation. The other two components each contribute about 10% of variance. That the between palm variance component should account for so large a proportion of the total phenotypic variance was not, surprising, because it measures not only of genetical variation between palms but also of the environmental difference between individual, which in the uncontrolled natural environment of a palm grove is expected, in general, to be considerable. Better estimates of these components should be available from the data that will be collected from the seedling progenies established in controlled experiments.

Discriminant function analysis (HOPE, 1968), a multivariate technique, using all the 14 variates, was carried out with the 595 *dura* palms. It revealed, not surprisingly, that the *dura* palms on some sites were very different from those of the others. These were sites 32, 33, 35 and 37 which were very different from each other as well as from all the other sites. Part of the reason for these differences was that site 37 had by far the largest fruits; 35, the largest bunch depth and 32, the smallest kernels. However, site 33, though most distant of all on an analysis including all the variates, did not stand out on any single variate and therefore differed from the others only in respect of a number of variates considered jointly. A similar analysis was done on the data of Ivory Coast palms by MEUNIER (1969, loc. cit.) as the result of which he waa able to divide the palms into five distinct groups based on fruit characters only by using the statistical concept, Mahalanobis generalised distance (D^2). It was not possible to divide the Nigerian palms into distinct groups by using D^2. This probably due to the continuous and over-lapping nature of the Nigerian groves.

In order to study the extent of heterogeneity in the different populations, a homogeneity test of variance within populations was carried out; the results of which are shown in *Table 8*. The characters of *dura* populations seemed to be more heterogenous than those of *tenera*. In *dura* populations, except for bunch length, bunch breadth, number of spikelets, diameter of fruits and diameter of nuts, the rest of the characters show significant heterogeneity of variance. Most of the characters of *tenera*(except bunch length, shell thickness, single fruit weight, single nut weight, % mesocarp) show non-significance of the variance between the populations. This could perhaps be explained by the different sample sizes of *dura* and *tenera*.

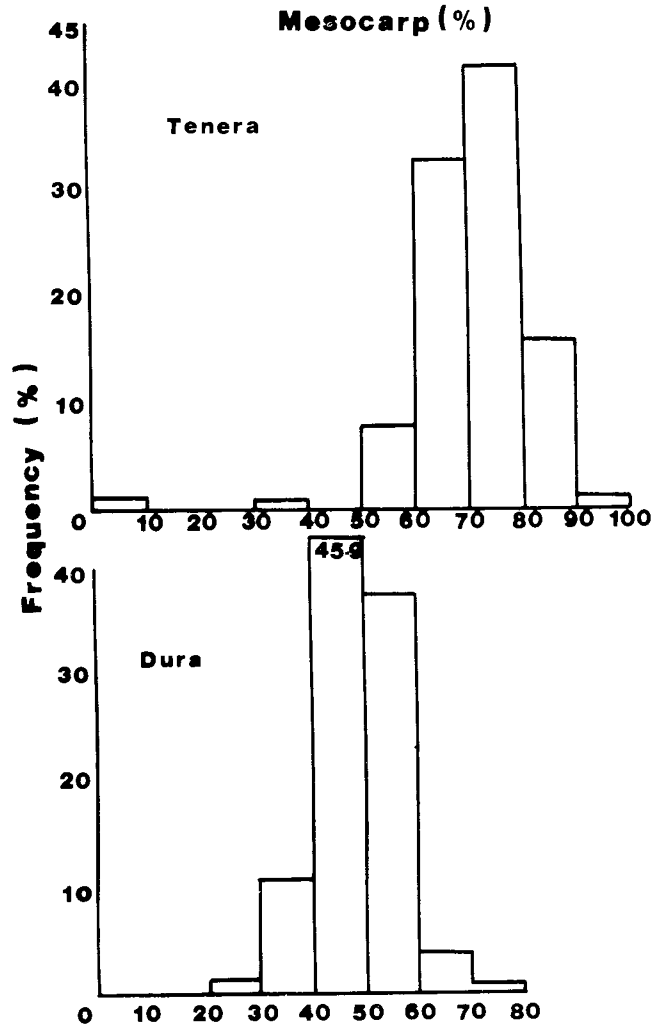


Fig. 2. Frequency distribution of % mesocarp in *dura* and *tenera* palms.

TABLE 4. COMPARISON OF IVORIAN AND NIGERIAN PALMS

Fruit form	IVORY COAST*									NIGERIA								
	Bunch weight			Mesocarp (%)			Single fruit weight			Bunch weight			Mesocarp (%)			Single fruit weight		
	Pop	$\bar{x}$	CV	Pop	$\bar{x}$	CV	Pop	$\bar{x}$	CV	Pop	$\bar{x}$	CV	Pop	$\bar{x}$	CV	Pop	$\bar{x}$	CV
Dura	Yacoboue	14.8	29.2	Yacoboue	48.8	10.2	Danae	9.3	36.8	14	17.33	37.1	16	52.92	11.7	37	13.43	28.4
	Tingrela	4.1	54.1	Man	35.1	12.6	Tingrela	4.1	28.1	39	5.21	46.6	4	37.81	15.6	41	4.93	22.5
Tenera	Yacoboue	12.8	34.6	Yacoboue	70.1	9.7	Tabou	7.1	21.0	21	19.70	36.5	43	80.94	8.0	22	10.1	68.6
	Man	7.6	41.3	Man	44.4	14.3	Man	4.5	38.2	40	4.16	37.0	22	58.70	2.4	24	4.35	37.4

*Figures for Ivory Coast were extracted from the paper by J. Meunier listed in the reference.

Key: $\bar{x}$ = mean
CV = percentage coefficient of variation
pop = population

TABLE 5. ANALYSES OF VARIANCE – DURA

	Items	df	MS
Bunch weight	Areas	19	1056.5*
	Sites within areas	24	381.9***
	Palms within sites within areas	551	142.1
Bunch length	Areas	19	261.34**
	Sites within areas	24	85.17***
	Palms within sites within areas	551	30.69
Bunch breadth	Areas	19	186.03**
	Sites within areas	24	50.62***
	Palms within sites within areas	550	20.52
Bunch depth	Areas	19	109.48**
	Sites within areas	24	35.44***
	Palms within sites within areas	550	13.51
No. of spikelets	Areas	19	12635*
	Sites within areas	23	5130***
	Palms within sites within areas	406	2371
Length of fruit	Areas	19	2.1687***
	Sites within areas	24	0.3918**
	Palms within sites within areas	551	0.2097
Diameter of fruit	Areas	19	1.08559**
	Sites within areas	24	0.38597***
	Palms within sites within areas	551	0.08472
Nut diameter	Areas	19	0.59380*
	Sites within areas	24	0.27570***
	Palms within sites within areas	550	0.06354
Kernel diameter	Areas	19	0.26047 N.S.
	Sites within areas	24	0.13054***
	Palms within sites within areas	551	0.03818
Shell thickness	Areas	19	0.037947*
	Sites within areas	24	0.013651**
	Palms within sites within areas	551	0.006467
No. of fruits/spikelets	Areas	19	12.408 N.S.
	Sites within areas	24	9.502**
	Palms within sites within areas	392	4.714
Single fruit weight	Areas	19	70.637***

