MATERNAL INHERITANCE OF KERNEL SIZE IN THE OIL PALM, *Elaeis guineensis* JACQ

KEYWORDS: *Elaeis guineensis*; Kernel size; Sex-determined inheritance; Extrachromosomal gene(s); Oil palm breeding

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A study of the inheritance of kernel size in the oil palm, Elaeis guineensis *Jacq., was conducted using the wide range of crosses between forms from the NIFOR breeding programme.*

Estimates of narrow sense heritability (h^2) using parent offspring regression analyses were carried out for 24 dura *(D) x* dura *(D), 13* dura *(D) selfings, 49* tenera *(T) x* tenera *(T), 24* tenera *(T) selfings, 33* dura *(D) x* tenera *(T) and 30* tenera *(T) x* dura *(D) crosses.*

Comparable levels of estimates were obtained for mid-parent-offspring comparisons of both dura *(D) and* tenera *(T) offsprings in all crosses except in T x D. For individual parent-offspring comparisons in D x D, D x T and T x D crosses, the female parents determined the kernel size of both the* dura *and* tenera *offspring. This sex-determined inheritance of kernel size was not apparent in T x T crosses.*

The inheritance of kernel size in the oil palm was considered to be determined by extrachromosomal gene(s) (plasmagenes) present in the endosperms of both dura *and* tenera *fruit forms but their expression may require interaction with gene(s) present in the* dura *form.*

INTRODUCTION

The oil palm, *Elaeis guineensis* Jacq. is characterized by polymorphism in its fruit composition. The presence or absence of shell in the fruit, determined by a single major gene with incomplete dominance, forms the basis for fruit form classification (Beinaert and Vanderweyen, 1941). The thick-

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shelled *dura* fruit form is homozygous dominant for the shell gene (*DD*) while the shell-less *pisifera* fruit form is homozygous recessive (*dd*). The thin-shelled *tenera* fruit form is heterozygous for the shell gene (*Dd*). Along with differences in shell characteristics of these three forms, there are also differences in fruit size, and kernel and mesocarp to fruit ratios. The *dura* form has generally larger fruits, characterized by larger kernels and thinner mesocarps than the *tenera* form. The shell-less *pisifera*, which rarely produces mature bunches, has fruits with little or no kernel and also has a high frequency of parthenocarpy and immature fruits. The variation in fruit composition among the three forms has been studied by Sparnaaij *et al.* (1963).

Fruit components, generally known not to be affected by environmental changes, are therefore considered highly heritable traits with selection traditionally based on phenotypic values of the parents. However, limited published estimates of heritability for kernel size tend to vary for the different forms. In estimating heritability using regression of parent on offspring, Menendez and Blaak (1964) obtained slightly different values for *dura* and *tenera* parents when compared with their *dura* and *tenera* offsprings respectively. Different values were also obtained for *dura* parents with their *tenera* offspring in *dura* x *pisifera* crosses. The average value of heritability for kernel to fruit ratio was found to be approximately 61 per cent. Meunier *et al.* (1970), using regression of mid-parent on offspring, in a population of 96 Deli x *tenera* and *tenera* x Deli crosses, did not obtain the same kernel to fruit ratio for *dura* offspring as for *tenera* offspring. While 65% was obtained for *tenera* offspring, 29% was obtained for *dura* offspring. Van der Vossen (1974) obtained 67% and 60% respectively for kernel to fruit ratio in *tenera* x *tenera* and *dura* x *tenera* crosses by regressing mid-parent value on *tenera* offspring; they concluded that inter-fruit form comparisons for fruit components were less correlated than intra-fruit form comparisons.

The objective of the present study was to analyse the various intra and inter-fruit form crosses derived from the first cycle of the reciprocal recurrent selection (RRS) breeding programme of the Nigerian Institute for Oil Palm Research (NIFOR), with a view to establishing the mode of inheritance for kernel size in the oil palm.

