ESTIMATES OF GENETIC PARAMETERS OF FRUIT TRAITS AMONG SOME DATE PALM (*Phoenix dactylifera*, L.) TYPES GROWN IN NIGERIA AND THEIR IMPLICATIONS IN SELECTION

BY

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D E C L A R A T I O N

I hereby declare that the whole of the work now submitted as a Thesis for the Master of Science degree in Crop Breeding of Ahmadu Bello University is the result of my investigation (except where reference is made to published literature and where assistance is acknowledged) and has not been part of any presentation for any other qualification.

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TABLE OF CONTENTS

LIST OF TABLES

CHAPTER I

INTRODUCTION

The date palm is one of the oldest cultivated tree crops with the earliest known records of its culture already established in Iraq as early as 3,000 B.C. The palm originated in South-west Asia probably in Iraq and has existed from prehistoric times in the warm dry zone, which extends from Northwest India across Arabia and North Africa, principally between parallels $15^{O}N$ and $30^{O}N$. Dates have long been a staple food for the native populations in these areas. The date palm was recently introduced into the Western Hemisphere.

The date palm Phoenix dactylifera, L., is an important member of the Palmaceae family. The inflorescence or flower cluster, is a branched spadix and is enclosed before maturity in a protecting sheath or spathe. The date palm is dioecious and heterozygous and the fruit is a berry which is usually, oblong or ellipsoidal in shape.

World date production was estimated for 1966 at 1,826,000 metric tons from 96,000,000 trees with 500,000 trees for West Africa. In the Middle East, all parts of the palm are utilized and about 800 uses have been recorded. The diverse uses include food in several forms for man and animals, fibre, wood, fuel, shelter and handsome ornamentals. The most important economic portion of the date palm, is the pericarp of the ripe fruit which can be directly consumed. The pericarp is also used in the biscuit and confectionary trade. The flesh of dates with a moisture content of 20 percent contains 60 to 65 percent sugar, about 2.5 percent fibre, 2 percent protein and about 2 percent each of fat, mineral matter and pectic substances.

In spite of its excellent nutritional values dates have not yet gained importance in Nigerian agriculture. There is no available estimate of the Nigerian population of the date palm though it is part of the 0.5 million trees estimated for West Africa. Date palm groves are found in Northern Nigeria ranging from populations of a few trees, to others of over 100 trees. These populations are found in the Sahel, Sudan, Northern Guinea and Southern Guinea areas of Nigeria. There are more concentrations of date groves in Sudan and Northern Guinea areas. Apart from the Government plantation at Fika, dates are usually 'compound crops' in Nigeria. All the parts of the palm are utilized and there is considerable local trade on the fruits which are usually directly consumed within the Northern States. Dates with sweet taste and attractive colour are preferred in Nigeria. There are few importations of dates from neighbouring countries with negligible quantities from the Middle East and North Africa.

The main objective of the studies reported here was to evaluate the genetic variability in fruit characteristics among the Nigerian populations of the date palm. A further objective was to estimate the heritabilities of the different traits; the correlations between traits, and the expected genetic advance from selection.

CHAPTER II

LITERATURE REVIEW

In the Middle East and North Africa where dates have been cultivated since the dawn of history, superior varieties have originated from chance seedlings as a result of natural selection, aided by man.

The genetic behaviour of the date palm is little known. Seedling populations of certain varieties tend to resemble the female parent in vegetative and fruit characteristics. This feature has been useful in selecting for further hybridization, backcrossed (BC) males with growth characters resembling those of the female parent. Fruit characters carried by male palms have not been properly evaluated, but a study of female progeny in BC populations may suggest which fruit characters are being transmitted. With advanced BC males, the study of the inheritance of characters in progenies derived from parents with distinctive attributes will be possible, Carpenter and Ream, (1976).

The effect of the pollen source on fruit characters in the date palm was first reported and called 'metaxenia' by Swingle, (1928). He defined metaxenia as a direct effect of pollen from a male clone on the morphology and other characters of seed and fruit tissues lying outside the embryo and endosperm. Swingle suggested that metaxenia was due to hormones secreted (diffused) into the surrounding mother tissues by (from) the fertilized embryo and associated endosperm.

Thus, the implication is that metaxenia is genetically controlled, but indirectly. Nixon, (1928), reported on his first experiments which he began in 1925 on the effects of pollen on date fruit characteristics which established clearly the significant effects of pollen source on size and shape of seed and fruit and on time of ripening of 'Deglet Noor' and several other commercial date cultivars.