TABLE 5. ANALYSIS OF VARIANCE – DURA

	Items	df	MS
	Sites within areas	24	9.521*
	Palms within sites within areas	546	5.404
Single nut weight	Areas	19	19.293***
	Sites within areas	24	2.498 N.S.
	Palms within sites within areas	547	1.757
Mesocarp (%)	Areas	19	296.05**
	Sites within areas	24	85.90*
	Palms within sites within areas	547	53.17

Note: The expected mean squares (EMS) for most of the characters is:–

Items	EMS
Areas	$\sigma_{0_2}^2 + 12.19\ \sigma_{1_2}^2 + 28.93\ \sigma_2^2$
Sites within areas	$\sigma_1{}^2 + 14.51\ \sigma_1^2$
Palms within sites within areas	σ_0^2

TABLE 6. ANALYSES OF VARIANCE -- TENERA

	Items	df	MS
Bunch weight	Areas	19	217.95 N.S.
	Sites within areas	22	387.05***
	Palms within sites within areas	280	100.92
Bunch length	Areas	19	106.89 N.S.
	Sites within areas	22	108.0***
	Palms within sites within areas	280	32.57
Bunch breadth	Areas	19	32.32 N.S.
	Sites within areas	22	55.91***
	Palms within sites within areas	280	19.54
Bunch depth	Areas	19	18.16 N.S.
	Sites within areas	22	28.36***
	Palms within sites within areas	280	11.12
No. of spikelets	Areas	19	6030 N.S.
	Sites within areas	22	6057***
	Palms within sites within areas	215	2793.3
Length of fruit	Areas	19	0.26 N.S.
	Sites within areas	22	0.26 N.S.
	Palms within sites within areas	282	0.20
Diameter of fruit	Areas	19	0.21 N.S.
	Sites within areas	22	0.27***
	Palms within sites within areas	282	0.04
Diameter of nut	Areas	19	0.16 N.S.
	Sites within areas	22	0.09***
	Palms within sites within areas	278	0.04
Diameter of kernel	Areas	19	0.068 N.S.
	Sites within areas	22	0.055***
	Palms within sites within areas	282	0.030
Shell thickness	Areas	19	0.011 N.S.
	Sites within areas	22	0.006***
	Palms within sites within areas	282	0.0027
Fruit spikelets	Areas	19	8.58 N.S.

TABLE 6. ANALYSES OF VARIANCE – TENERA

	Items	df	MS
	Sites within areas	22	8.86 N.S.
	Palms within sites within areas	201	6.02
Single fruit weight	Areas	19	9.32 N.S.
	Sites within areas	22	5.18 N.S.
	Palms within sites within areas	278	3.45
Single nut weight	Areas	19	3.20**
	Sites within areas	22	0.85*
	Palms within sites within areas	278	0.51
Mesocarp (%)	Areas	19	248.4*
	Sites within areas	22	94.2 N.S.
	Palms within sites within areas	278	76.9

Note: The expected mean squares (EMS) for most of the characters is:–

Items	EMS
Areas	$\sigma_0^2 + 7.5\,\sigma_1^2 + 15.51\,\sigma_2^2$
Sites within areas	$\sigma_0^2 + 7.95\,\sigma_1^2$
Palms within sites within areas	σ_0^2

TABLE 7. COMPONENTS OF VARIANCE (%)

Characters		Components		
		σ_0^2 (Palm)	σ_1^2 (Site)	σ_2^2 (Area)
Bunch weight	D	77.57	9.01*	13.43
	T	73.71	26.29***	–
Bunch length	D	75.17	9.18***	15.65***
	T	76.79	22.37***	0.84 N.S.
Bunch breadth	D	74.75	7.54***	17.70**
	T	76.86	17.98***	5.16 N.S.
Bunch depth	D	76.28	8.53***	15.19**
	T	83.67	16.33***	–
No. of spikelets	D	79.54	8.59***	11.88
	T	83.92	15.83***	0.24 N.S.
Fruit length	D	73.68	4.39**	21.93***
	T	95.71	4.18 N.S.	0.11 N.S.
Fruit diameter	D	64.51	15.81***	19.68
	T	67.54	29.51***	2.95 N.S.
Nut diameter	D	70.34	16.19***	13.47*
	T	78.20	12.34***	9.46 N.S.
Kernel diameter	D	77.05	12.86***	10.09 N.S.
	T	88.60	8.79**	2.59 N.S.
Shell thickness	D	82.47	6.31**	11.22**
	T	67.50	25.00***	7.5 N.S.
Fruit/spikelets	D	88.53	8.58**	2.89 N.S.
	T	92.57	7.43 N.S.	–
Single fruit weight	D	68.93	3.65*	27.42***
	T	87.66	5.54 N.S.	6.79 N.S.

TABLE 7. COMPONENTS OF VARIANCE (%)

Characters		Components		
		σ_0^2 (Palm)	σ_1^2 (Site)	σ_2^2 (Area)
Single nut weight	D	73.30	2.13 N.S.	24.57***
	T	72.33	6.08**	21.58**
Mesocarp (%)	D	84.49	3.61*	11.90**
	T	86.22	2.45 N.S.	11.35*

Key:–

D = *dura* palm
T = *tenera* palm
* < 5% probability
** < 1% probability
*** < ·1% probability

TABLE 8. HOMOGENEITY TEST OF VARIANCE WITHIN POPULATIONS

Character	Dura		Tenera	
	d.f.	X^2	d.f.	X^2
Bunch weight	43	115.15***	38	52.95N.S.
Bunch length	43	52.98N.S.	38	57.76*
Bunch breadth	43	57.35N.S.	38	38.77N.S.
Bunch depth	43	69.99**	38	42.98N.S.
No. of spikelets	43	42.52N.S.	38	27.94N.S.
Length of fruits	43	94.24***	38	45.60N.S.
Diameter of fruits	43	46.75N.S.	38	44.47N.S.
Diameter of nuts	43	43.96N.S.	38	45.61N.S.
Diameter of kernels	43	63.80*	38	49.50N.S.
Shell thickness	43	104.36***	38	75.75***
No. of fruits/spikelets	43	89.86***	38	42.94N.S.
Single fruit weight	43	110.32***	38	83.27***
Single nut weight	43	92.05**	38	113.06***
Mesocarp (%)	43	106.94***	38	98.51***

Key:–

N.S. = Non significant
* ⩽ 5% Probability
** ⩽ 1% Probability
*** ⩽ 0.1% Probability

Since the univariate analysis of variance had shown significant differences between areas and between sites, a closer examination of the populations was carried out by studying their mean and variance relationships as shown in *Fig. 3* (a–n) for *tenera* populations. The *dura* populations, too, show a similar trend. Generally, the extreme sites, from dry area, tend to have low mean and variance, indicating certain level of uniformity in the populations, possibly, due to extreme selection pressures. Shell thickness *(Fig. 3j)*, showed two distinct groups of populations. The extreme sites (from dry areas) possessed low mean and high variance and the other group had high mean level and low variance, possibly due to different selection forces operating on these two groups of populations.

