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Research Article

Heritability Estimate for Fruit Traits in Date Palm Crosses (*Phoenix dactylifera* L)

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ABSTRACT

Date palm progress derived from 60 crosses replicated twice, subjected to analysis of variance using nested design for the purpose of estimating fulsibs, broad sense and narrow sense heritability's, genetic advance and genetic advance as percentage mean for the eight fruit traits. Positive estimates were recorded for fulsibs heritability for the traits. Broad sense heritability for the traits was high. Narrow sense estimates were low and negative indicating that the estimates were not different from zero or they were very small. Heritability indicates the effectiveness with which selection of genotype can be based on phenotypic performance, though it does not provide any indication of the amount of genetic progress that will result from selecting the best individuals. The relatively high estimates obtained for broad sense and medium estimates for fulsibs heritability 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 and thus shows that the traits are under strong genetic control. Broad sense heritability estimate for any one trait is useful when high genetic advance in that trait is feasible, because high heritability coupled with high genetic advance is the true index for effective selection. It was necessary that expected genetic advance be estimated to know what level of improvement can be expected from selection of each of the characters examined. Pollen source has strong influence on fruits and seed characters of date palm. Among the palms used for this study, male 1R12 GPIII; 6R3 GPIII and 1R7 NCRP performed better than the rest. Mass, recurrent and backcross selection are recommended for further breeding programs in development of date palms in Nigeria.

INTRODUCTION

Pollination in plants is carried out naturally by wind, insects or dusting the male inflorescence on the female (artificial) (Okolo et al., 2000). According to Zaid and de Wet (1999), one male palm can pollinate up to 50 females. Artificial or controlled pollination in date palm is necessary for successful fruit set and fruiting (El-Ghayaty, 1983). Pollen has direct effect or influence on physical and chemical characteristics known as metaxenia effect (Osuhor, 1991). Pollen also influence percentage of fruit set, fruit shape, fruit size, fruit color and total soluble solid (T.S.S) (Nixon, 1934; 1951; Ahmad and Ali, 1960; Al-Delaimy and Ali, 1969; El-Hammady et al., 1977 and El-Sabrout, 1979).

Heritability analyses estimates the relative contribution of difference in genetic and non-genetic factors to the total phenotypic variance in a population (Wikipedia, 2009). According to Cassell (2001), heritability is a measure of the degree (0 to 100%) to which offspring resembles their parent for specific traits. According to Wikipedia (2009), broad sense heritability reflects all possible genetic contribution to population phenotypic variance that is additive by nature. Osuhor (1991) reported medium broad sense heritability for seven out of eight fruit traits he studied and low estimates for length of seed. And he obtained high estimates of broad sense heritability's for mesocarp thickness, fruit length and seed circumference. Medium estimates were obtained for fruits weight, fruit circumference, mesocarp weight and seed weight. Low estimates were recorded for seed length. Osuhor (1991) and Kaul and Bhan (1974) stated that broad sense heritability may be useful when high gain is possible. Heritability together with genetic advance is more useful in predicting the result of selecting the best individual. High heritability values together with high genetic advance are probably due to high additive gene effect (Panse, 1957). Obilana and Fakorede (1981) stated that heritability used to be high at non-stress relative to stress environments.

MATERIAL AND METHODS

The experiment was carried out at Nigeria Institute for Oil Palm Research (NIFOR) Date Palm Research Dutse, Jigawa state during 2004-2005 flowering season. It lies on latitude 10^0 14'N and longitude 4^0 25 E. The vegetation is Sudan savannah, with annual rainfall of about 600mm. The soil is sandy loam in nature and the soil height level is at sea level, with an average temperature of 32.4^0C. 5 male palms were randomly selected from the gene pool (GP) at the Dutse substation, 3 male palms from gene pool III field and 2 from the nationally coordinated research project (NCRP) field. 10 female palms were randomly selected from the gene pool at Dutse substation. 9 from gene pool III and one from gene pool IV.