Osman et al., (1974), reported on two experiments conducted in 1970 and 1972 to obtain a more precise insight into the relation of pollen source to the dispersion and variability of date fruit characteristics. The data obtained in 1970 agree with previous studies (Swingle, (1928), and Nixon, (1928)) in showing large metaxenia effects of pollen sources on size, shape and weight of the pericarp and seed of date fruits as well as on the time of ripening of the fruits. Furthermore, they showed that the pollen source may have even more striking effects on the dispersion of such characters about the mean; that is, on the shape of their frequency distribution curves. They first reported on the effect of pollen source on dispersion of characters. They also indicated that the pollen source exerts a significant influence on the frequency distribution of such characters as seed and pericarp weights in a manner suggesting that metaxenia effects are under relatively simple genetic control. They stated that their data indicate that a significant part of the spread in size, in time of ripening and in other characters of the fruit on a given bunch of dates is related to the heterozygousity of the pollen clone used. This implies that by selection or inbreeding, a male clone might be obtained which would reduce the variability in such factors as fruit size, shape, seed size and time of ripening within bunches as compared with the commercial pollen clones in general use. The 1972 data on uniformity of effect of male clones on female cultivars suggest that a pollen clone which has a tendency to produce small fruit and seed sizes may be expected to do so on female cultivars and conversely too. They also showed that female cultivars vary in their seed-fruit weight ratios and that male clones affect this relation considerably. They stated that the female cultivar effect on fruit variability may be influenced by environmental conditions, insects and diseases, time of pollination, bunch handling and nutrition as well as by genetic factors.

The need for variety improvement in the date industry resulted from the defects of the known world varieties, Nixon and Furr, (1965). In 1912, the University of Arizona in a study of inheritance in 'Deglet Noor' variety found out after three generations that none of the seedlings produced fruits equal to the parents when they employed inbreeding by crossing selected female palms with selected male palms of the same generation. Early attempts to breed superior female varieties in which unproven males were used had little chance of success because the date palm is dioecious and heterozygous. Sibling crosses were not much better. The U.S.D.A. date breeding project which was started in 1948 had the first objective of obtaining males that approach the female parent in genetic composition. In making selections for backcrosses, primary consideration was given to fruit characters such as large size, attractive colour and appearance, good texture and flavour, good shipping and keeping qualities, early ripening, late ripening, high yield and rain tolerance.

CHAPTER III

MATERIALS AND METHODS

3.1 SOURCE MATERIAL

Fruit samples from the twenty-six entries used in this study, were collected in 1980 from 106 palms, in a random sample survey of the ecogeographical areas between latitude $10^{O}N$ - $14^{O}N$ and longitude $4^{O}E$ - $12^{O}E$ where the date palm is maximally distributed in Nigeria. The sampling was done in Sokoto, Kaduna, Kano, Bauchi and Borno States of Nigeria. Sixteen areas sampled within these five states are : Gwadawa, Anka, Funtua, Katsina, Wudil, Gaya, Dutse, Birnin Kudu, Gombe, Ningi, Bauchi, Darazo, Misau, Shira, Fika and Potiskum as shown in Table 1. The fruits from each palm were stored separately in jutebags at the Nigerian Institute for Oil Palm Research Substation, Dutse, Kano State.

3.2 OBSERVATIONS TAKEN

A total of 2,120 fruit samples consisting of a random sample of 20 fruits from each of the 106 palms were used to evaluate each of the following fruit traits: Length, circumference, weight, mesocarp weight and mesocarp thickness. The length, circumference and weight of each seed were also evaluated. Vernier callipers, micrometer guages, meter rule and threads were used for the measurements while the weights were taken on mettler balance.

Table 1. Origin of Datepalm Entries in Nigeria used in this Study

ECOGEOGRAPHICAL AREA	STATES	AREAS	ENTRIES	NO. OF PALMS SAMPLED
SUDAN	SOKOTO	GWADAWA	KELLA	1
		ANKA	MARU	1
NORTHERN GUINEA	KADUNA	FUNTUA	FUNTUA	1
		KATSINA	KATSINA	5
SUDAN	KANO	WUDIL	ZUGA	5
			GAMANA	6
		GAYA	TSANGAYA	5
			PANDA	5
		DUTSE	GURDUBA	5
			DUHUWA	5
		BIRNIN-KUDU	KILA	2
			SAMAMIYA	1
			KANGIRE	7
NORTHERN GUINEA	BAUCHI	GOMBE	GOMBE	10
		NINGI	TIFFI	9
		BAUCHI	MIRI	6
			TIRWIN	4
		DARAZO	DARAZO	1
			GABARIN	2
			KONKIEL	4
			LAGO	3
		MISAU	MISAU	4
			AJILI	1
		SHIRA	SHIRA	5
SUDAN	BORNO	FIKA	FIKA	1
		POTISKUM	POTISKUM	7
	5	16	26	106

The fruit traits measured were:-

(a) Fruit Length: This was measured to the nearest centimeter from the perianth or calyx to the remains of the stigma.

