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Research Note

Association studies in okra (*Abelmoschus esculentus* (L.) Moench)

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Abstract:
The present study was undertaken on 163 genotypes including 43 parents and 120 crosses of okra to determine the genetic variability, nature of association among different yield attributes and their direct and indirect contribution towards yield. From the analysis of variance, it was observed that mean squares due to genotypes were significant for all the traits, indicating the presence of genetic variability in the experimental material. The values of PCV were higher than that of GCV values for all the ten characters indicating influence of environmental effects in the expression of these characters. The GCV, heritability and genetic advance as percentage of mean were higher for plant height, fruit yield per plant, fruit weight and days to 50 per cent flowering which might be attributed to additive gene action of inheritance. The Fruit yield has significantly positive correlation with plant height, number of branches per plant, inter nodal length, fruit length, fruit weight and number of fruits per plant at both genotypic and phenotypic level, indicating mutual association of these traits. Path coefficient analysis revealed that fruit weight had maximum direct contribution (0.884) towards fruit yield followed by number of fruits per plant (0.852), plant height (0.024) and number of branches per plant (0.020). However, days to 50 per cent flowering exhibited highest negative direct effect (-0.013) followed by test weight (-0.009) and fruit diameter (-0.003). These important traits may be viewed in selection programme for the further improvement of okra.

Key words: Genetic variability, Correlation, Path analysis and Okra

Okra (*Abelmoschus esculentus* (L.) Moench) is one of the important vegetable crop grown for its tender green fruits through out India, Turkey and other neighboring countries. It has high nutritive value and export potential. To improve yield and other characters, information on genetic variability and inter-relationship among different traits is necessary. The improvement in any crop is proportional to the magnitude of its genetic variability present in the germplasm (Dhankhar and Dhankhar, 2002). The genotypic coefficient of variation indicates the range of genetic variability present in different characters. The partitioning of total variance so as to assess the true breeding nature of a particular trait under selection is important as the phenotypic expression of the character is the result of interaction between the genotype and environment. A relative comparison of heritability and expected genetic advance gives an idea about the nature of gene governing a particular character. Yield, which is a multiplicative product function of various yield attributing plant characters, but direct selection for yield is often misleading and hence knowledge of inter-relationship between pairs of these characters and yield is essential to bring a rational improvement in the desirable traits. The correlation coefficients alone are inadequate to understand the cause and effect relationships. However, path analysis furnishes a method of partitioning the correlation coefficient between various characters into direct and indirect effects; provide the actual contribution of an attribute and its influence through other traits.

Correlation coefficient analysis measures the mutual relationship between two plant characters and determines component characters in which selection can be based for genetic improvement in yield. Whether the association of these characters due to their direct effect on yield or is a consequence of their indirect effects via other component characters may be answered through path coefficient analysis. Such information reveals the possibility of simultaneous improvement of various attributes and also helps in increasing the efficiency of selection of complex inherited traits. Keeping this in view, the present investigation was aimed at assessing the genetic variability, association of various characters and direct and indirect path effects of nine independent components on fruit yield in one hundred and twenty derivatives of forty double cross derived lines and three testers.

Experimental material consisted of forty double cross derived lines and three testers *viz.,* Arka Anamika, Pusa Sawani and Prabhani Kranthi selected on the basis of *per se* performance, adaptation and geographical diversity. One hundred and twenty hybrids, forty lines, three testers with six checks (Syngenta, Sinnova, Mahyco 10, Ankur, US agro and Mahyco 417) were evaluated in Simple Lattice Design with two replications during *kharif* 2009 at Main Agricultural Research Station, Dharwad. Each entry was sown in three rows of 5 m length with inter and intra row spacing of 60 cm and 30 cm, respectively, and all the recommended cultural practices were followed. Data on nine quantitative characters viz., days to 50 per cent flowering, plant height, number of branches per plant, inter nodal length, fruit length, fruit diameter, test weight, number of fruits per plant and fruit yields per plant were recorded. Mean values were subjected to analysis of variance, genotypic and phenotypic correlation coefficient and path coefficient was computed by using the formula of Dewey and Lu (1959).

Good amount of variation was observed in all the 163 genotypes for all the characters studied. The extent of variability was measured in terms of mean, range, phenotypic co-efficient of variation, genotypic co-efficient of variation, heritability, genetic advance and genetic advance as per cent mean (Table 1). From the analysis of variance, it was observed that mean squares due to genotypes were significant for all the traits, indicating there by the presence of genetic variability in the experimental material. The maximum range of variation (161.21- 447.72) was recorded in fruit yield per plant, followed by plant height (38-147.65) and number of fruits per plant (22-41.5). In general, estimates of phenotypic co-efficient of variation (PCV) were comparable with genotypic co-efficient of variation (GCV) for all the traits studied. However, the estimates of PCV were, in general, higher than the estimates of GCV for all the characters. Similar observations were made by Singh *et al.* (1998). This may be due to the involvement of environment and genotypic x environment effect in character expression. The genotypic and phenotypic co-efficient of variation were found maximum for number of branches per plant (33.78 and 34.46 respectively). Other characters have moderate estimates of GCV and PCV.

