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Genetic Studies on Earliness in West African Okra (*Abelmoschus caillei* [A. Chev.] Stevels)

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Abstract: A total of 3, 360 plants from six generations of West African Okra (P_1, P_2, F_1, F_2 BC_1, BC_2) derived from crosses between early and late maturing accessions of West African Okra were used to evaluate inheritance pattern of earliness. Using the generation mean analysis, the additive gene effect was important in the inheritance of earliness as compared with other gene effects. A high additive gene accounts for high heritability estimates recorded for earliness. As found in the study the relative proportion of additive gene effect was important for high heritability estimates recorded. This suggests that its contribution to the inheritance of earliness is ideal for developing hybrids and purelines.

Key words: Segregating generation, additive, generation, heterosis, heritability

INTRODUCTION

West African Okra (*Abelmoschus caillei* [A. Chevy] Stevels) is a common household vegetable crop, cultivated primarily for its fresh pods and leaves. Nutritional importance of okra pods have been documented (Adeniji, 2003). Developing early flowering and consequently early maturing genotypes of West African Okra with short growth cycle, high pod and seed yield has become an important breeding objective in this crop. West African Okra is photoperiod sensitive (short day), with number of days to flowering ranging between 57 and 105 days in some accessions. Variation among accessions for days to flower bud appearance and flowering has been reported (Adeniji, 2003). This apparently makes it difficult cultivate this crop twice during the growing season. Early cultivation in March/April often results into excessive vegetative growth as compared with planting in July/August. A number of factors have been identified to influence flower bud initiation in crops, hence maturity and adaptation. Among these are photoperiod, temperature and intensity of radiation, insects and disease (Adeniji, 2003).

In the process of transition from late flowering to early flowering genotypes, important issues to be considered include the relationship among the parents for flowering and the genetic action involved. The economic importance of West African Okra makes developing hybrid of improved genetic potential ideal. Technological options for evolving early flowering genotypes of West African Okra will require explanation of inheritance pattern, heterotic components and heritability.

Developing early flowering and early maturing genotypes of crop, is costly and time-consuming phase of crop improvement. In maize (*Zea mays*), early maturing and extra-early varieties have been developed (IITA, 2000; Ogunbodede *et al*., 2000). Presents investigation intend to evaluate the genetic action underlying inheritance of earliness and its heritability. This will provide genetic information necessary to advance improvement in this specie.

MATERIALS AND METHODS

Six accessions of West African Okra were crossed, F_1, F_2, backcross progenies (Bc_1 and Bc_2) were produced for each of the five crosses. Parents, F_1 and segregating generations were evaluated at the

Teaching and Research Farm, University of Agriculture, Abeokuta (Latitude 7.35° N, 3.83° E, 450 m as1). The soil analysis of the experimental site collected at 1-15 cm indicated a pH 5.10, total N (%) = 0.06, organic matter (%) = 1.10 Available P (mg kg^{-1}) = 2.80, Exchangeable Ca = (Cmo1kg^{-1}) = 1.51, Exchangeable (Cmo1 kg^{-1}) = 0.23, Exchangeable Mg. (Cmo1 kg^{-1}) = 0.48, Exchangeable Na (Cmo1 kg^{-1}) = 0.09, Total P (mg kg^{-1}) = 91.5, Texture is a loamy sand.

Six generation from the six crosses were planted for field evaluation in a randomized complete block design with three replications. Between and within row spacing was 1 m, respectively. Two seeds of each generation were planted per hole, 2-3 cm deep; a total of 560 plants were established for each cross. Compound fertilizer NPK 15: 15: 15 was applied to the plant at the rote of 60 kg N ha^{-1} at 2-3weeks after planting and at flowering. Data was collected from 64 plants for each parent and F_1 generation, 96 stands for each backcross generation and 128 stand for each F_2 generation. The individual scaling test of Mather (1949) was used to test the adequacy of the additive-dominance model for earliness in each case i.e.,

$$A = 2BC_1\text{-}F_1 - P_1$$
$$B = 2BC_2 - F_1 - P_1$$
$$C = 4F_2\text{-}2F_1 - P_2 - F_1$$