MATERIALS AND METHODS

Crosses from the first cycle reciprocal recurrent selection (RRS) oil palm breeding programme of NIFOR, Benin City, Nigeria, were analysed for this study. The population was particularly suitable for the purpose as *dura* x *tenera*/*tenera* x *dura* test crosses were carried out simultaneously, along with *dura* x *dura*, *tenera* x *tenera* recombinants as well as *dura* and *tenera* selfings for future seed production. The details of the six types of crosses evaluated are presented in *Table 1*.

Fruit analysis by weight percentages as described by Blaak *et al.* (1963) was carried out on an individual palm basis. The parents were evaluated over a long period of time, from the early 1950s through the 1960s. Between 15 and 49 analyses were carried out on each parent and used to determine parental value. For the progenies, the average number of analyses per palm was between 3.5 and 6.2. The progeny means for the different fruit forms were determined based on the evaluation of between 15 and 39 palms. Parent-offspring regression analysis was then carried out between each parent/mid-parent value on progeny mean value for each segregating fruit form. Narrow sense heritability was estimated as twice the regression coefficient for single parent-offspring analysis and by the regression coefficient for the mid-parent-offspring analysis (Falconer, 1960). The level of significance of the estimates was determined by a calculated Student-t estimated as $t = b/s_b$, where b is the regression coefficient and s_b is the standard error.

RESULTS

The mean kernel to fruit ratio (% K/F) and the coefficient of variation for parents and offsprings in the different types of crosses are presented in *Table 2*. The *tenera* progeny % K/F in all segregating crosses gave lower values than the *dura* sibs. The *tenera* mean % K/F as a fraction of *dura* mean % K/F was similar for *tenera* x *tenera* and *tenera* selfed progenies (0.77 and 0.78 respectively) and for *tenera* x *dura* and *dura* x *tenera* crosses (0.81 and 0.86 respectively).

The narrow sense heritability (h^2) estimated by parent-off spring regression for the different crosses is presented in *Table 3*. In *dura* x *dura* crosses, h^2

TABLE 1. SUMMARY OF THE SIX INTER AND INTRA FRUIT FORM CROSS TYPES EVALUATED

Type of Cross	Number of Crosses	Year Planted	Average Bunch Analysis Per Palm	Average Number of palms Analysed Per Progeny	
				Dura	Tenera
Dura X Dura	24	1960 - 63	3.5	39.2	-
Dura Selfed	13	1962 - 65	4.1	22.1	-
TeneraX Tenera	49	1960 - 63	6.2	19.4	32.6
Tenera Selfed	24	1960 - 64	5.7	15.6	30.4
Dura X Tenera	33	1962 - 64	4.4	20.1	20.3
Tenera X Dura	30	1962 - 64	4.0	20.4	20.1

estimated by the female parent is higher (0.56) than the value estimated by the male parent (0.14), but is similar to the h^2 estimate obtained for *dura* selfings (0.60). In segregating *tenera* x *tenera* crosses, female and male parents gave similar h^2 estimates (0.45 and 0.46 respectively) for the *dura* offspring. Similar h^2 estimates for *tenera* offspring (0.61 and 0.67 respectively) were also obtained for both parents. The h^2 estimates for *tenera* offspring of the *tenera* x *tenera* crosses were higher than those obtained for *dura* offspring for either the female or male parents or for the mid-parent value. Similar estimates were obtained for intra-form comparisons of mid-parents to offspring in *dura* x *dura*, *dura* selfings, *tenera* x *tenera* and *tenera* selfings.

For *dura* x *tenera* crosses with *dura* as the female parent, very high h^2 estimates were obtained for both *dura* and *tenera* offsprings (0.74 and 0.91 respectively). However, with the *tenera* as male parent, very low values (0.14 and 0.17 respectively) were obtained for *dura* and *tenera* offsprings. Heritability estimates for mid-parent values were also low and similar for either *dura* or *tenera* offspring (0.27 and 0.33 respectively). For the reciprocal *tenera* x *dura* crosses, using *tenera* as the female parent, h^2 estimated by the *tenera* female parent on *dura* offspring was high (0.60) and higher for *tenera* offspring (1.22). With the *dura* male parent, h^2 estimated were much lower and similar (0.40 and 0.38 respectively) for *dura* and *tenera* offsprings. Regression with mid-parent value in *tenera* x *dura* crosses gave higher h^2 value for *tenera* offspring (0.94) than for *dura* offspring (0.54). The higher h^2 estimates associated with intra-fruit form comparison which were apparent in *tenera* x *tenera* crosses and *tenera* selfings were not seen in *dura* x *tenera* crosses. They were only obvious between *tenera* parent and *tenera* offspring in *tenera* x *dura* crosses.