The efficiency of selection not only depends on the magnitude of genetic variability but also on the heritability of the characters. The high heritability (>70%) in broad sense was recorded for all the traits except inter nodal length (63.4%), fruit length (68.5%), test weight (61.5%) and number of fruits per plant (68.9%). The high heritability denotes high proportion of genetic effects in the determination of these traits and can be selected for improving fruit yield in okra.

The genetic advance as per cent of mean was maximum for number of branches per plant (68.02) followed by fruit weight (37.56), fruit yield per plant (36.10), plant height (34.26) and inter nodal length (28.38), whereas it was minimum for days to 50 per cent flowering (6.05). In the present investigation, high heritability coupled with high genetic advance observed for plant height, fruit yield per plant, fruit weight and days to 50 per cent flowering might be due to large additive gene effects which revealed that the selection based on these traits will improve fruit yield.

On the basis of heritability and expected genetic advance as per cent mean for different traits studied, selection criteria based on, number of branches per plant, inter nodal length, fruit weight, number of fruits per plant and fruit yield per plant may be useful for developing high yielding genotypes.

The association analysis (Table 2) showed highly significant and positive correlation of fruit yield per plant with plant height, number of branches per plant, inter nodal length, fruit length, fruit weight and number of fruits per plant at both genotypic and phenotypic level, indicating mutual association of these traits. It could be suggested from correlation estimates that yield could be improved through selection based on these characters. These findings are in agreement with those of Mandal and Dana (1993), Gondane *et al.* (1995) and Yadav (1996). Significant negative correlation at genotypic level was observed between fruit yield per plant and days to 50 per cent flowering, indicating that yield was quite high if flower appear early and *vice-versa*. Similar results were also reported by Majumdar *et al.* (1974). Fruit length showed highly significant and positive correlation with number of fruits per plant and internodal length. Similar results were also reported by Sood *et al.* (1993) and Chandra *et al.* (1996).

Like wise days to 50 per cent flowering with plant height at genotypic level; plant height with number of branches per plant, inter nodal length, test weight and number of fruits per plant exhibited significant positive association. This indicates the interdependency of the various characters on each other. Jayapandi and Balkrishnan (1992) and Chitra (1999) reported similar results.

In general, the genotypic correlation coefficients are observed to be higher than the corresponding phenotypic correlations for all the character combinations under study, indicating that there was an inherent association among various characters and phenotypic expression of correlation was lessened under the influence of environment.

In the path coefficient analysis (Table 3), fruit weight recorded highest direct effect (0.884) followed by number of fruits per plant (0.852), plant height (0.024) and number of branches per plant (0.020). However, days to 50% flowering exhibited highest negative direct effect (-0.013) followed by test weight (-0.009) and fruit diameter (-0.003). Ariyo *et al.* (1987) obtained similar results earlier. All characters mentioned earlier, which contributed directly and positively to fruit yield per plant possess significant correlations suggesting that the association between these traits is perfect and it was due to genetic factors only. Looking to the indirect effects, high positive indirect effect was found in case of number of fruits per plant via number of branches per plant, plant height and fruit length. These have also been corroborated by Reddy *et al.* (1985). Therefore, one can rely upon fruit weight, number of branches per plant, plant height and number of fruits per plant while selecting high fruit yielding genotypes in okra.

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Table 1. Estimates of range, grand mean and components of variation for different characters in okra.

Characters	Range	Grand mean	Phenotypic coefficient of variation	Genotypic coefficient of variation	Heritability (%) in broad sense	Genetic advance as per cent mean
Days to 50% flowering	46-55.5	50.05	4.13	3.48	71.2	6.05
Plant height (cm)	38-147.65	103.34	16.74	16.69	99.3	34.26
Number of branches per plant	0.65-3.9	1.72	34.46	33.78	96.1	68.02
Inter nodal length (cm)	4.53-11.24	6.87	21.77	17.34	63.4	28.38
Fruit length (cm)	9.1-17.35	13.28	15.8	13.07	68.5	22.29
Fruit diameter (cm)	4.1-6.35	5.61	7.44	6.51	76.5	11.76
Test weight (g)	5-9	7.58	11.56	9.07	61.5	14.64
Fruit weight (g)	10.18-25.51	15.47	19.32	18.77	94.3	37.56
Number of fruits per plant	22-41.5	29.88	13.66	11.33	68.9	19.38
Fruit yield per plant (g)	161.21-447.72	301.16	19.92	18.68	88	36.10

Table 2. Genotypic and phenotypic correlation between 10 characters in okra.