(b) Fruit Circumference: With the aid of a string and meter rule, this was measured to the nearest centimeter at the midpoint of the length and round the fruit.

(c) Fruit Weight: The weight of each fruit was recorded to the nearest gram.

(d) Mesocarp Weight: This was obtained for each fruit after the seed had been removed and was recorded to the nearest gram.

(e) Mesocarp thickness: The micrometer guage was used for measuring the mesocarp thickness in millimeter which was converted to centimeter.

(f) Seed Length: This was measured to the nearest centimeter from one pointed end to the other.

(g) Seed Circumference: With the aid of a thread and meter rule, this was measured to the nearest centimeter at the midpoint of the seed length and round the seed.

(h) Seed Weight: The weight of each seed was recorded to the nearest gram.

3.3. *STATISTICAL ANALYSIS*

A hierarchal design Kempthorne, (1952) was used for the analysis of variance for each of the eight fruit traits.

3.3.1 THE STATISTICAL MODEL

The linear statistical model used for the analysis of variance was as follows:

$$y_{ijkl} = \mu + a_i + b_{ij} + c_{ijk} + e_{ijkl}$$

where μ = overall mean

a_i = the effect of the i^{th} State; $i = 1, 2 .. 5$

b_{ij} = the effect of the j^{th} area in the ith State;

$j = 1, 2, ... 16$

c_{ijk} = the effect of the k^{th} entry, $k = 1, 2 ..... 26$

and a_i - NID $(0, \sigma^2 a)$

b_{ij} - NID $(0, \sigma^2 b)$

c_{ijk} - NID $(0, \sigma^2 c)$

e_{ijkl} - NID $(0, \sigma^2)$

The form of analysis of variance with the expected mean squares which were used for the estimation of genetic parameters is shown in Table 2.

3.3.2 ESTIMATION OF VARIANCE COMPONENTS

The observed mean square values for each character were used to estimate the components of variance and their standard errors (S.E.) from Table 2 as follows:

Error variance = $\hat{\sigma}^2$ = M_4 with S.E. = $\sqrt{\dfrac{2\ (M_4)^2}{d.f. + 2}}$

Genotypic variance for entries = $\sigma^2 c$ = $\dfrac{M_3 - M_4}{d}$

with S.E. = $\sqrt{\dfrac{1^2}{(d)} \left[\dfrac{2\ (M_4)^2}{d.f. + 2} + \dfrac{2\ (M_3)^2}{d.f. + 2}\right]}$

Table 2. Form of analysis of variance (ANOVA) with expected mean squares (EMS) for the estimation of genetic parameters

Sources of Variation	d.f.	M.S.	E.M.S.
States	4	M_1	$\sigma^2 + d\,\sigma^2 c + cd\,\sigma^2 b + bcd\,\sigma^2 a$
Areas within States	15	M_2	$\sigma^2 + d\,\sigma^2 c + cd\,\sigma^2 b$
Entries within Areas	25	M_3	$\sigma^2 + d\,\sigma^2 c$
*Error	1989	M_4	σ^2

* Error degrees of freedom of 1989 resulted from unequal numbers of subsamples.

Where M subscript = the observed mean square of the subscripted effect.

σ^2 = error variance = $\hat{\sigma}^2 + d\hat{\sigma}^2_{\mu}$ $\hat{\sigma}^2_{\omega}$

where d = number of replications (palms) and its value was calculated owing to unequal numbers of subsamples.

and $\hat{\sigma}^2 \mu$ = within plot variance

$\sigma^2 c$ = the genetic variance among entries.

$\sigma^2 b$ = the genetic variance among areas within States

$\sigma^2 a$ = the genetic variance among States.

Owing to the unequal number of subsamples, the coefficient d for the component $\sigma^2 c$ in the EMS was computed according to Steele and Torrie, (1960).

Phenotypic variance for entries $= \sigma^2 ph = M_4 + \dfrac{M_3 - M_4}{d}$

with S.E. $= \sqrt{\left(\dfrac{1}{d}\right)^2 \dfrac{2(M_3)^2}{d.f + 2}}$

3.3.3 ESTIMATIONS OF HERITABILITY (h^2) GENETIC COEFFICIENT OF VARIABILITY (G.C.V. %), EXPECTED GENETIC ADVANCE (ΔG) AND EXPECTED GENETIC ADVANCE EXPRESSED AS PERCENTAGE OF THE MEAN ($\frac{\Delta G}{\bar{x}}$ 100)

(i) Heritability (h^2) Estimates: Broad sense heritability (h^2) for each trait was estimated from the variance components using the formula of Burton and De Vane, (1953) and Johnson et al, (1955).