DISCUSSION

The regression of parent on offspring to estimate narrow sense heritability (h^2) is based on the assumptions of normal diploid Mendelian inheritance, no environmental correlation among relative, population in linkage equilibrium, the relatives non-inbred, and the genetic population mating at random. Heritability estimates by this method tend to be inflated if there is environmental correlation among relatives (Vogel *et al.* 1980). Since estimates are valid, both when parents are selected or are chosen at random from a population, this method of estimating heritability is favoured in evaluating breeding populations (Falconer, 1960).

Though parent-offspring regression methods have been used to estimate heritability for kernel to fruit ratio in the past, most often mid-parent values were used. The estimates for this ratio obtained by Menendez and Blaak (1964) and Van der Vossen (1974) (0.61 and 0.66) are quite comparable with the estimates of 0.54 and 0.56 obtained in this study for both *dura* x *dura* and *tenera* x *tenera* crosses.

The earlier work of Meunier *et al.*, (1970) and Van der Vossen (1974) which showed that inter-fruit form comparisons for kernel to fruit ratio were less correlated than intra-fruit form comparisons is fur-

TABLE 2. THE MEANS AND THE COEFFICIENTS OF VARIATION (CV%) OF KERNEL TO FRUIT RATIO (% K/F) FOR THE PARENTS AND OFFSPRING IN DIFFERENT TYPES OF CROSSES

Type of Cross	No. of Crosses	Parent						Offspring				
		Female Mean %K/F	CV %	Male Mean %K/F	CV %	Mid-Parent Mean %K/F	CV %	Dura Mean %K/F	CV %	Tenera Mean %K/F	CV %	Tenera %K/F As Fraction of Dura %K/F
Dura X Dura	24	11.5	13	10.7	10	11.1	7	11.6	10	-	-	-
Dura Selfed	13	11.0	13	-	-	-	-	10.9	14	-	-	-
Tenera X Tenera	49	7.0	34	6.8	24	6.9	22	10.8	12	8.4	16	0.77
Tenera Selfed	24	7.6	35	-	-	-	-	10.1	18	8.0	27	0.78
Dura X Tenera	33	11.6	10	7.5	33	9.5	14	11.3	11	9.7	12	0.86
Tenera X Dura	30	7.0	22	10.8	11	8.5	11	10.7	10	8.7	16	0.81

TABLE 3. PARENT-OFFSPRING REGRESSION FOR KERNEL-TO-FRUIT RATIO (%K/F) IN DIFFERENT TYPES OF CROSSES

Type of Cross	N	Parent	Offspring					
			Dura			Tenera		
			b	h^2	$t = \frac{b}{s_b}$	b	h^2	$t = \frac{b}{s_b}$
Dura X Dura	24	Female	0.2792	0.56	1.829NS	-	-	-
	24	Male	0.0706	0.14	0.309NS	-	-	-
	24	Mid-parent	0.5424	0.54	1.9385NS	-	-	-
Dura Selfed	13	Female = Male	0.5961	0.60	2.1986*	-	-	-
Tenera X Tenera	49	Female	0.225	0.45	3.0907**	0.3072	0.61	6.8725**
	49	Male	0.2323	0.46	1.9358NS	0.3346	0.67	2.902**
	49	Mid-parent	0.4087	0.41	3.6556***	0.5591	0.56	5.7051***
Tenera Selfed	24	Female= Male	0.5366	0.54	2.9162***	0.6701	0.67	3.2217***
Dura X Tenera	33	Dura Female	0.3681	0.74	2.1539*	0.4542	0.91	2.8388**
	33	Tenera Male	0.0703	0.14	0.8174NS	0.0859	0.17	1.0263NS
	33	Mid-parent	0.2739	0.27	1.8055NS	0.3286	0.33	2.2678*
Tenera X Dura	30	Tenera Female	0.2983	0.60	2.6375*	0.6108	1.22	5.1378***
	30	Dura Male	0.2002	0.40	1.2053NS	0.1898	0.38	0.8627NS
	30	Mid-parent	0.8347	0.54	3.008**	0.9363	0.94	4.1509***