Generation mean analysis was conducted under the assumptions that observed variation was due to additive and dominance effects, with no epitasis or linkage (Mather and Jinks, 1971). The mean effect (m), pooled additive effect (d), pooled dominance gene effects (h), pooled additive×additive (i) and pooled additive×dominance interaction effects (j) and pooled dominance× dominance interaction effects (l) are related to the generation means by the following equations:

$$M = (P_1)/2 + (P_2)/2 + 4F_2 - BC_1 - BC_2$$
$$[d] = (P_1)/2 - (P_1)/2$$
$$[h] = 6B_1+6B_2\text{-}8F_2\text{-}F_1\text{-}1/2P_1\text{-}1/2P_2$$
$$[i] = 2B_1+2B_2\text{-}4F_2$$
$$[j] = 2B_1\text{-}P_1\text{-}2B_2+P_2$$
$$[l] = P_1+P_2+2BF_2+4F_2\text{-}4B_1\text{-}4B_2$$

The estimates were tested for significance by their respective standard errors. Degree of dominance (H) was completed as a ratio between the dominant genetic effects and additive gene effects across loci. Heritability estimates in broad and narrow sense were estimated as specified by Ketata (1952). Mid parent heterosis was computed as F1-Mp/Mp

RESULTS AND DISCUSSION

The number of days to flowering among the accession of West African okra varied between 58 days in accession 2 and 105 days in accession 1. The F_1 mean for earliness was intermediate between the two parents involved in each cross. The mid parent value for days to flowering was least (74 days) in the cross Acc3×Acc 6. F_1 mean were greater than the mid parent value in three crosses (Acc1×Acc2, Acc1×Acc3, Acc3×Acc4). The mean values of BC_1 and BC_2 were close in Acc3×Acc4 and Acc4×Acc5 for earliness (Table 1).

The A, B and C scaling test were statistically significant ($p<0.05$ and $p<0.01$) in two crosses (Acc1×Acc2, Acc1×Acc3). Significant and non-significant A, B and C scaling tests were recorded in Acc4×Acc5, Acc3×Acc6 and Acc3×Acc4. Significant scaling tests suggest adequacy of the additive-dominance scale in understanding the inheritance of earliness. Conversely, A non significant tests a clear indication of the inadequacy of the additive-dominance model in explaining the inheritance of earliness among the generation evaluated (Table 2).

Table 1: Estimation of generation means and within variance for days to plot flowering in West African Okra

Crosses	Acc1×Acc2	Acc1×Acc3	Acc4×Acc5	Acc3×Acc6	Acc3×Acc4
	105.00±0.40	105.00±0.40	91.50±0.97	85.00±0.21	85.00±0.33
	57.75±0.31	85.00±0.33	87.20±0.97	82.00±0.33	81.80±0.97
F_1	91.71±1.07	97.00±0.97	76.00±1.01	65.75±0.97	86.00±1.01
F_2	93.74±1.07	87.35±1.31	74.19±2.37	70.29±1.33	80.00±1.31
Bc_1	107.21±0.97	97.80±0.81	80.90±1.41	85.88±0.51	85.07±0.87
Bc_2	60.80±0.81	76.20±0.72	78.78±1.67	54.77±0.61	80.07±0.87
Mp	81.38	95.00	89.35	73.50	83.25

Table 2: A,B and C scaling tests for earliness

Crosses	Acc1×Acc2	Acc1×Acc3	Acc4×Acc5	Acc3×Acc6	Acc3×Acc4
A	17.71±2.25*	-6.40±1.93*	25.70±3.26*	21.01±1.37*	-0.98±1.56ns
B	-29.46±1.97*	-29.60±1.96*	-5.64±3.56ns	-18.21±14.70ns	-7.36±1.81*
C	28.79±5.63*	-32.60±5.61*	-33.94±9.76*	2.66±5.68ns	-18.80±5.71*

*Statistically significant at p<0.05; ns: non significant

Table 3: Estimates of gene effects using the six parameter model of parents F_1, F_2, BC_1 and BC_2 for number of days to flowering

Gene effects	Acc1×Acc2	Acc1×Acc3	Acc4×Acc5	Acc3×Acc6	Acc3×Acc4
M	121.92±5.82*	98.40±5.68*	67.75±10.46*	73.16±5.56*	73.09±5.66*
(d)	23.63±6.28*	10.00±0.26*	1.15±0.59*	11.50±0.20*	1.75±0.51*
(h)	-82.50±13.00*	-40.80±13.07*	20.51±20.11ns	-4.87±11.81ns	14.60±10.52ns
(i)	-40.54±5.31*	-3.40±5.67ns	22.60±12.44ns	0.14±5.55ns	10.16±3.65*
(j)	47.17±2.58*	23.20±2.23*	0.06±4.53ns	39.22±1.61*	6.36± 2.53*
(l)	52.29±7.61*	43.40±7.09*	-11.26±13.11ns	-2.94±5.51ns	-5.02±7.06ns

