Heritability and Number of Genes Governing Pod Yield in West African Okra (*Abelmoschus caillei* (A.chev) Stevels

Adeniji and Olawale Taiwo
Department of Crop Science, Adamawa State University,
P.M.B. 25 Mubi, Adamawa State, Nigeria

Abstract: Heritability, genetic action and number of genes moderating the inheritance of pod yield was investigated in 5 crosses of West African okra accessions. Parents with variation for pod yield were used in hybridization process. Generations developed (parents, F_1, F_2 and BC_1 BC_2) were planted for evaluation in a randomized complete block design with 2 replications. The results showed that the additive-dominance model was adequate in explaining the inheritance of pod yield. This was ascribed to a non significant estimate of A, B and C scaling tests. The results of the generation mean analysis indicated that the additive genetic effects (d) significantly accounted for a large proportion of variability observed for pod yield in the crosses evaluated. A partial dominance loci (H/D<0.75) and over dominance loci (H/D>1.00) revealed an intermediate performance and the possibility of developing hybrids for pod yield. Narrow sense heritability estimates (sensus stricto) were low to moderate. An additive genetic effect suggests that selection among segregating population could provide an average improvement in the performance of pod yield in subsequent generations. The study indicated that the inheritance of pod yield was polygenic, thus safeguarding against genetic loss of pod yield in selection process.

Key words: West African Okra, polygenic, additive gene action, generation means, pod yield and hybridization

INTRODUCTION

West African okra (*Abelmoschus caillei*) belongs to the family Malvaceae. It is photo period sensitive (short day) and cultivated primarily for its fresh pods and leaves. In Sub Sahara Africa, the utilization of West African okra seeds for nutritional and biomedical purposes is limited, as compared with *Abelmoschus esculentus* from the Asian continent. West African Okra grows naturally in this environment; the availability of lowland ecology (Fadama) has encouraged dry season cultivation of this crop. Nutritionally, Okra pods contain 85ml water, 2.1 g protein 0.2 fat 8 g carbohydrate 332.72 mg vitamins in 100 g of edible portion (Berry *et al.*, 1988). Pod yield in Okra has been identified to be a function of physiological and agronomic characters acting singly or in interaction with each other (Adeniji and Peter, 2005). During vegetative phase of growth in West African Okra, the leaves and the roots are the only competetory sink for assimilate. At the on set of reproductive phase the reproductive parts could be competetory sink for seed bound assimilate. Genetic studies in West African Okra is limited (Ariyo, 1993) reported the existence of genetic diversity in West African Okra accessions. Kehinde and Adeniji (2003) indicated that West African okra pods are either pigmented or non pigmented, pubescent or glabrous and arranged in vertical or horizontal direction. In addition, Adeniji and Kehinde (2003) had noted the preponderance of additive genetic action in the inheritance of pod length and width, seeds per pod and seed per ridge.

Heritability of metric characters has been identified as a genetic relationship between the parents and the offspring. This genetic components has been widely used to asses the degree to which a character is transmitted from one parent to the offspring. Genetic information on heritability could as well indicate the possibility and the extent to which improvement in a character is possible. More often in biological research, broad and narrow sense heritabilities are used to evaluate the proportion of heredity and environment in the expression of a character. In West African Okra, high narrow sense heritability has been reported for pod length and width, plant height and number of seeds/pod (Adeniji, 2003).

West African Okra pods are consumed fresh (a maximum of 7 days after anthesis). Obviously a high number of pods/plant is a desirable horticultural characteristic for genetic improvement in West African Okra. Since this Okra specie has a higher pod yield potential compared with *A. esculentus* (Adeniji, 2003)

Corresponding Author: Adeniji, Department of Crop Science, Adamawa State University, P.M.B 25 Mubi, Adamawa State, Nigeria

therefore exploiting genetic divergence and pod yield potential could provide basis for hybridization and a better understanding on inheritance paradigm and heritability for pod yield. This will consequently give rise to the possibility of evolving in the short run pure lines and hybrids into the cropping system. This present investigation was carried out to evaluate: The mode of inheritance and genetic control of pod yield ,and heritability and heterotic estimates for pod yield in West African Okra.