Heritability (h^2) $= \dfrac{\sigma^2 c}{\sigma^2 c + \sigma^2 e}$; with S.E. $= \dfrac{\text{S.E. of } \sigma^2 c}{\sigma^2 ph}$

where $\sigma^2 c$ = Genetic variance

$\sigma^2 c + \sigma^2 e$ = Phenotypic variance

(ii) Genetic Coefficient of Variability (G.C.V.%) Estimates: Genetic coefficient of variability (G.C.V.%) for the different traits were estimated using the formula suggested by Burton and De Vane, (1953) and Hanson et al, (1956).

G.C.V. % $= \sqrt{\dfrac{\sigma^2 g}{\bar{x}}}\ 100$

where $\sqrt{\sigma^2 g}$ = the square root of the genetic variance

$\bar{x}$ = Entry mean

(iii) Expected Genetic Advance from Selection (ΔG):

Expected genetic advance from selection (ΔG) was computed using the formula given by Johnson, et. al. (1955).

$$\text{Genetic Advance } (\Delta G) = \frac{\sigma^2 g}{\sigma^2 ph} \times k\sigma ph$$

where $\frac{\sigma^2 g}{\sigma^2 ph}$ = heritability

$k\sigma ph$ = Selection differential expressed in phenotypic standard deviations.

For this purpose, k was given the value 2.06, which is its expectation in the case of five percent selection in large samples from a normally distributed population.

(iv) Expected Genetic Advance expressed as percentage of mean: This was computed according to Kaul and Bhan (1974)

$$\frac{\Delta G}{\bar{x}} \times 100$$

where ΔG = Expected genetic advance from selection

$\bar{x}$ = Entry mean

3.3.4 CORRELATIONS

The Estimates for genotypic, phenotypic and environmental correlations between traits were estimated from analysis of variance and covariance according to Mode and Robinson (1959), as shown in Table 3.

Table 3. Form of analysis of variance and covariance with expected mean cross products for two traits (x and y)

Source of Variation	d.f.	M.S.(x)	M.S. (y)	M.C.P(xy)	E.M.C.P
Entries	(a-1)	$M_1S(x)$	$M_1S(y)$	$M_1CP(xy)$	Cov e(xy)+d Covg(xy)
Error	ab(c-1)	$M_2S(x)$	$M_2S.(y)$	$M_2CP(xy)$	Cov e (xy)

Where M.S. (x) = Mean squares for trait x

M.S.(y) = Mean squares for trait y

M.C.P.(xy) = Mean cross products for x and y

E.M.C.P. = Expectations of mean cross products for x and y

d = Calculated value due to unequal number of subsamples for entries.

(i) Genotypic correlations:

$$rg(xy) = \frac{Covg\ (xy)}{\sqrt{\sigma^2\ c(x)\ \sigma^2 c(y)}}$$

where $r_g(xy)$ = Genotypic correlation between traits x and y

Cov g(xy) = Genotypic covariance of traits x and y

$$= \frac{M_1.C.P.(xy) - M_2.C.P.\ (xy)}{d}$$

$\sigma^2 c(x)$ = Genotypic variance of trait x

$\sigma^2 c(y)$ = Genotypic variance of trait y

d = Calculated value due to unequal numbers of subsamples.

(ii) Phenotypic correlations:

The phenotypic correlations were computed using mean squares and mean cross products in the following formula:

$$rph(xy) = \frac{M_1 CP(xy)}{\sqrt{(M_1 S(x))(M_1 S(y))}}$$

where $M_1S(x)$ = mean square for trait x

$M_1S(y)$ = mean square for trait y

$M_1CP(xy)$ = mean cross products for x and y

rph(xy) = Phenotypic correlation for x and y

(iii) Environmental correlations:

The environmental correlations were also computed for a pair of characters using mean squares and mean cross products for environment as the measure of the effect of environment on the association of the characters in each pair.

$$re(xy) = \frac{Cov\ e\ (xy)}{\sqrt{\sigma^2(x).\sigma^2(y)}}$$

where $re(xy)$ = Environmental correlation for x and y

$Cov\ e(xy)$ = Environmental covariance for x and y

$\sigma^2(x)$ = Environmental variance for trait x

$\sigma^2(y)$ = Environmental variance for trait y

CHAPTER IV

RESULTS

4.1 FRUIT VARIABILITY

The Means, Standard Error of Means, Ranges and Phenotypic Coefficients of Variation for the eight fruit traits are shown in Table 4. Considerable and significant variations among the entries for each of the eight traits were observed. The standard error of the means were very much lower than their respective means. (S.E.' for fruit circumference and mesocarp thickness were 89 and 3 times respectively lower than their respective means).

