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Additive, Dominance and Epistatic Variation for Yield and Yield Traits in Okra (*Abelmoschus esculentus* (L) Moench)

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ABSTRACT: *Triple Test Cross analysis involving three testers (P1, P2 and F1) and twenty lines was performed to detect epistasis for days to first flowering, node at which first flower appears, plant height, number of primary branches/plant, number of pods/plant and pod yield/plant. Epistasis was found to contribute significantly for all the traits, except node at which first flower appears and number of primary branches/plant. Additive effects were the main source of variation for node at which first flower appears, number of pods/plant and pod yield/plant, while both the additive and dominance effects were important for days to first flowering and plant height.*

Keywords*: Triple Test Cross, gene effects, okra, yield traits*

INTRODUCTION

The Triple Test Cross (TTC) design (Kearsey and Jinks, 1968 ; Jinks *et al.*,1969; Jinks and Perkins, 1970; Perkins and Jinks, 1971) is one of the most efficient designing for genetic analysis of breeding materials, since it provides an unambiguous test for the presence of epistatic variation and also independent and equally precise estimates of the additive and dominance components of genetic variation, besides providing additional information about the direction of dominance. In the present study, TTC has been applied for investigation of genetic systems controlling metric traits of yield and yield attributes and to evaluate the relative magnitude of additive and dominance components of variance in okra in order to formulate a proper breeding methodology and its further improvement.

MATERIALS AND METHODS

The experimental materials were generated following the TTC design (Kearsey and Jinks, 1968; Jinks *et al.*, 1969). For the present study, Arka Anamika and Pusa Sawani and their F_1s were crossed as female testers to twenty open pollinated varieties/ lines of okra to generate L_1i, L_2i and L_3i families of TTC. Sixty TTC families along with twenty two parents were grown in a randomized block design with three replications during the summer and rainy seasons. Each family was assigned a single row plot of 3m length with inter-row and intra-row spacing of 45 and 40cm, respectively. To ensure a uniform plant stand, the initial narrow spaced plant population was subsequently thinned at appropriate stage of growth. Five randomly selected plants per plot were used to record observations on days to first flowering, node at which firsts flower appears, plant height, number of primary branches / plant, number of pods / plant and pod yield / plant.

The TTC analysis of family means was carried out according to the methodology proposed by Kearsey and Jinks (1968), except that instead of F_2 individuals, twenty open pollinated varieties/breading lines were crossed to the testers (Ketata *et al.* 1976). The presence of epistasis was detected from the significance of variance of $L_1i + L_2i - 2L_3i$ values. Analysis of sums ($L_1i + L_2i$) and differences ($L_1i – L_2i$) provided estimates of variances due to sums (6_2s) = 1/8 and additive genetic variance (D) and differences (6_2d) = 1/8 the dominance variance (H).The average degree of dominance was computed as $(H/D)^{1/2}$. The parameter 'F' was computed as the variance of sums and differences such that sums / differences = -1/4 F and their F estimate was tested for significance by converting the co-variance into correlation (r sums /

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differences), which was subsequently tested at (n-3) d.f.

RESULTS AND DISCUSSION

Test for Epistasis

A reference to Table 1 clearly indicates that epistasis ($L_1i + L_2i - 2L_{3i}$) was found to be significant for all the yield contributing characters during both the summer and rainy seasons except node at which first flower appears and number of primary branches/plant, whereas interaction between epistasis x blocks was found to be non-significant in all the cases except plant height in summer season.

Test and Estimates of Components of Genetic Variance

The analysis of variance for sums ($L_1i + L_2i$) and difference items ($L_1i - L_2i$) was performed assuming no epistasis and the estimates are presented in Table 2. When the variance due to sums was tested with error variance, this component was found to be significant for all the characters except number of primary branches/plant in both the seasons. Similarly variance due to difference items were also important for the trait like plant height in both the seasons and days to first flowering in summer season. It was also observed that both sums ($L_1i + L_2i$) and difference items ($L_1i - L_2i$) were significant for plant height during both the summer and rainy seasons, when items due to sums x blocks and differences x blocks were tested against the within families variances, it was found that both of the block interactions were non-significant during both the seasons. Hence, the within families variances were the appropriate error items for testing the significance of main items for all the characters.

Estimates of Genetic Component, Directional Elements and Degree of Dominance

The estimates of genetic components of variance i.e. additive, dominance and other genetic parameters like directional element 'F' showing direction of dominance and degree of dominance $(H/D)^{1/2}$ are presented in Table 3.

Both the components (additive and dominance) were found to be important for days to first flowering and the additive components was greater in magnitude over dominance component during both the seasons and hence, partial dominance became the important feature for this trait. The non-significant estimate of 'F' genetic parameter when considered with significant 'H' component of genetic variance revealed ambidirectional dominance i.e. both increasing and decreasing alleles have equal contribution towards dominance.

For node at which first flower appears, the estimate of the additive component of genetic variance 'D' was only significant in both the seasons. The directional element 'F' being negative and non-significant in both the seasons suggests that genes with decreasing effect are more often responsible for these characters.

Highly significant estimates of both the components of genetic variance (D and H) were observed for plant height in both the seasons. The magnitude of 'H' component was relatively more as compared to 'D' component in both seasons and hence partial dominance became the important feature of these traits. The significant values of 'H' and non-significant values of 'F' in both the season revealed ambidirectional dominance i.e. both increasing and decreasing alleles have equal importance towards dominance contribution.

Both the components (additive and dominance) were found to be non-significant for number of primary branches / plant in both the seasons as a result, the estimates of degree of dominance and directional element do not bear any significance.