MATERIALS AND METHODS

Experimental materials, location and design: Six accessions of West African okra (Acc11, 21, 31, 71, 81 and 91) were sourced from the germplasm collection of the University of Agriculture, Abeokuta Nigeria. Existing accessions in the germplasm collection of the university were collected. Two to three seeds of each accession were planted in polythene pots (35 cm width×25 cm length) filled with sterilized soil. Five pots were allotted to each parental in the screen house, Department of Plant Breeding and Seed Technology, University of Agriculture Abeokuta. Single crosses without reciprocals were carried out among the accessions to produce the first filial generation seeds. Mature flower buds which are likely to open the next day were selected for emasculation, because the stigma of *Abelmoschus caillei* remains receptive on the day of anthesis. Flower buds for emasculation were held gently to avoid stress on the fragile attachments of the buds. A slight ring was made at the base of the flower bud with the help of a blade, to facilitate easy removal of the petals, along with calyx sheath to expose the staminal tubes and the stigma. Undehisced anthers were removed using a pair of forceps. Male flowers were selected by 11:00 h and preserved in a cold environment (-5-10°C) for use in hybridization among the parents, which was carried out in the evening. F_1 seeds were planted in pots and each F_1 plant was allowed to self pollinate to produce F_2 seeds. Subsequent flower buds were backcrossed to the parents.

Field evaluation of the parental, F_1, F_2, BC_1 and BC_2 was carried out in 2003 at the Teaching and Research Farm, University of Agriculture, Abeokuta Nigeria. (Lat 7.53°N, 3.88°E, 458 m asl). The experimental layout was a randomized complete block design with three replications. The plot consisted of a single row of 10 meters long with an inter row measurement of 1 m. The number of rows for each replication was three for each non segregating generation, 4 for each back cross and F_2 generations 2-3 seeds of each generation were planted per hole, with an intra row spacing of 0.60 m and later thinned to one

plant per stand. The plots received equal dosage of fertilizer (NPK 15:15:15) at the rate of 60 kg Ha^{-1}, 2-3 weeks after planting and at flowering.

Data collection and analysis: Pod yield per plant was consistently collected on 64 stands for each parent and F_1 generation 96 stands for each backcross generation and 128 stands for each F_2 generation. Pod yield was determined by counting the number of pods per plant over replications. The individual scaling tests of Mather (1949) were employed to test their fitness to the additive-dominance model. The generation mean analysis was calculated using the method of Mather and Jinks (1971) where m is the mid point, d is the additive genetic effects, h is the dominance genetic effects, I is the additive× additive genetic effects, j is the additive×dominance genetic effects and l is the dominance×dominance genetic effects. P1 is the parent with a high mean value, while P2 is the parent with a lower mean value. B_1 and B_2 are corresponding backcrosses to parent 1 and parent 2, respectively. The significant test for the various genetic effects for this model were determined by computing the Standard Error (SE) form the variance of each corresponding population mean. The variance components E, D and H representing the additive variance, dominance variance and environmental variance were calculated as specified by Scheffe (1959). Broad sense and narrow sense heritability estimates were estimated as specified by Warner (1952).

RESULTS AND DISCUSSION

Table 1 shows the estimate of generation means and within plot variance for pod yield in the crosses of West African Okra. Under additive gene action, the F_1 mean is expected to be midway between the means of their parental combinations (Mather and Jinks, 1971). This observation is true for the cross Acc11×Acc31. But other crosses showed that the F_1 mean tend towards the parent with a low number of pods per plant. This could imply a dominance of a low pod number per plant in this cross. The F_1 mean for the number of pods per plant was less than the mid parent value in all the crosses evaluated. The F_2 mean were intermediate between the better parent value and the mid parent value. The within plot variance for the segregating generation were greater than the variance estimates of the parental and the F_1 generations The high variance estimates recorded for the F_2 generation revealed that a substantial estimate of the genetic variability for pod yield does exist among the segregating F_2 generations. Thus providing a frame work to advance selection for genetic improvement in pod yield. The mean

Table 1: Estimates of generation means and within plot variance for pod yield in crosses of West African Okra (*A. caillei* (A. Chev) Stevels)