Table 9 shows the correlation between the characters of *dura* palms at site 45. Similar studies were made on palms at 9 other sites. Generally, it was found that bunch characters, that is, weight, length, breadth and depth, were significantly correlated to each other. In a number of cases, it was found that the number of spikelets were significantly correlated with bunch length only. Among fruit characters; fruit diameter is correlated with nut diameter, kernel diameter and shell thickness. Similarly, nut weight is correlated with nut diameter and fruit weight. Incidently, % mesocarp is only occassionally correlated with other characters but the trend was not consistent.

Fig. (3a) Bunch weight

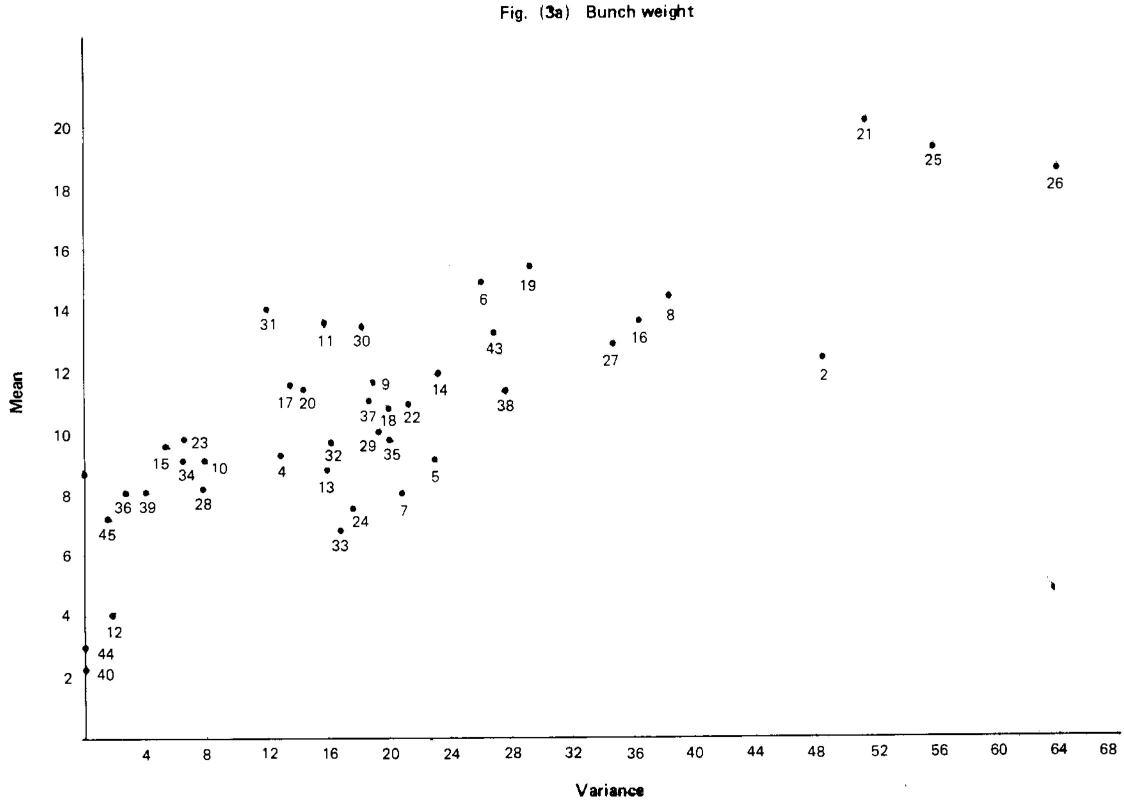


Fig. (3 c) Bunch breadth

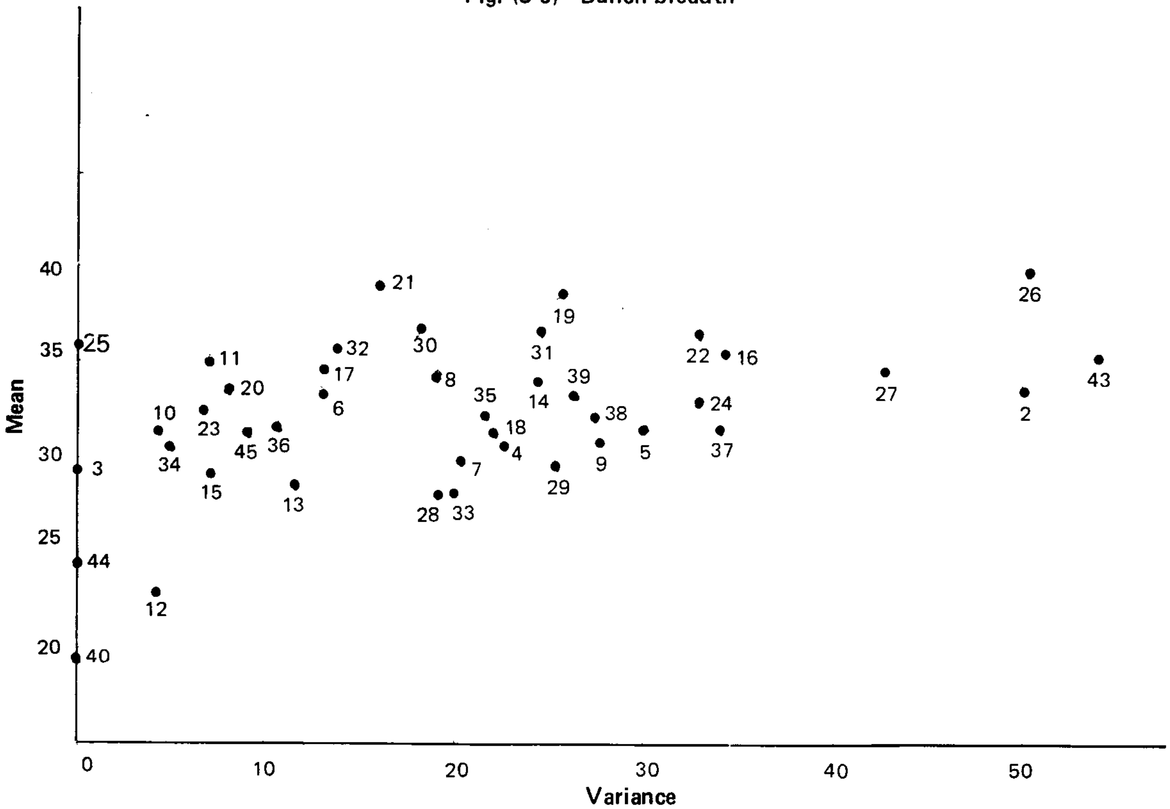


Fig. (3 b) Bunch length

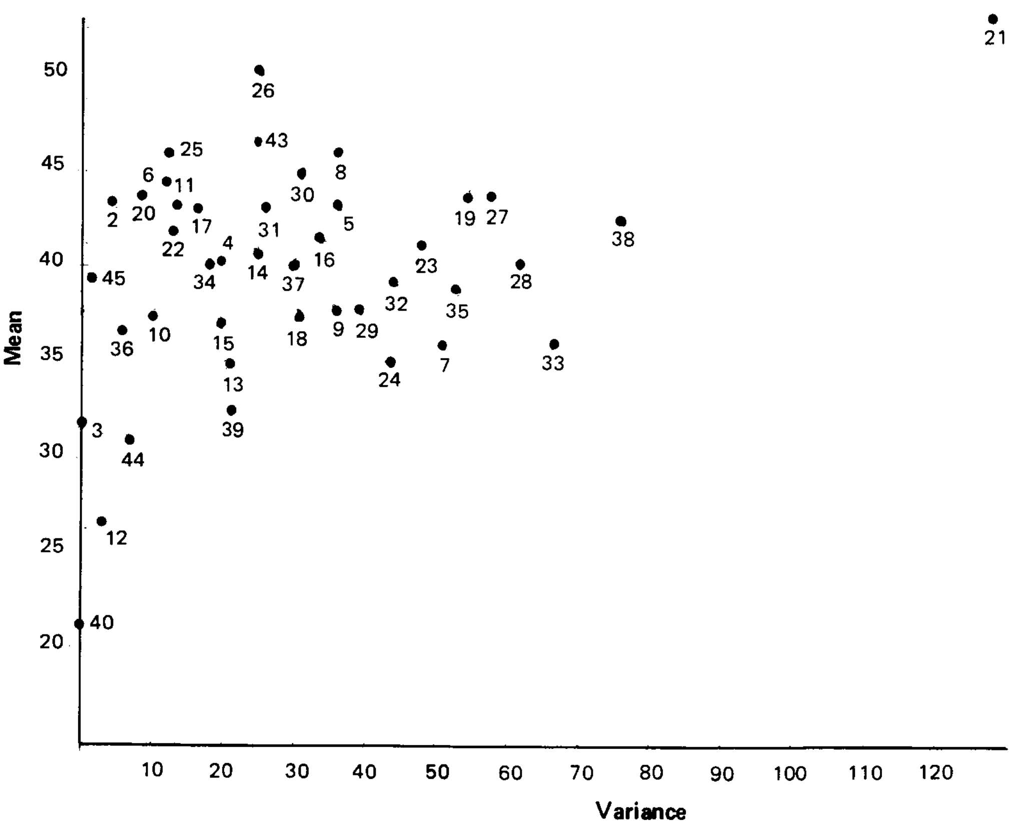


Fig. (3 d) Bunch Depth

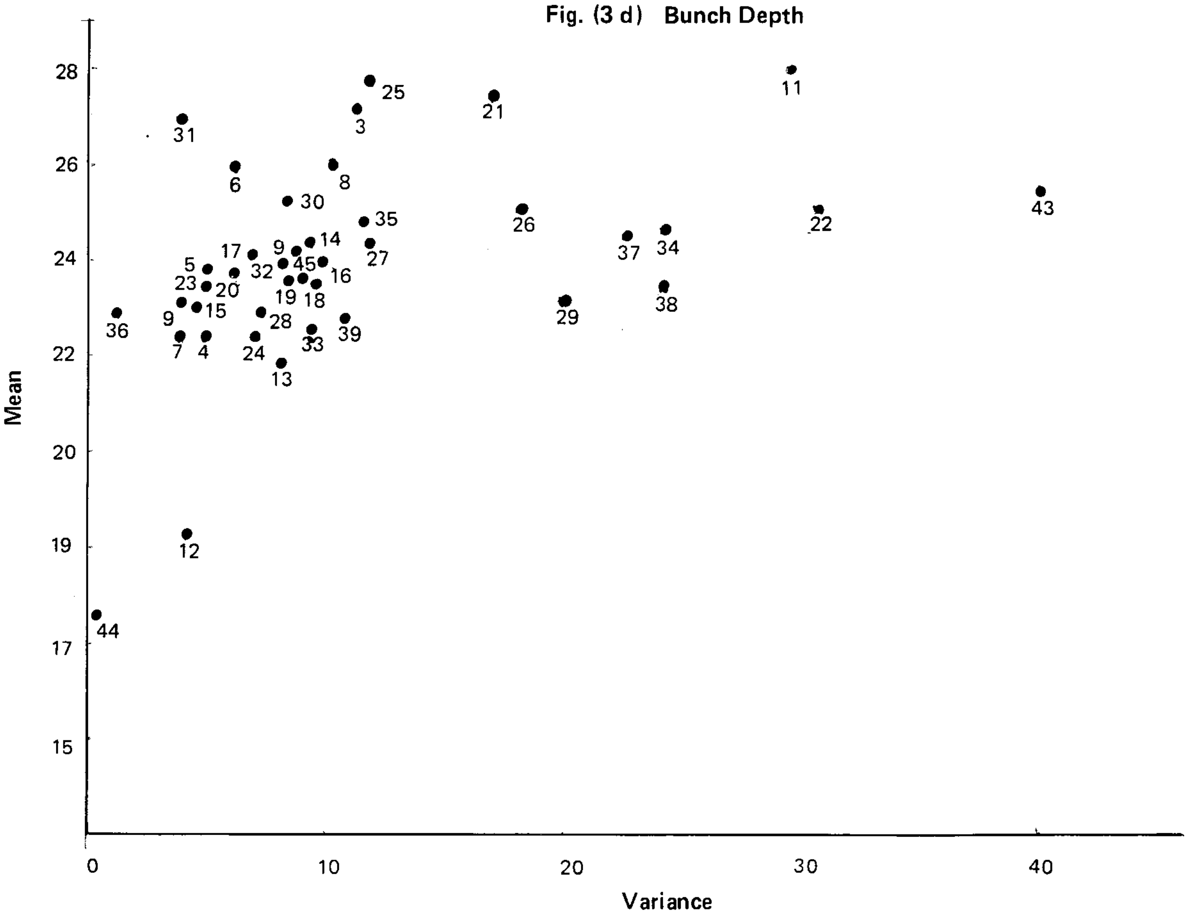


Fig. (3 e) No. of spikeless

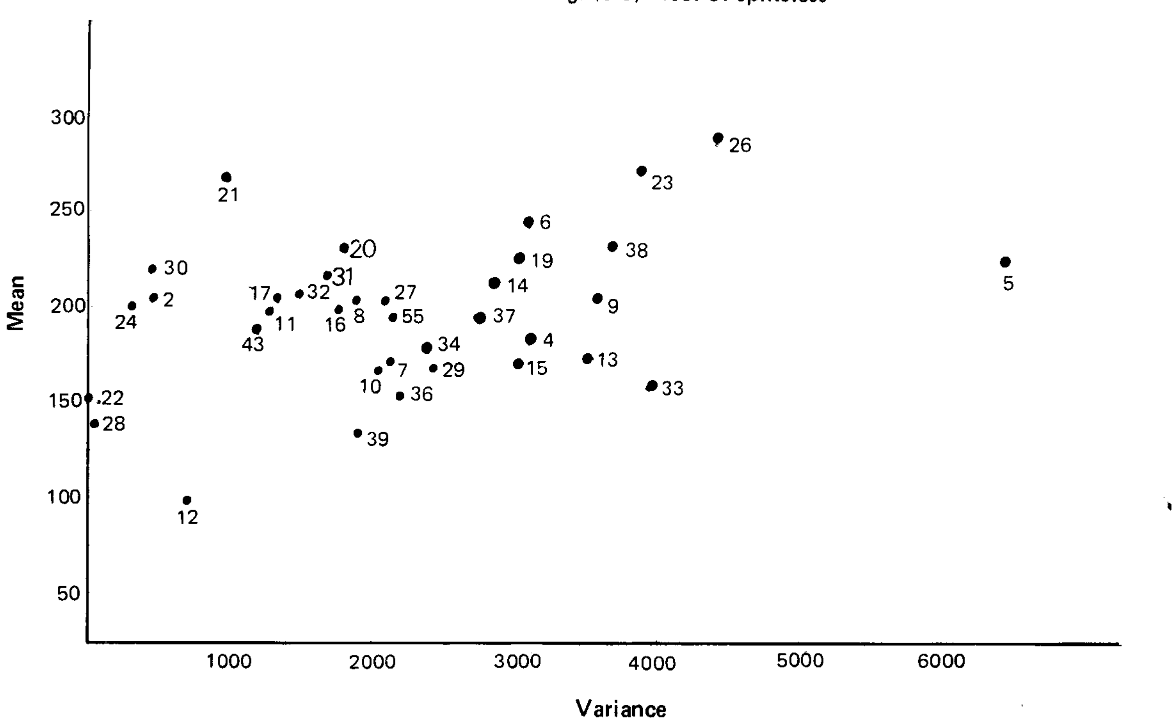


Fig. (3 f) Length of fruits