Table 1: Brief Description of the male spathe

s/n	Name	Location	Color	Size	Color of powder	Texture of powder
1	19R1	GP III	Greenish brown	Large	Cream	Fine
2	1R12	GP III	Light green	Large	Cream	Fine
3	6R3	GP III	Light green	Large	Cream	Fine
4	5R2	NCRP	Greenish brown	Large	Cream	Fine
5	1R7	NCRP	Greenish brown	Large	Cream	Fine
6	Open pool					

Source: Field survey

Table 2: Characteristic of female palms

s/n	Name	Location	Age	Height(m)	No of bunches	Fruit type
1	3R3	GP III	20	2.2	12	Soft
2	12R3	GP III	20	2.8	12	Dry
3	6R5	GP III	20	2.5	12	Dry
4	2R8	GP III	20	3.4	12	Dry
5	1R11	GP III	20	3.2	12	Soft
6	7R14	GP III	20	3.6	12	Semi dry
7	2R15	GP III	20	2.7	12	Dry
8	5R16	GP III	20	2.2	12	Semi dry
9	1R27	GP III	20	3.6	12	Soft
10	5R5	GP IV	17	2.7	12	Dry

Source: Field survey (2004-2005).

Adult female palms on average produce 15-25 spathes (inflorescence) (Zaid and de Wet, 1999). Nested design I was the mating design used for the crosses. Twelve inflorescence (spathe) were chosen with six as crosses and six as replicates, the extra ones were cut up. One variety of pollen was used in pollination of two female inflorescence (spathe) making a total of 10 pollinated spathes using controlled pollination technique, while the remaining two spathe (inflorescence) were open pollinated by wind or insect and they served as control.

Data collected for the eight fruit traits were follows:

Fruit length using cannier caliper (cm), fruit circumference using thread and ruler (cm), fruit weight using digital weighing balance (g), Mesocarp thickness using micrometer screw gauge (mm), Mesocarp weight using digital weighing balance (g), Seed length using Vanier caliper (cm), Seed circumference using thread and ruler (cm), Seed weight using digital weighing balance (g).

Nested design 1 of Comstock and Robison (1948) was used for the analysis of variance for the bunch traits studied. Design 1 is appropriate for the estimates of heritability components in a reference population (Hallauer and Miranda, 1986).

RESULT AND DISSCUSION

Variability among entries (one-way Anova)

The mean square for the entries from one way Anova for fruit are shown in table 3. The result shows highly significant difference (p=0.01) for all the traits with the exception of fruit circumference and mesocarp thickness, with a significant difference at 5% level (p=0.05). The one way Anova helps us to determine whether significant differences exist among the entries. The highly significant difference observed shows that variability exist among the entries for the eight fruit traits and as such significant improvement could be achieved.

Table 3: Mean squares from the analysis of variance for fruit traits

Source	df	Fruit weight	Fruit length	Fruit circumference	Mesocarp thickness	Mesocarp weight	Seed length	Seed circumference	Seed weight
Entries	59	33.50**	4.499**	134.47*	60.44*	28.02**	23.68**	4.37**	27.57**
Error	2324	2.27	0.684	121.42	43.85	2.94	23.61	0.742	2.22

* Significant difference at 5% level of probability
** Significant difference at 1% level of probability

Mean Performance

The mean square error of the mean, range and coefficient of variation for each of the eight fruit traits studied are shown in Table 4. A wide range with each trait was observed. In all cases the means were much larger than their respective standard errors. The coefficient of variation for the different traits ranges from 9.1 for fruit length to 28.4% for mesocarp thickness. The character which show highest mean performance are fruit circumference, fruit length and mesocarp weight.