Wide ranges in the means were observed for fruit weight (0.95 - 18.43g) and mesocarp weight (0.46 - 18.35g). The lowest range in the means was observed for mesocarp thickness (0.10 - 0.94 cm).

The phenotypic coefficient of variation ranged from 14.9% to 49.9%. The highest coefficients of variation were for mesocarp weight (49.9%), and fruit weight (43.1%) while the lowest were for fruit circumference (14.9%) and seed circumference (14.9%).

4.2. ANALYSIS OF VARIANCE

The analysis of variance of the eight fruit traits studied are presented in Table 5. The mean squares among entries within areas for all traits were highly significant (P = 0.01). Except for seed weight, similar results were obtained for Areas within States for all traits. Similar results for States were obtained for all traits with the exception of seed length and seed weight.

Table 4. Mean ($\bar{x}$), Standard Error of the Mean (S.E.$\bar{x}$), Range and Coefficient of Variation (C.V.%) for the eight fruit characters of 26 entries

TRAIT	MEAN $\pm$ S.E.$\bar{x}$	RANGE	C.V. %
Fruit Length (cm)	3.4640$\pm$0.0462	1.50-6.90	16.20
Fruit Circumference (cm)	5.7871$\pm$0.0648	3.00-9.40	14.87
Fruit Weight (g)	5.4850$\pm$0.1586	0.95-18.43	43.09
Mesocarp Weight (g)	4.2864$\pm$0.1357	0.46-18.35	49.93
Mesocarp Thickness (cm)	0.3501$\pm$0.1252	0.10-0.94	31.16
Seed Length (cm)	2.3691$\pm$0.0595	1.10-3.90	28.24
Seed Circumference (cm)	2.8179$\pm$0.0582	0.60-4.10	14.90
Seed Weight (g)	1.2146$\pm$0.0328	0.01-4.14	24.91

Table 5. Analysis of variance for eight fruit traits of the twenty-six date palm entries

SOURCE OF VARIATION	d.f.	MEAN SQUARES							
		Fruit Length	Fruit Circumference	Fruit Weight	Mesocarp Weight	Mesocarp Thickness	Seed Length	Seed Circumference	Seed Weight
States	4	12.0717**	18.2170**	117.5995**	100.5568**	77.8531**	1.9672	6.2919**	1.8261
Areas/States	15	10.5366**	17.9504**	120.2097**	109.0117**	40.3212**	2.3048**	2.7461**	1.2945
Entries/Areas	25	10.5335**	16.4626**	134.0350**	113.6919**	30.5244**	2.7248**	4.0040**	2.2603**
Error	1989	0.1704	0.5075	3.7573	3.5395	0.4212	0.5012	0.0945	0.0921

** = Significant Difference at .01 level of probability.

4.3 ESTIMATES OF VARIANCE COMPONENTS

Table 6 shows the estimates of genetic variance ($\sigma^2 g$), phenotypic variance ($\sigma^2 ph$) and environmental variance (σ^2) with their standard errors for the eight traits. All traits showed positive genetic variances, which in all cases were about four times larger than their respective standard errors. Relatively high genetic variances ($\sigma^2 g$) were obtained for fruit weight (5.0456), mesocarp weight (4.2661) and mesocarp thickness (1.1659); medium genetic variances for fruit circumference (0.6179) and fruit length (0.4014); and low genetic variances for seed circumference (0.1514), seed length (0.0861) and seed weight (0.0840).

The genetic variances were one to three times larger than their respective environmental variances for the following traits: fruit circumference (x1), fruit weight (x1), mesocarp weight (x1), fruit length (x2), seed circumference (x2) and mesocarp thickness (x3); while the genetic variances were lower than the environmental variances for seed length and seed weight. The highest phenotypic variances were obtained for fruit weight (8.8029) and mesocarp weight (7.8056), and the lowest estimate was for seed weight (0.1761). The Phenotypic and environmental variance estimates were also positive for all traits.

4.4. HERITABILITY

Broad sense heritability (h^2) estimates (Table 7) were high for mesocarp thickness (0.7346), fruit length (0.7020) and seed circumference (0.6157). Medium heritability estimates were obtained for fruit weight (0.5732), fruit circumference (0.5491), mesocarp weight (0.5465) and seed weight (0.4770) and a low estimate for seed length (0.1459). The heritability estimates for all traits were significant, being larger than thrice the value of their respective standard errors.