Acc11 11.27±3.56	Acc21 29.00±1.97	Acc11 27.61±3.56	Acc21 29.00±1.97	Acc91 21.40±3.40
Acc31 13.00±2.70	Acc31 13.00±2.70	Acc81 19.00±1.01	Acc71 18.00±2.44	Acc31 13.00±2.70
F_1 16.89±4.79	F_1 13.60±4.29	F_1 10.00±1.01	F_1 18024±5.38	F_1 10.60±5.20
Bc_1 16.80±4.79	Bc_1 18.27±5.24	Bc_1 18.79±2.25	Bc_1 22.07±3.25	Bc_1 18.27±4.24
Bc_2 12.99±5.33	Bc_2 15.00±3.06	Bc_1 19.21±2.21	Bc_2 18.27±5.21	Bc_2 12.00±3.06
MP 20.31	MP 21.00	MP 23.31	MP 23.30	MP 17.20

Table 2: A, B and C scaling test for pod yield in West African Okra (*A. caillei* (A. Chev) Stevels)

Acc11×Acc31	Acc21×Acc31	Acc11×Acc81	Acc21×Acc71	Acc91×Acc31
A -14.65±11.07ns	A -3.06±10.95ns	A -0.03±5.74ns	A -3.06±10.95ns	F_1 10.60±5.20
B -6.46±17.25ns	B -0.46±7.13ns	B 9.42±4.74ns	B -0.46±7.13ns	Bc_1 18.27±4.24
C -15.34±10.24ns	C -10.33±9.74ns	C 12.79±14.93ns	C -10.33±9.74ns	Bc_2 12.00±3.06

Table 3: The estimates of genetic effects using six parameter model of the parents F_1, F_2 BC_1 and BC_2 for pod yield in crosses of West African Okra (*A. caillei* (A. Chev) Stevels)

Acc11×Acc31	Acc21×Acc31	Acc11×Acc81	Acc21×Acc71	Acc91×Acc31
M 22.85±28.34ns	25.66±21.12ns	26.39±15.76ns	15.90±24.83ns	21.88±23.70ns
[d] 6.98±2.16*	8.00±1.58*	4.37±1.86*	5.50±1.57*	4.20±2.10*
[h] -32.20±5.26*	-2.38±56.33ns	9.99±1.33*	6.38±56.86ns	-10.98±53.13ns
[i] -5.22±28.16ns	-4.66±21.01ns	-3.26±12.09ns	7.60±24.78ns	-4.86±23.60ns
[j] -6.34±14.57ns	-3.46±12.85ns	-9.45±7.32ns	-3.40±13.55ns	4.14±11.27ns
[l] 25.37±38.73ns	7.32±27.97ns	-5.99±19.54ns	-3.28±31.88ns	-0.2830.52ns

m = generation mean (d) = additive gene effect (h) = dominant gene effect (I) = additive×additive gene effects (j) additive×dominance gene effects (l) dominant×dominant gene effects, *= significant (p<0.01) ns = not significant

values for pod yield subjected to the individual scaling test of Mather (1949) showed that the A, B and C scaling tests were not significantly different from zero. This is a clear indication of the adequacy of the additive dominance model in explaining the inheritance pattern for pod yield (Table 2). Furtherance, it indicates that the mean value for pod yield could be free from linkage bias.

The 6 parameter model (Mather and Jinks, 1979) for pod yield indicated that the estimates of the additive gene effects (d) were significant (p<0.05) and greater in magnitude as compared with the dominant gene effects (h) in all the crosses evaluated (Table 3). This foregoing genetic information could as well imply that the additive gene action form a high proportion of the mean effects. Hence the inheritance for pod yield was additive. This result agrees with the findings for length and width of pods in West African okra (Adeniji, 2003). In situations where the additive gene effects moderate the inheritance pattern, early selection among the segregating population could be worthwhile for genetic improvement in this specie. The estimates of dominant gene effects (h) were low in magnitude and negative (Acc21×Acc31, Acc11×Acc31, Acc21×Acc31, Acc11×Acc81 and Acc91×Acc31). This however had a low impact on the expression of the phenotype (pod yield) in the crosses evaluated. Interaction components I (additive×additive, j (additive×dominance) and l (dominance×dominance) were low in magnitude, non-significant, positive or negative in direction. the study showed that the additive×dominance digenic interaction are positive in some crosses and negative in others, implying the potential for enhancement and depression of pod yield as the case may be. A non

significant interaction components (I, j, l) in all the crosses evaluated, indicated additivity in the inheritance of pod yield. This agrees with the conclusions of the individual scaling test A, B and C for pod yield.