NS = Not Significant

*; ** and *** = significant at 5%, 1% and 0.1% levels respectively

ther confirmed in this study only for *tenera* parents and their segregating *tenera* offspring in *tenera* x *tenera* and *tenera* x *dura* crosses, and *tenera* selfings. This was not the case with *tenera* offspring and *tenera* parent in the reciprocal *dura* x *tenera* crosses. A higher heritability estimate for intra-fruit form comparison of *dura* parents in *dura* x *tenera* or *tenera* x *dura* crosses was not evident, thus indicating some basic difference between the *dura* and *tenera* forms in the transmission of this trait in the oil palm. The difference was further exemplified by the results obtained from *dura* x *dura* and *tenera* x *tenera* crosses. In *dura* x *dura* crosses, the transmission of the trait is influenced by the sex of the parent, and the % K/F of the *dura* offspring is, to a greater extent, determined more by the female parent than by the male parent.

In inter-fruit form *dura* x *tenera* crosses where the *dura* form is the female parent, the effect of the *dura* parent is as in *dura* x *dura* crosses, with the female parent determining the % K/F of both the *dura* and *tenera* offsprings. The *tenera* male parent in *dura* x *tenera* crosses behaves similarly to the *dura* male parent in *dura* x *dura* crosses. Similarly, in the reciprocal *tenera* x *dura* crosses with *tenera* as female and *dura* as male parent, the female *tenera* parent also determines the % K/F of the *dura* and *tenera* offspring.

Earlier reports have been based on mid-parent comparison, so that possible sex determined inheritance for kernel-to-fruit ratio could not be evaluated as has been done in this study. The sex determined behaviour of the *dura* parent in *dura* x *dura*, *dura* x *tenera* and *tenera* x *dura* crosses for *dura* and *tenera* offsprings is similar to that of the *tenera* parent in *dura* x *tenera* and *tenera* x *dura* crosses. In the oil palm, the kernel is the endosperm. Maternal influence of the endosperm on phenotypic expression of traits by offspring is commonly attested in the literature. Offsprings subjected to different maternal environments during the sensitive period of development may show differences in phenotype in reciprocal crosses. Thus even if the contributions of male and female parents to the genome and plasmon of offspring are equal, the female parent, because of its special contribution to the early development of the embryo, may still exert a greater influence on its phenotype. This special contribution to the early development may be in the form of activities of extrachromosomal genes (plasmagenes), leading to the differences in phenotype observed in some reciprocal crosses.

It is also known that extrachromosomal systems in certain instances may be influenced by chromosomal genes which may alter the stability of their components, as in the case of the recessive *iojap* gene, which gives rise to white striped maize plants when homozygous (Jinks, 1964). In such cases, expected differences in reciprocal crosses may not be observed but deviation may remain consistent.

Heritability estimates obtained on regression of female *dura* on both *dura* and *tenera* offsprings in all crosses involving *dura* showed obvious maternal influence on the inheritance of % K/F. In *tenera* x *tenera* crosses, heritability estimates obtained did not show such an influence. However, in *tenera* x *dura* crosses with *dura* as the male parent, there was obvious maternal influence of the *tenera* on the offspring for the character. It would then appear that the factors responsible for the expression of the maternal influence by the *tenera* parent resulted from some interaction of extrachromosomal gene(s) with chromosomal gene(s) present only in male *dura* gamete but not in the *tenera* male gamete.

Concluding, therefore, inheritance of kernel size in the oil palm is sex determined. It may be attributed to plasmagenes of the maternal parent of both *dura* and *tenera* fruit forms but its expression may be obvious only in the presence of chromosomal gene(s) of *dura*. This may be described as a form of uniparental inheritance.

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