Table 4: Mean, Standard Error (SE), Range and Coefficient of variation (C.V) for eight fruit traits

Traits	Mean ± SE	Range	C.V (%)
Fruit weight	4.398 ± 0.0004	1300 – 32.00	23.3
Fruit length	3.979 ± 0.0001	0.300 – 6.400	9.1
Fruit circumference	5.405 ± 0.0007	0.000 – 49.00	24.6
Mesocarp thickness	2.298 ± 0.0002	0.410 – 20.60	28.4
Mesocarp weight	3.283 ± 0.0003	0.500 – 7.400	24.3
Seed length	2.558 ± 0.00002	0.000 – 3.900	9.5
Seed circumference	2.724 ± 0.00003	0.000 – 4.00	10.3
Seed weight	1.094 ± 0.00002	0.000 – 2.10	18.5

The coefficient of variation expresses the experimental error as percentage of mean, thus the higher the coefficient of variation indicates the degree of precision with which the treatments are compared and is good index of reliability of any experiment. It expresses the experimental errors as percentage of mean, thus the higher the coefficient of variation value the lower the reliability of the experiment (Gomez and Gomez, 1984). The coefficient of variation varies greatly with the type of experiment, the crop and the character measured. For date palm, it was established that coefficient of variation (C.V.) of date palm ranges from 13.7 – 18.6. It is assumed to be optimum, if environmental variation was to be similar then the palm to palm variation within the population may be attributed to genotypic difference between the males and females. Since date palm is dioecious and heterozygous, an individual male palm can be genotypically unique.

Duncan multiple range tests was used to compare mean performance of the males and also to determine whether significant difference among the males for fruit traits studied, Table 5. There are significant difference among the males for fruit weight, fruit length, fruit circumference, mesocarp weight, seed circumference and seed weight.

Table 5: Mean performance for fruit traits

Male	Fruit weight	Fruit length	Fruit circumference	Mesocarp thickness	Mesocarp weight	Seed length	Seed circumference	Seed weight
19R1	4. 53525a	4.05150a	5.57125a	2.29680	3.33275a	2.55250	2.69500b	1.11075a
1R12	4.45650ab	4.00310ab	5.35464b	2.28657	3.36800a	2.55103	2.76500a	1.08425ab
6R3	4.43425a	3.98825bc	5.44775ab	2.35125	3.43275a	2.56975	2.77000a	1.09925ab
5R2	4.30802bc	3.94085c	5.32632b	2.31992	3.19548b	2.54849	2.68693b	1.08693ab
1R7	4.24350c	3.93975c	5.96425b	2.28020	3.16817b	2.57223	2.70501b	1.07544b
Control	4.31250bc	3.94800c	5.36750b	2.25555	3.19950b	2.55650	2.72150b	1.10650ab

Means sharing similar letter(s) do not differ significantly at p = 0.05

Variability among males and females within males

The mean square from the analysis of variance for the eight fruit traits are shown in Table 6. The result show highly significant difference (p=0.01) for all traits in females within males, and also highly significant difference were observed for fruits weight, fruit length, mesocarp weight and seed circumference in the males. There was non-significant difference for fruit circumference, mesocarp thickness, seed length and seed weight for the males (Table 6).

Table 6: Mean squares for fruit traits

Source	df	Fruit weight	Fruit length	Fruit circumference	Mesocarp thickness	Mesocarp weight	Seed length	Seed circumference	Seed weight
Rep	1	0.725	0.031	6.961	1.472	0.003	0.267	0.038	0.125
Male	5	6.406**	0.789**	3.299	0.445	4.790**	0.04	10.509**	0.076
Female/male	5	34.4894**	4.282**	10.459**	13.397**	28.745**	0.694**	4.092**	1.575**
Error	59	1.057	0.130	1.772	0.428	0.798	0.059	0.079	0.041

* Significant difference at 5% level of probability
** Significant difference at 1% level of probability

According to Osuhor and Samarawira (1981), most of the Nigeria date palms compare favorably in fruit characteristic with leading world varieties like the deglet noor. It is obvious from these results that with careful planning, significant improvement could be achieved by selection and hybridization of those traits with significant means square. Through selection of outstanding males and females significant improvement could be achieved (Abubakar, 1984).