The estimate of additive components of genetic variance was found to be highly significant for number of pods/ plant during both the seasons whereas the dominance component of genetic variance was found to be non-significant. The estimate of additive variance was greater in magnitude as compared to that dominance component in both the seasons. The significant test of correlation (r) between sums and differences provides a indirect basis for testing the significance of directional element 'F' when the values was positive and non-significant during summer where it was negative and non-significant during rainy season, suggests that genes with decreasing effect are more often responsible for this character. The positive and non-significant 'F' value reveals the ambidirectional nature of dominance.

The estimate of additive component of genetic variance was found to be significant for pod yield / plant during both the seasons whereas the dominance component of genetic variance was found to be non-significant. The relative magnitude of component was invariably greater than that of 'H' component. When the values of 'r' (RF) and 'F' were considered together, it was found that the estimate of directional element 'F' was positive and non-significant for pod yield /

Table 1
Mean Square for Epistatic Deviation for the Six Characters of Okra

Source	*Season*	*d.f.*	*Days to first flowering*	*Node at which first flower appears*	*Plant height*	*Number of primary branches/ plant*	*Number of pods/ plant*	*Pod yield/ plant*
Epistasis	S	19	4.61**	0.09	8.45**	0.21	5.91**	1129.38**
(L_1i+L_2i-2L_3i)	R	19	2.33**	0.48*	526.18**	0.11	1.23	452.69*
Error	S	720	1.34	0.36	4.79	0.35	1.79	314.78
	R	720	0.84	0.21	11.29	0.33	0.95	291.03

*, ** Significant at P= 0.05 and P= 0.01 respectively, S-Summer, R-Rainy

Table 2
Analysis of Variance for Sums and Differences which Estimate Additive (D) and Dominance(H) Components of Variances for Different Characters in Okra

Source	*Season*	*d.f.*	*Days to first flowering*	*Node at which first flower appears*	*Plant height*	*Number of primary branches/ plant*	*Number of pods/ plant*	*Pod yield/ plant*
A. Additive Variance (L_1i + L_2i - L_3i)								
Sums	S	19	6.48**	0.22	199.07**	0.19	11.08**	2318.49**
	R	19	3.01**	1.09**	1813.24**	0.15	2.36**	510.31*
Errors	S	480	1.49	0.37	4.76	0.35	1.78	269.70
	R	480	0.84	0.39	9.85	0.33	0.96	328.10
B. Dominance Variance (L_1i - L_2i)								
Difference	S	19	2.02	0.08	46.97**	0.11	2.23	341.09
	R	19	2.09	0.32	324.0**	0.21	0.74	225.23
Errors	S	480	1.49	0.37	4.76	0.35	1.78	269.70
	R	480	0.84	0.39	9.85	0.33	0.96	328.10

*, ** Significant at P= 0.05 and P= 0.01 respectively, S-Summer, R-Rainy

Table 3
Estimates of Additive (D), Dominance (H), Variance Components and Degree of Dominance (H/D)1/2 for Six Traits in Okra

Genetic Components of variance	*Season*	*Days to first flowering*	*Node at which first flower appears*	*Plant height*	*Number of primary branches / plant*	*Number of pods / plant*	*Pod yield / plant*
D	S	8.12**	-0.02	259.08**	-0.21	12.4**	2731.72**
	R	2.89**	1.07**	2404.52**	-0.24	1.87**	243.61*
H	S	0.71	-0.39	56.28**	-0.32	0.6	105.85
	R	2.24**	-0.04	418.99**	-0.16	-0.29	-136.76
(H/D)1/2	S	0.29	1.39	0.47	1.23	0.22	0.19
	R	0.88	0.19	0.42	0.82	0.39	0.75
F	S	1.16	-0.2**	57.96	0.04	2.32	227.32
	R	1.72	-0.52	162.22	0.28	-0.72	0.84

*, ** Significant at P = 0.05 and P = 0.01 respectively, S-Summer, R-Rainy

plant in both the seasons. The positive value of 'F' reveals the ambidirectional nature of dominance suggesting that genes with increasing and decreasing effect were equally important for this trait.

Degree of Dominance

The measure of degree of dominance which gives a weighted average effect of alleles at all the segregating loci, revealed that it was less than unity which suggests the partial dominance for most of the traits except for node at which first flower appears and number of primary branches/plant in summer season which exhibited over dominance. The overall picture of degree of dominance revealed that almost all the characters were highly influenced by additive gene effects in both the seasons but dominance gene effective was relatively more important for node at which first flower appears and number of primary branches/plant in summer season.

The higher magnitude of additive genetic variance assessed consistently for almost all the characters under study, may be due to presence of common alleles for certain traits of two testers used. The additive component was consistently greater in most of the traits while dominance was relatively more important for the two traits i.e. node at which first flower appears and number of primary branches / plant during the summer season. The probable cause of high estimates of additive genetic variance may be ascribed to biasness to an extent related to the dominance and dominance x additive effect of the common loci, whereas the dominance variance has been deflated because they reflect the dominance effect at the non-common loci only (Virk and Jinks, 1977). It is also evident from the analysis that, epistasis and dominance components though relatively being less important, additive component has considerable role to play, which is in conformity with the observations made from different traits of okra by Singh and Singh (1978), Partap and Dhankhar (1983), Poshiya and Vashi (1995), Chandra Deo *et al.* (2004), Saravanan *et al.* (2005), Senthil Kumar *et al.* (2005), Arora and Ghai (2007) and Akhatar *et al.* (2010). The simultaneous occurrence of high epistasis with significant coefficients of dominance components observed in most of the characters suggests that dominance and epistasis generally arise together in response to the same environmental factors (Jinks and Perkins, 1970).

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