Table 6. Estimates of Genetic Variance ($\sigma^2 g$), Phenotypic Variance ($\sigma^2 ph$) and Environmental Variance (σ^2) for the eight fruit traits of twenty-six Date Palm entries in Nigeria in 1980

TRAIT	COMPONENTS OF VARIANCE		
	σ^2 g	σ^2ph	σ^2
Fruit Length	0.4014±0.1110	0.5718±0.1110	0.1704±0.0054
Fruit Circumference	0.6179±0.1735	1.1254±0.1735	0.5075±0.0161
Fruit Weight	5.0456±1.4129	8.8029±1.4129	3.7573±0.1191
Mesocarp Weight	4.2661±1.1984	7.8056±1.1984	3.5395±0.1122
Mesocarp Thickness	1.1659±0.3218	1.5871±0.3218	0.4212±0.0134
Seed Length	0.0861±0.0287	0.5873±0.0287	0.5012±0.0159
Seed Circumference	0.1514±0.0422	0.2459±0.0422	0.0945±0.0030
Seed Weight	0.0840±0.0238	0.1761±0.0238	0.0921±0.0029

Table 7. Estimates of Heritability (h^2), Genetic Coefficient of Variability (G.C.V%), Expected Genetic Advance (ΔG) and Expected Genetic Advance Expressed as Percentage of Mean ($\frac{\Delta G}{\bar{x}}$ 100) for Eight fruit traits of 26 Datepalm entries in Nigeria in 1980

TRAIT	h^2	G.C.V.%	ΔG	$\frac{\Delta G}{\bar{x}}$ 100
Fruit Length	0.7020±0.1941	18.2798	1.0936	31.5519
Fruit Circumference	0.5491±0.1542	13.5899	1.2000	20.7457
Fruit Weight	0.5732±0.1605	40.9846	3.5034	63.9220
Mesocarp Weight	0.5465±0.1535	48.2267	3.1453	73.4400
Mesocarp Thickness	0.7346±0.2028	30.8417	1.9064	54.4530
Seed Length	0.1459±0.0489	12.3788	0.2303	9.7170
Seed Circumference	0.6157±0.1716	13.8161	0.6290	22.3325
Seed Weight	0.4770±0.1352	25.0045	0.4770	34.9074

4.5 GENETIC COEFFICIENT OF VARIABILITY

The estimates of Genetic Coefficient of Variability (G.C.V.%) are shown in Table 7. The G.C.V.% were relatively high for mesocarp weight (48.23%) and fruit weight (40.99%); medium for mesocarp thickness (30.84%), seed weight (25.01%) and low for fruit length (18.28%), seed circumference (13.82%), fruit circumference (13.59%) and seed length (12.38%).

4.6 EXPECTED GENETIC ADVANCE AND EXPECTED GENETIC ADVANCE EXPRESSED AS PERCENTAGE OF MEAN

The expected genetic advance varied from 0.2303 for seed length to 3.5034 for fruit weight (Table 7). The expected genetic advance expressed as percentage of mean varied from 9.7% to 73.4% for the different traits as shown in Table 7. High values were obtained for mesocarp weight(73.4%) and fruit weight (63.9%). The lowest value was for seed length (9.7%).

4.7 CORRELATIONS

The genotypic, phenotypic and environmental correlations for pericarp characters (fruit length, fruit circumference, fruit weight, mesocarp weight and mesocarp thickness) are shown in Table 8. Fruit length was significantly and positively correlated genotypically and phenotypically with fruit circumference (rg = 0.140, rph = 0.451), mesocarp thickness (rg = 0.475, rph = 0.593). Mesocarp thickness was significantly and positively correlated genotypically and phenotypically with fruit weight (rg = 1,892, rph = 1.907) and

Table 8. Genotypic (rg), Phenotypic (rph) and Environmental (re) Correlations for Pericarp Characters[1]

	FRUIT CIRCUMFERENCE	FRUIT WEIGHT	MESOCARP WEIGHT	MESOCARP THICKNESS
Fruit Length	0.140* 0.451* 0.018	0.293 0.105 0.004	0.114 0.117 0.005	0.475** 0.593** 0.025
Fruit Circumference		0.066 0.069 0.006	0.065 0.069 0.006	0.581** 0.593** 0.025
Fruit Weight			0.085 0.085 0.003	1.892** 1.907** 0.057
Mesocarp Weight				1.589** 1.609** 0.058

1. = The upper, middle and lower values for each trait refer to the genotypic (rg) phenotypic (rph) and environmental (re) correlations respectively.

* = Significant at .05 level of probability

** = Significant at .01 level of probability mesocarp weight (rg = 1.589, rph = 1.609). The environmental correlations were positive but not significant in all cases. The correlation values that are higher than one (1 unit) could be due mainly to the unequal numbers of subsamples or the statistical proceedure used or the metaxenia effects on fruit characters.