Heritability

The heritability estimates for fulsibs, broad sense, narrow sense, expected genetic advance (G) and expected genetic advance expressed as percentage means (∆G/X* 100) for fruit traits were presented in Table 7. The estimates for fulsibs were positive. The standard errors were about twice larger than the estimates for all the traits. The low estimate value recorded was for seed length (0.2900.761). The broad sense estimate values were positive, high estimate were recorded for all the traits with the exception of seed length which has estimate value of (0.646). For narrow sense heritability, negative estimates were recorded and unlike in the broad sense heritability, low estimate were recorded for all the traits. For the expected genetic advance (G), the estimates ranges from (16.977) for fruit weight to (2.438) for seed length. For expected genetic advance expressed as percentage means (∆G/X* 100) the highest value was recorded for fruits weight (387.603) and the lowest for fruit circumference (80.018).

Table 7: Estimates of fulsib Heritability, Broad Sense Heritability, Narrow Sense Heritability, Expected Genetic Advance (∆G) and Expected Genetic Advance Expressed as Percentage of Mean for fruit traits

Traits	Fulsibs h^2	Broad Sense h^2	Narrow sense h^2	∆G	(∆G / X) 100
Fruit weight	0.451 ± 0.945	0.984	- 0.083	17.977	387.603
Fruit length	0.450 ± 0.950	0.985	-0.083	3.511	87.821
Fruit circumference	0.415 ± 0.911	0.908	-0.075	4.325	80.018
Mesocarp thickness	0.442± 0.941	0.984	-0.098	4.668	203.133
Mesocarp weight	0.452 ± 0.95	0.989	-0.085	5.649	172.068
Seed length	0.290 ± 0.761	0.646	-0.067	2.438	95.309
Seed circumference	0.451 ± 0.950	0.990	-0.088	3.473	126.216
Seed weight	0.445± 0.944	0.987	-0.095	2.735	250.000

According to Silva (1974), since variance by definition is either zero or larger than zero, the negative estimates of narrow sense heritability are disturbing and they must either be estimates of true zero value or they reflect some deficiency in the model.

Broad sense heritability was used because the date palm, a perennial plant, has a very large generation interval. Broad sense heritability reflects all possible genetic contribution to population phenotypic variance. Using the broad sense heritability estimates in the early stages of breeding work. Osuhor (1983) reported that broad sense heritability does not distinguish between components of genetic variance such as additive variance (A) and dominance variance (D) and as such it is difficult to make reliable predication of genetic advance through selection. However, Kaul and Bhan (1974) stated that broad sense heritability may be useful when high genetic gain is possible. In crops that can be asexually propagated by clones like date palm, both additive components of genetic variance are flexible, hence broad sense heritability with the exception of seed length, and they all have low genetic gain which indicates that the heritability is mainly due to non-additive gene effect. This is also in agreement with the findings of (Johnson et al., 1955; Panse, 1957; Swarup and Chaugale, 1962; and Otegbeye, 1989). According to Otegbeye (1989), if broad sense heritability is high it shows that the traits are under strong genetic control and some of the traits studied were found to be under strong genetic control than others. It was observed that high heritability was not in most cases associated with high genetic advance, which is in agreement with the findings of Swarup and Chaugale (1962). However, broad sense heritability estimate for one trait is useful when high genetic advance in that trait is feasible (Otegbeye, 1989). High heritability with high genetic advance for a trait means that additive gene effect is involved while low genetic advance would be obtained if heritability is mainly due to non-additive gene effects (Otegbeye, 1989). It was necessary that expected genetic advance be estimated to know what level of improvement can be expected from selection of each of the characters examined.

Among the palms used for this study, male 1R12 GP111, 6R3 GP 111 and 1R7 NCRP performed better than the rest. Mass, family and backcross selection are recommended for further breeding programs in development of date palm in Nigeria.

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