*Statistically significant at p<0.05; ns: non significant

Both additive and dominant gene effects were significant for earliness. Estimates of additive effects were positive and statistically significant (p<0.05) in the crosses evaluated. Dominance, additive×additive interaction effects and dominance×dominance digenic interaction effect were positive and negative in direction and statistically significant. But the additive×dominance digenic interaction effect was positive in direction. The measures of the relative contribution of additive and non-additive gene effects showed that additive gene effects made the major contribution to earliness in most of the crosses evaluated. The relative proportion of additive gene effects suggests that their contribution to inheritance of earliness is high enough to be significant in developing early maturing hybrids and purelines (Table 3).

The analysis indicate that of the individual type of digenic epistatic effects, dominance× dominance interaction effects though positive were relatively large in magnitude in two crosses (Acc1×Acc2) (Acc1×Acc3), suggesting an increasing effects. The additive× additive interaction effects on the other hand was statistically significant (Acc1×Acc2, Acc4×Acc5, Acc3×Acc4) suggesting an enhancing effects in the inheritance of earliness. The additive×dominance gene effects was positive and statistically significant (p<0.05) (Acc1×Acc2, Acc1×Acc3, Acc3×Acc6, Acc4×Acc3) and negative in Acc4×Acc5 implying the potentials for enhancement and depression of characters as the case may be. The results of the analysis are indicators assuming that a negligible epistasis would bias the dominance components to some extent. Therefore, inheritance of earliness has been found to be moderated by varying proportion of additive and non-additive gene effects.

A non significant I, J, l interaction effects revealed absence of non-allelic gene interaction in the Acc4×Acc5. This agrees with the conclusion of the individual scaling tests of Mather (1949). A significantly negative (h) and positive (l) observed in Acc1×Acc3, Acc1×Acc2 suggest involvement of duplicate epitasis. This precludes complication factors such as trigenic interaction and linkages. This cross combinations is highly undesirable for selection and consequently for genetic improvement.

This evaluation revealed that the additive gene effect was important for inheritance of earliness. This was evidenced by (i) The estimates of the degree of dominance which was invalidated due to a

Table 4: Components of genetic variation for days to first flowering in the crosses of West African Okra

Genetic variation	Acc1×Acc2	Acc1×Acc3	Acc4×Acc5	Acc3×Acc6	Acc3×Acc4
E	0.71	0.67	0.92	0.62	0.83
D	1.68	2.18	3.32	3.08	2.36
H	0.96	-1.80	-0.84	3.32	2.80
vH/D	-	-	-	-	-
Hb	0.46	0.49	0.61	0.53	0.37
Hn	-	-	-	-	-
MPH	1.13	1.01	0.85	0.89	1.03

E = Environmental variance; D = Additive variance; H = Dominant variance; Hb = Broad sense heritability; Hn = Narrow sense heritability; MPH = Mid parent heterosis; vH/D = Dominance ratio

negative estimates of dominance (H) across loci in all the crosses evaluated; (ii) estimates of additive gene effects were larger, positive and greater in magnitude as compared with dominant genetic effects (Table 4).

Broad sense heritability estimates were moderate (Acc1×Acc2, Acc1×Acc3, Acc3×Acc4) to high (Acc4×Acc5). The computation of the narrow sense was impossible due to a negative estimate of dominance (H). High estimates of broad sense heritability as found in this study suggest that the earliness among the generations was highly heritable. Similar result was obtained for maize (Ogunbodede *et al*., 2000). The presence of duplicate epistasis as found in this study might have inflated the estimates of heritability recorded. The estimates of mid parent heterosis were high, this range between 85 and 1.13% in cross combinations Acc4×Acc5 and Acc1×Acc2, respectively. This imply a high genetic determination for earliness among the crosses combinations Positive estimates of MPH for earliness suggest the presence of genes for development of earliness in the cross combinations. This present evaluation indicated that direct selection among segregating population may advance genetic improvement for earliness as well in incorporating earliness in elite lines.

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