Table 9 shows the genotypic, phenotypic and environmental correlations for seed characters (seed length, seed circumference and seed weight). Seed length was highly significant and positively correlated genotypically and phenotypically with seed circumference (rg = 0.695, rph = 0.708) and seed weight (rg = 0.692, rph = 0.720). Seed circumference was positively and highly significantly correlated genotypically and phenotypically with seed weight (rg = 0.697, rph = 0.706). The environmental correlations were positive but not significant in all cases.

Table 9. Genotypic (rg), Phenotypic (rph) and Environmental (re) Correlations for seed characters[1]

	SEED CIRCUMFERENCE	SEED WEIGHT
Seed Length	0.695** 0.708** 0.090	0.692** 0.720** 0.112
Seed Circumference		0.697** 0.706** 0.033

1. = The upper, middle and lower values for each trait refer to the genotypic (rg), phenotypic (rph) and environmental (re) correlations respectively.

** = Significant at .01 level of probability.

CHAPTER V

DISCUSSION

The means, ranges and coefficients of variability for the different traits (Table 1), and the significant mean squares of variation among entries for all the fruit traits (Table 2), showed considerable variability for these traits. Carpenter and Ream, (1976), stated that the date palm being dioecious and heterozygous, and a remarkably diverse species in fruit and vegetative characters and adaptation to a wide range of environments, exhibits much genetic variation. Therefore with selection and hybridization of entries with significant mean squares especially for the economic fruit traits such as fruit weight, mesocarp weight and mesocarp thickness superior cultivars could be obtained through a planned breeding programme.

A well planned programme is always determined by the genetic component of variability. Estimates of genotypic, phenotypic and environmental variance components (Table 6), were positive for all traits and had low standard errors. The genetic variances were close to the phenotypic variances and they were one to three times larger than their respective environmental variances for the different traits except for seed length and seed weight. Hence variation in most fruit traits were largely due to genetic influence. Relatively high genetic variances were obtained for the economic fruit traits of fruit weight, mesocarp weight and mesocarp thickness.

The genetic coefficient of variability (G.C.V.%), indicates the range of genetic variability existing in a trait. Relatively high G.C.V. were shown (Table 7) for mesocarp weight (48%), fruit weight (41%) and mesocarp thickness (31%).

Falconer, (1960), stated that the values of genetic variance alone are not helpful in determining the heritable portions of variation. Hence heritability estimates are necessary. The lower the heritability, the more difficult it is to distinguish genotypic variation phenotypically. Table 7 shows the broad sense heritability estimates for the eight fruit traits which were relatively high for mesocarp thickness, fruit length and seed circumference, medium for fruit weight, fruit circumference, mesocarp weight and seed weight and low for seed length. Broad sense heritability was used because the date palm,, a perennial plant, has very large generation interval, hence other estimation proceedures are not adequate due to the long generation interval. Using the broad sense heritability was of special importance because it was necessary to get heritability estimates in the early stages of breeding work. Broad sense heritability does not distinguish between components of genetic variation such as additive variance (σ^2A) and dominance variance (σ^2D) and as such it is difficult to make reliable predictions of genetic advance through selection. However, Kaul and Bhan, (1974), have stated that broad sense heritability may be useful when high genetic gain is possible. In crops that can be assexually propagated by clones like the date palm, both additive and non additive components of genetic variance are fixable, hence broad sense heritability is meaningful. Heritability indicates the effectiveness with which selection of genotypes can be based on phenotypic performance though it does not provide any indication of the amount of genetic progress that would result from selecting the best individuals. Johnson _et al._, (1955), from their studies with soybeans, have suggested that heritability, together with genetic advance is more useful in predicting the result of selecting the best individuals. High heritability values together with high genetic advance is probably due to high additive gene effects (Panse, 1957). Table 7 shows the expected genetic advance and the expected genetic advance expressed as percentage of the mean. The expected genetic advance expressed as percentage of the mean were relatively high for mesocarp weight (73%), fruit weight (64%) and mesocarp thickness (54%). The high values of expected genetic advance and expected genetic advance expressed as percentage of the mean were expected since genetic advance is commonly predicted as the product of heritability ratio, the selection differential which is a very high pressure of 5% in this study and the phenotypic standard deviation. This high predicted value needs to be tested, however, with empirical results, in order to bring out its significance, whether it is high or low. Interestingly the heritability values obtained for the different traits are not too high, ranging from a low value of 15% to a medium high value of 73%. Thus, the high selection pressure represented by the high k value of 2.06 together with high phenotypic standard deviation especially in this kind of highly localised and specific occurrence of date palms in Nigeria, could have accounted for the extremely high genetic advance.