The result of the component analysis for pod yield (Table 4) showed that the estimates of the additive gene effects (D) were greater in magnitude as compared with the dominant gene effects (H) across loci in 4 crosses out of five crosses evaluated. This suggests the preponderance of the additive gene effects in the inheritance of pod yield. The estimates of dominant gene effects were found to be greater than the additive gene effects and environmental variation (E) in the cross Acc21×Acc31. This may be ascribed to the preponderance of dominant gene effects in the inheritance of pod yield in this cross. A unidirectional dominance of a lower pod yield (H) across loci among the segregating generations towards the parents with a lower pod number was observed in the 2 crosses (Acc11×Acc81, Acc91×Acc31). In addition, the presence of dominance was indicated by the estimated value ofv H/D, which were between 0.50 and 3.24, suggesting both partial and overdominance loci in the inheritance of pod yield in Acc11×Acc31, Acc31×Acc71, Acc21×Acc31. This foregoing statement indicates the possibility of developing hybrid varieties for pod yield in West African okra.

The study indicated that the broad sense heritability estimates were never below 40%, but the narrow sense heritability estimates range between 6 and 43%. A low to moderate heritability estimate in narrow sense recorded in this study is in consonance with findings

Table 4: Components of genetic variation for pod yield in crosses of West African Okra (*A. caillei* [A. Chev] Stevels)

Genetic components	Acc11xAcc31	Acc21xAcc31	Acc11xAcc81	Acc21xAcc71	Acc91xAcc31
E	3.64	2.49	1.72	1.65	2.82
D	4.00	0.48	5.32	4.6	6.56
H	1.68	6.08	-3.36	5.72	-3.34
$\sqrt{H/D}$	0.65	3.20	-	1.24	-
HB	0.40	0.47	-0.51	0.69	0.47
HN	0.33	0.06	-	0.43	-
MPH	0.94	0.63	0.45	0.93	0.62
N1	12.18	13.30	3.59	5.58	2.69
N2	11.02	17.77	4.98	4.18	3.57
N3	11.00	19.50	4.99	4.06	3.57
N4	13.30	114.00	3.43	6.59	2.68
N5	11.46	264.32	-	8.78	-

E = environmental variation, D = additive gene effects, H = dominant gene effect, $\sqrt{H/D}$ = dominance ratio, Hb = broad sense heritability, Hn = narrow sense heritability, MPH = mid parent heterosis, N1-N6 = effective factors

of Ariyo (1993) in *Abelmoschus esculentus* (L) Moench. High additive gene effect and moderate heritability estimates in narrow sense suggest an average performance in pod yield, if the segregating generations are selected for improvement in pod yield. However, a pedigree program could be worthwhile to advance improvement in pod yield. Narrow sense heritability estimates were low (0.06) in Acc21×Acc31, this may be ascribed to the presence of non additive gene effects and the influence of environmental factors in the inheritance of this character. Therefore improvement for pod yield in this cross will require a recurrent selection procedure, to allow for recombination in the subsequent generations before the final selection for pod yield is made.

CONCLUSION

The methods of estimating the minimum number of effective factors in the genetic system of pod yield is dependent on the assumption that there was no epistatic variation and all the genes had equal effects, dominance and epistasis were absent. The study indicated that a minimum of three genes govern the inheritance of pod yield in West African okra. This suggest a polygenic action in the inheritance of pod yield. The presence of a higher estimate of dominance for pod yield in this study may result in an underestimation of the actual number of segregating genes. The study showed a high level of homogeneity among the estimates of the minimum number of effective factors for pod yield from the methods employed in the analysis. Both additive gene effects and non additive gene effects were found in the inheritance of pod yield. The possibility of developing pure lines and hybrids were evinced in this study. The polygenic inheritance observed indicated that genotypes with stable performance could be developed.

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