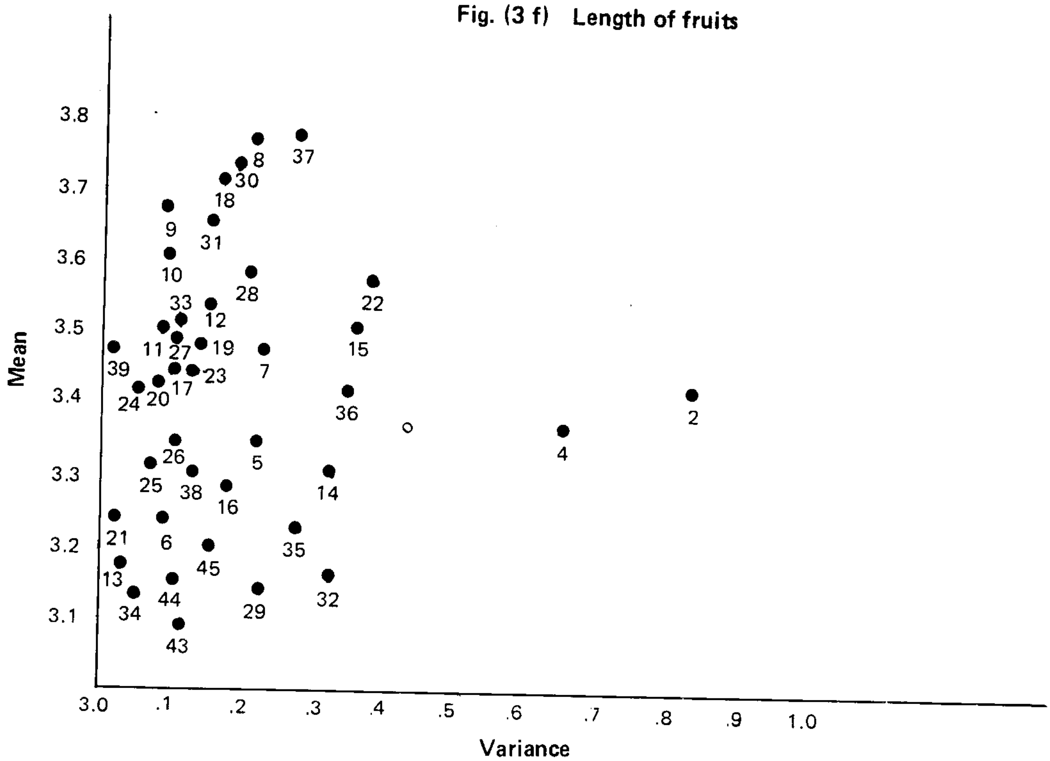


Fig. (3 g) Diameter of fruit

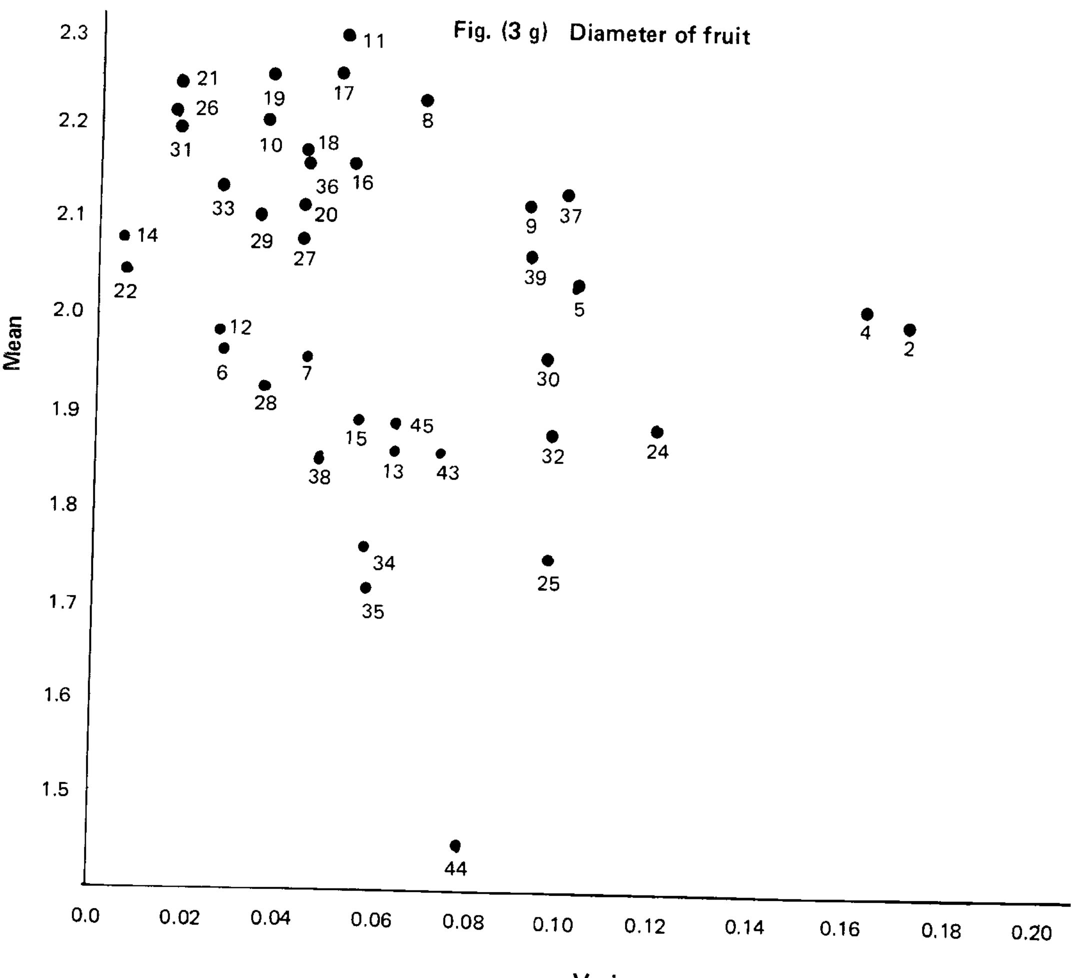


Fig. (3 i) Diameter of kernels

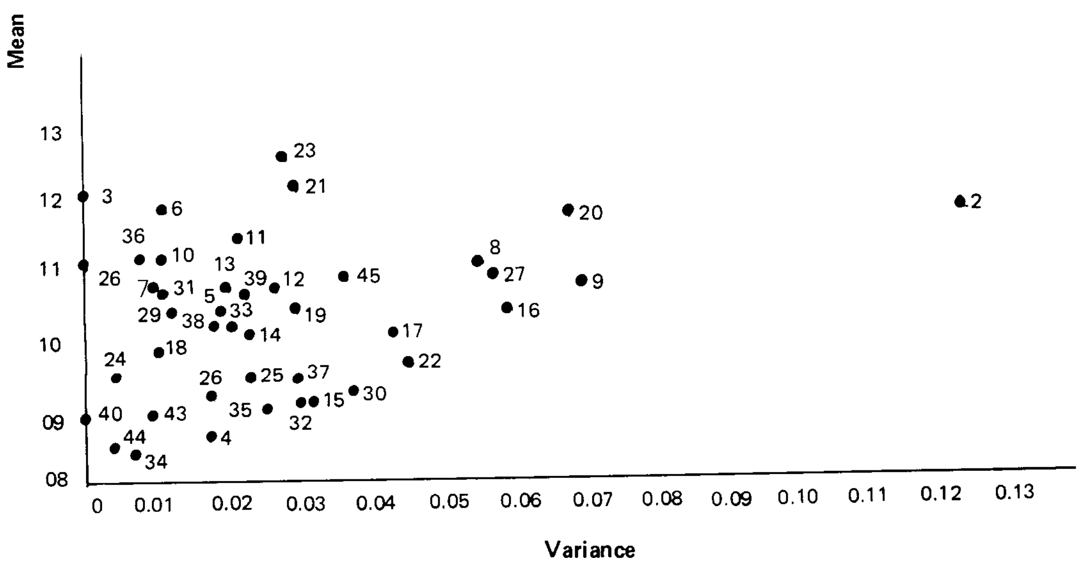


Fig. (3 h) Diameter of nuts

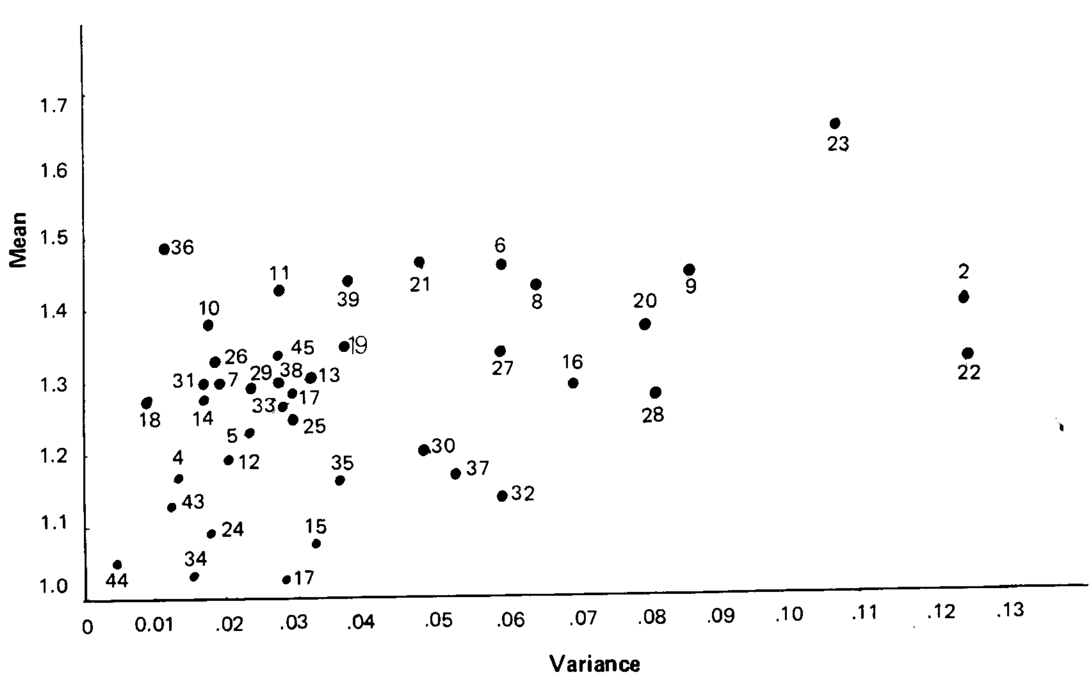


Fig. (3j) Shell thickness

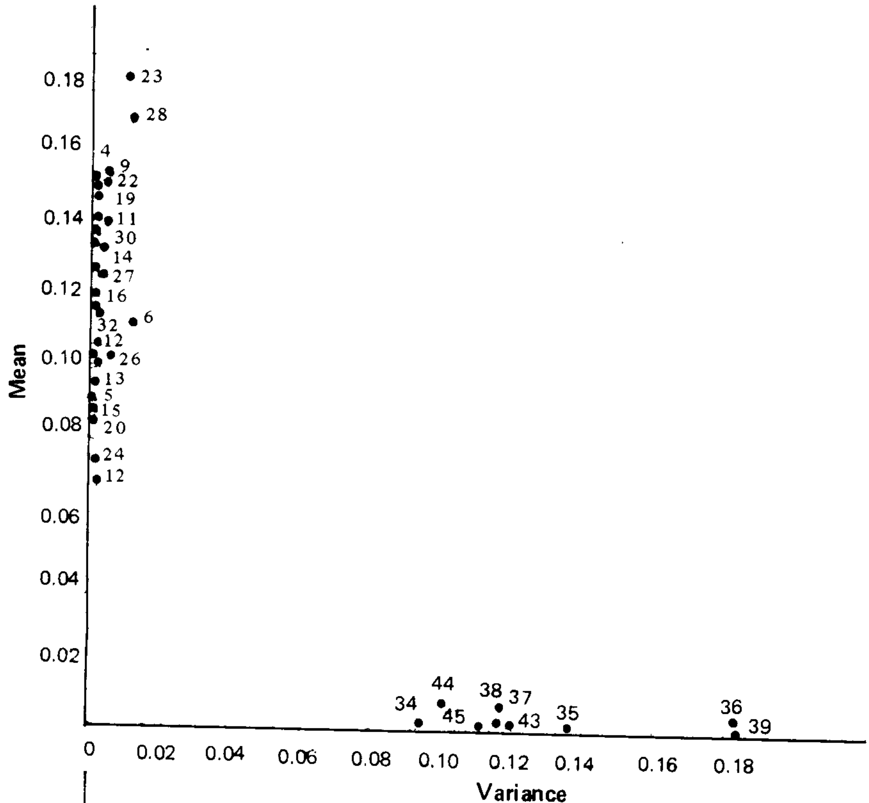
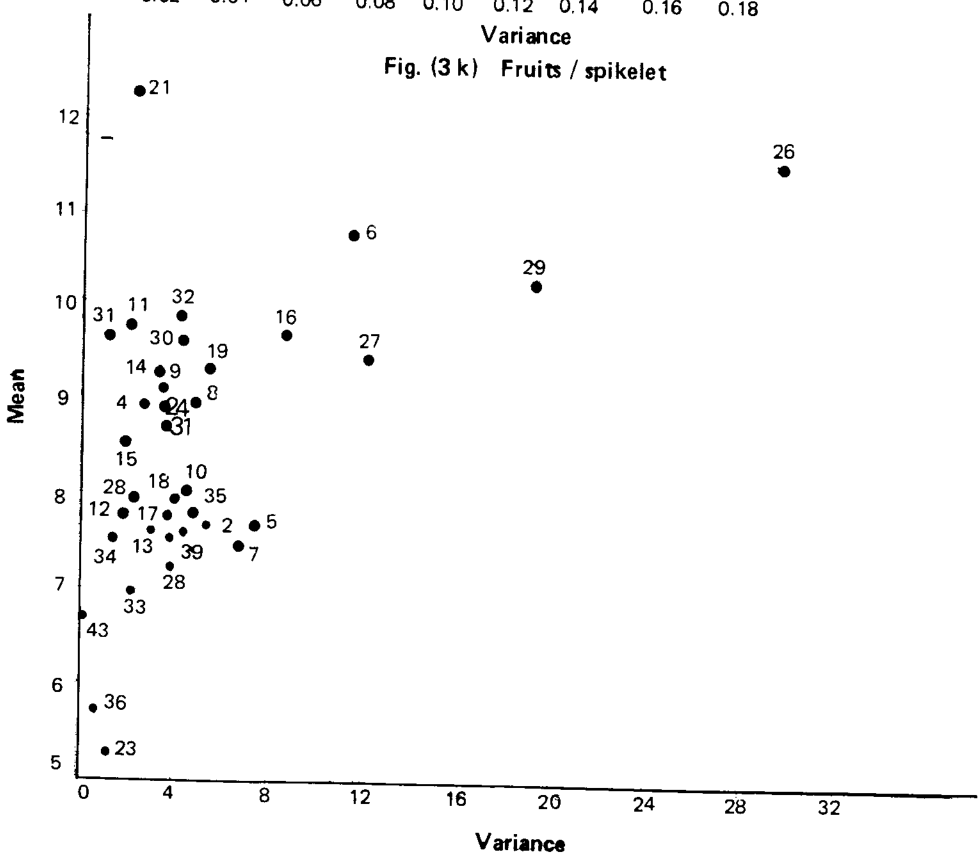