The relatively high values obtained for heritability, genetic coefficient of variability and expected genetic advance for fruit weight, mesocarp weight and mesocarp thickness suggest that variation in these traits may be attributed to a high degree of additive gene action and selection for these traits would, therefore, be effective.

Steele and Torrie (1960), stated that correlations are a measure of the intensity of association between variables. The genotypic (rg), phenotypic(rph) and environmental (re) correlations for the pericarp traits are shown in Table 8. The environmental correlations (re) were positive but not significant in all the traits. This confirms the statement of Carpenter and Ream (1976) , that the date palm adapts to a wide range of environments. Mesocarp thickness was positively and significantly correlated with fruit weight (rg = 1.907, rph = 1.892) and mesocarp weight (rg = 1.589, rph = 1.609). Fruit length was positively and significantly correlated genotypically and phenotypically with fruit circumference (rg = 0.140, rph = 0.450) and mesocarp thickness (rg = 0.475, rph = 0.593). The positive and significant phenotypic and genotypic correlations of mesocarp thickness with mesocarp weight and fruit weight suggest that selection for any of these traits would lead to an improvement in that trait in a positive direction.

The correlation of seed traits is shown in Table 9. The positive and highly significant correlations genotypically and phenotypically between seed length and seed circumference, seed length and seed weight, and between seed circumference and seed weight, show that either of the seed traits could be used as selection criterion for seed. The non-significant environmental correlations for the seed traits show that environmental effects do not have any serious effect on seed traits.

The variation within the Nigerian date palm entries studied would be attributed to genotypic differences between the male and female palms since the date palm is dioecious and heterozygous. Since Swingle, (1928), reported on the effect of pollen source on fruit characteristics in the date palm which he called 'metaxenia', this effect has also been reported for other crops: (cotton, Harrison, 1931; coconuts, Ninan et al., 1936; and citrus, Hearn et al., 1969. Experiments by Osman et al., (1974) have shown that the pollen parent may strongly influence size, shape and weight of pericarp and seed of date fruits as well as on the time of ripening. Nigerian dates are pollinated without control of the pollen sources. The significant variation agrees with Osman et al., (1974) who indicated that the significant part of the spread in size, in time of ripening and in other characters of the fruit on a given bunch of dates is related to the heterozygousity of the pollen sources used. This implies that by selection or inbreeding, a male clone might be obtained which would reduce the fruit variability for the establishment of commercial date plantations. The effect of the female date cultivar on fruit variability which may be influenced by environmental conditions, insects and disease, time of pollination, bunch handling and nutrition as well as by genetic factors would also be reduced by systematic selection and breeding.

The reliability of the estimates obtained in this study is however limited due to genotype by environment interactions which are known to be important factors in most traits. Genetic variance estimates based on data from a single year are undoubtedly biased upward by genotype by environment interaction Johnson *et al.*, (1955).

CHAPTER VI

SUMMARY

Twenty-six date palm entries from sixteen areas of five States in Nigeria were used to estimate genetic parameters of eight fruit traits and to evaluate their implications in selection. The fruit traits evaluated were five pericarp characters (fruit length, fruit circumference, fruit weight, mesocarp weight and mesocarp thickness) and three seed characters (seed length, seed circumference and seed weight).

Considerable and significant variations were observed for each trait. Phenotypic coefficient of variation (C.V.) ranged from 14.87% for fruit circumference to 49.93% for mesocarp weight. The significant mean squares of variance for all traits confirmed the presence of considerable variability among entries for all traits studied.

The high genetic variance and genetic coefficient of variability for fruit weight, mesocarp weight and mesocarp thickness suggest that there is scope for further improvement of these traits.

Broad sense heritability estimates were medium to relatively high for fruit weight (57%), fruit length (70%) and mesocarp thickness (73%). Broad sense heritability was used because the date palm apart from being a perennial crop had no previous breeding or selection records in Nigeria — Commercial date plantations are established with suckers, hence the components of genetic variation such as additive variance and dominance variance would be fixed.

Heritability estimates calculated in the broad sense could be useful when high genetic gain in a particular trait is also possible. The expected genetic advance expressed as percentage of the mean was relatively high for fruit weight (64%), mesocarp weight (73%) and mesocarp thickness (54%) respectively.

The relatively high values obtained for heritability, genetic coefficient of variability and expected genetic advance for fruit weight, mesocarp weight and mesocarp thickness suggest that the variation in these traits may be attributed to a high degree of additive gene action and selection for these traits would therefore be effective.

Genotypic correlations provide a measure of genetic association between traits and help identify the more important as well as the less important traits to be considered in breeding programmes. Mesocarp thickness was positively and significantly correlated phenotypically and genotypically with fruit weight and mesocarp weight thereby suggesting that selection for any of these traits would lead to an improvement in that trait in a positive direction.

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