Characters	Days to 50% flowering	Plant height (cm)	Number of branches per plant	Inter nodal length (cm)	Fruit length (cm)	Fruit diameter (cm)	Test weight (g)	Fruit weight (g)	Number of fruits per plant	Fruit yield per plant (g)
Days to 50% flowering	G	0.175*	-0.024	-0.134	-0.172*	0.113	-0.023	-0.072	-0.125	-0.181*
	P	0.147	-0.023	-0.075	-0.12	0.067	-0.009	-0.08	-0.046	-0.114
Plant height (cm)	G		0.177*	0.204**	-0.019	0.036	0.403**	0.045	0.400**	0.401**
	P		0.171*	0.158*	-0.017	0.036	0.315**	0.044	0.332**	0.377**
Number of branches per plant	G			0.05	-0.015	-0.238**	0.036	-0.05	0.472**	0.382**
	P			0.04	-0.015	-0.206**	0.016	-0.039	0.366**	0.338**
Inter nodal length (cm)	G				0.397**	0.1	0.13	0.145	0.29	0.385**
	P				0.247**	0.101	0.087	0.118	0.166*	0.272**
Fruit length (cm)	G					0.06	0.006	0.016	0.314**	0.293**
	P					0.031	0.023	0.013	0.223**	0.231**
Fruit diameter (cm)	G						-0.001	0.072	-0.046	0.017
	P						-0.019	0.078	-0.068	0
Test weight (g)	G							0.015	0.058	0.064
	P							-0.02	0.131	0.111
Fruit weight (g)	G								-0.373**	0.566**
	P								-0.401**	0.457**
Number of fruits per plant	G									0.545**
	P									0.609**

*,** significant at 5 and 1 per cent level, respectively.

Table 3. Direct (diagonal) and indirect path effects of different characters towards fruit yield per plant in okra.

Characters		Days to 50% flowering	Plant height (cm)	Number of branches per plant	Inter nodal length (cm)	Fruit length (cm)	Fruit diameter (cm)	Test weight (g)	Fruit weight (g)	Number of fruits per plant	Correlation with Fruit yield per plant (g)
Days to 50% flowering	G	**-0.013**	0.004	0.000	0.000	-0.002	0.000	0.000	-0.064	-0.106	-0.181
	P	**-0.009**	0.005	-0.001	-0.001	-0.002	0.000	0.000	-0.065	-0.042	-0.114
Plant height (cm)	G	-0.002	**0.024**	0.003	0.000	0.000	0.000	-0.004	0.040	0.341	0.401
	P	-0.001	**0.034**	0.005	0.002	0.000	0.000	-0.001	0.036	0.302	0.377
Number of branches per plant	G	0.000	0.004	**0.020**	0.000	0.000	0.001	0.000	-0.044	0.402	0.382
	P	0.000	0.006	**0.031**	0.001	0.000	0.000	0.000	-0.032	0.333	0.338
Inter nodal length (cm)	G	0.002	0.005	0.001	**0.000**	0.004	0.000	-0.001	0.128	0.247	0.385
	P	0.001	0.005	0.001	**0.014**	0.003	0.000	0.000	0.097	0.151	0.272
Fruit length (cm)	G	0.002	0.000	0.000	0.000	**0.010**	0.000	0.000	0.014	0.268	0.293
	P	0.001	-0.001	0.000	0.003	**0.013**	0.000	0.000	0.011	0.203	0.231
Fruit diameter (cm)	G	-0.001	0.001	-0.005	0.000	0.001	**-0.003**	0.000	0.064	-0.039	0.017
	P	-0.001	0.001	-0.006	0.001	0.000	**0.002**	0.000	0.064	-0.062	0.000
Test weight (g)	G	0.000	0.009	0.001	0.000	0.000	0.000	**-0.009**	0.013	0.049	0.064
	P	0.000	0.011	0.000	0.001	0.000	0.000	**-0.005**	-0.016	0.119	0.111
Fruit weight (g)	G	0.001	0.001	-0.001	0.000	0.000	0.000	0.000	**0.884**	-0.318	0.566
	P	0.001	0.001	-0.001	0.002	0.000	0.000	0.000	**0.819**	-0.365	0.457
Number of fruits per plant	G	0.002	0.009	0.009	0.000	0.003	0.000	-0.001	-0.330	**0.852**	0.545
	P	0.000	0.011	0.011	0.002	0.003	0.000	-0.001	-0.329	**0.910**	0.609

Genotypic residual effect: 0.0143, Phenotypic residual effects: 0.0411
The bold figures represent direct effect