Fig. (3k) Fruits / spikelet



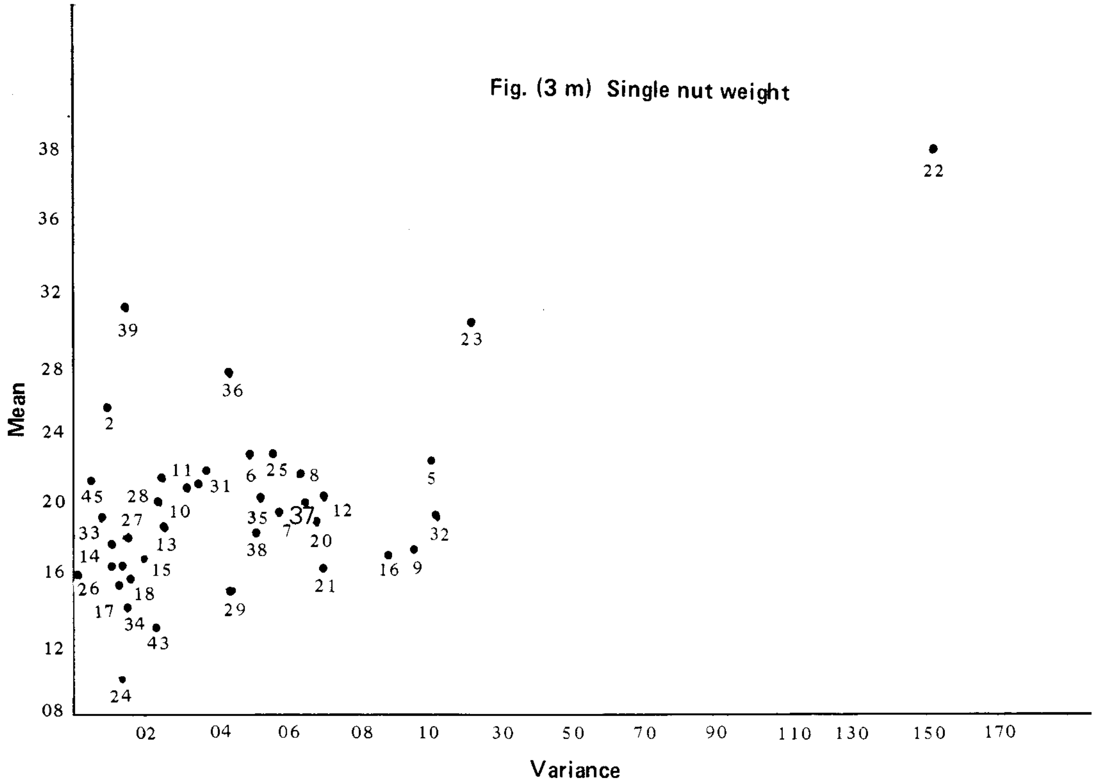


Fig. (3 m) Single nut weight

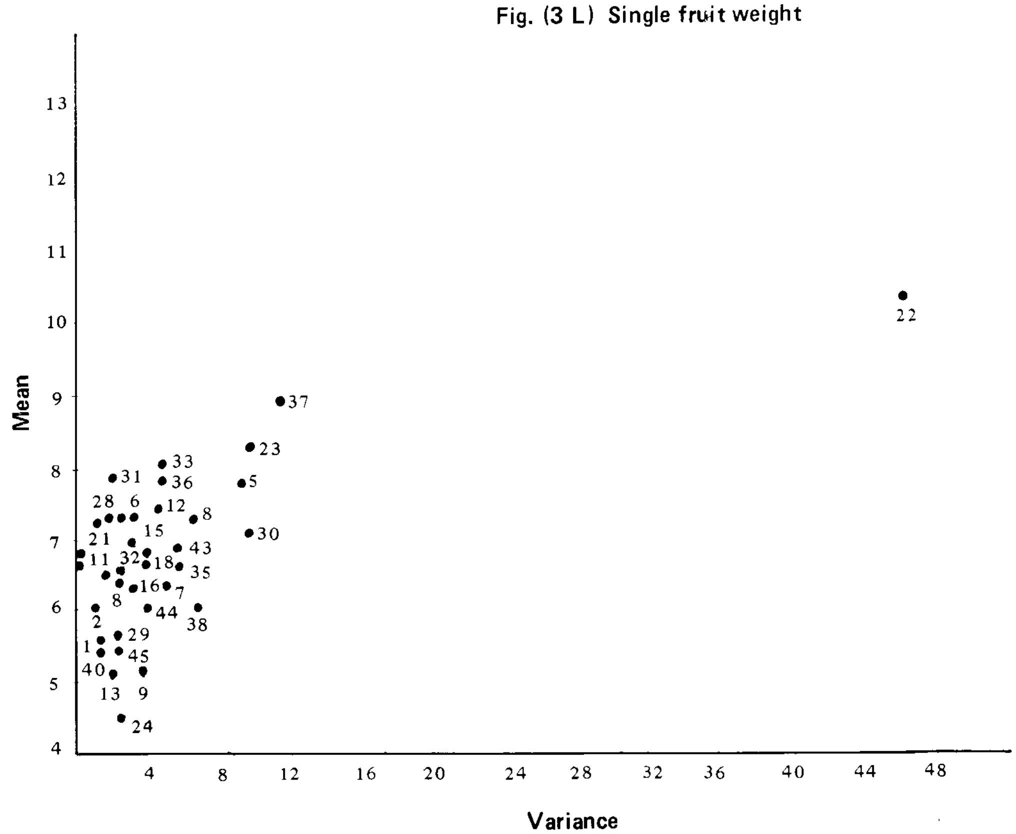


Fig. (3 L) Single fruit weight

Fig. (3 n)   % Mesocarp

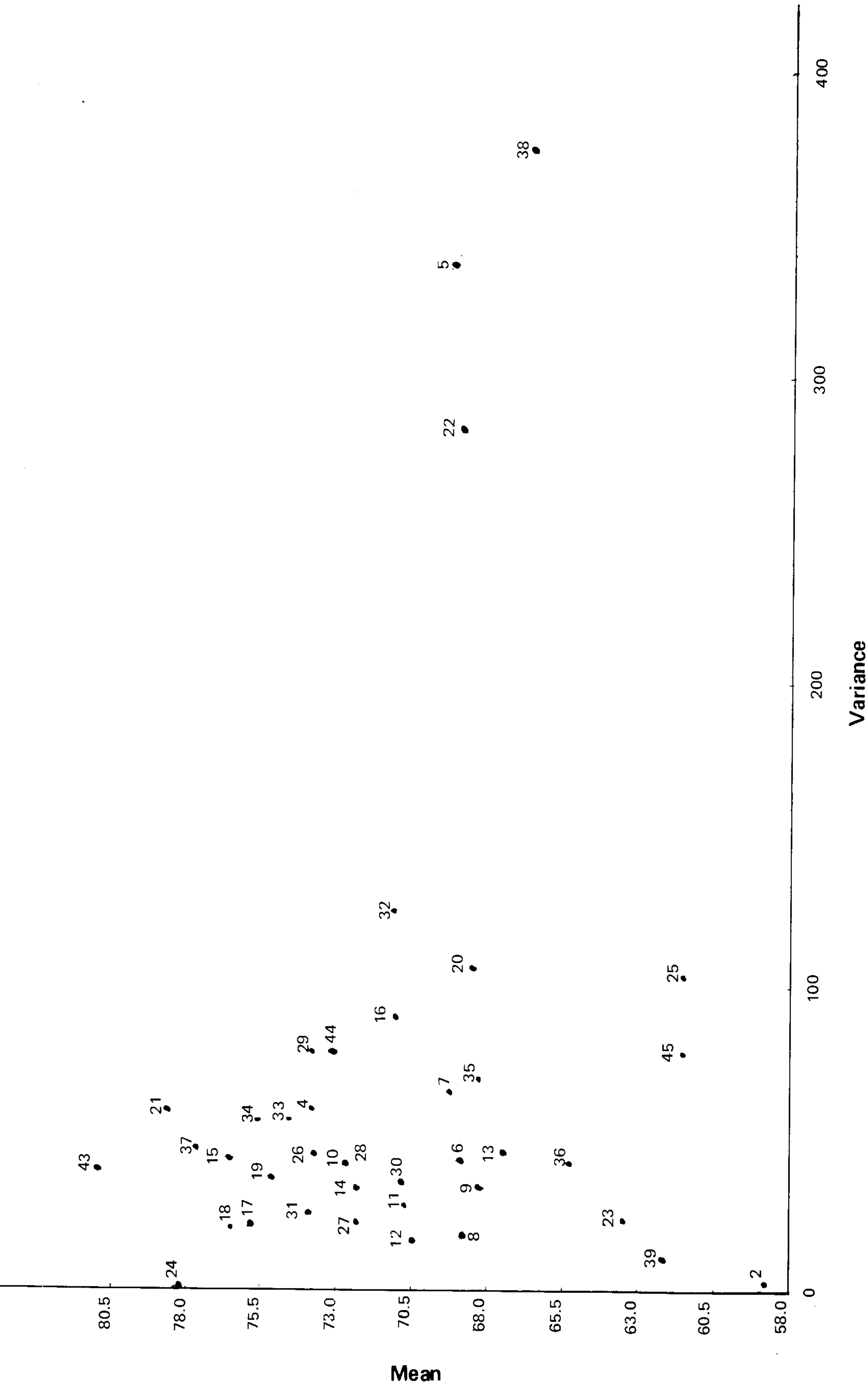


TABLE 9. CORRELATION BETWEEN CHARACTERS (SITE 45)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Bunch weight		0.7272*	0.8544**	0.9109**	0.4503	0.4644	0.1507	0.1480	0.3362	0.1893	0.9188**	0.3132	0.3254	0.1663
Bunch length			0.6766**	0.6985**	0.6770*	0.1314	0.1372	0.0999	0.4137	0.3791	0.4979	0.2422	0.3369	-0.2862
Bunch breadth				0.8865**	0.4913	0.2304	0.0854	0.2705	0.3668	0.0128	0.8786**	0.2753	0.2644	0.0773
Bunch depth					0.2335	0.3346	0.0544	0.2174	0.3498	0.0841	0.9003**	0.3614	0.3370	0.0489
No. of spikelets						0.0756	0.1238	0.3152	0.6353	0.8162**	0.2941	0.3671	0.4946	0.3401
Fruit length							0.3496	0.4194	0.2852	0.3618	0.5903	0.3300	0.3641	0.2423
Fruit diameter								0.8406**	0.6472**	0.6234**	0.1392	0.5365*	0.6616**	0.5827**
Nut diameter									0.8300**	0.6606**	0.0941	0.3593	0.4747*	0.4520*
Kernel diameter										0.1297	0.1319	0.1863	0.2439	0.2484
Shell thickness											0.1047	0.3880	0.5155*	0.4692*
Fruits/spikelet												0.0141	0.6655	0.2376
Single fruit weight													0.9288**	0.2923
Single nut weight														0.6563**
Mesocarp (%)														

Key:—

* P<0.05
** P<0.01
Figures without asterik are non significant.

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SUMMARY

Forty-five populations from 21 areas distributed throughout Nigeria were studied. The means and variance of the populations were examined. The phenotypic variation of natural Nigerian palms showed that there were differences between both the sites and areas. However, most of the variation was accounted for by the palms themselves rather than by sites and areas.

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