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Genetic Divergence, Correlation and Path Analysis in Okra (*Abelmoschus esculentus* (L.) Moench)

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The nature and magnitude of genetic divergence in 35 okra genotypes for ten characters were assessed using Mahalanobis D^2 statistic. The mean for pod yield per plant was higher in the genotype Pusa A4 (443.00 g) followed by Parbhani Kranti (406.03 g) and Punjab Padmini (378.67 g). The genotypes were grouped into ten clusters. Cluster III was the largest containing 16 genotypes followed by cluster VIII with four genotypes. Composition of clusters indicated non existence of correspondence between genetic diversity and geographical distribution. Pod yield, plant height and length of edible pod were the major characters contributing towards divergence. Cluster VII and X (83.25) were the most divergent followed by cluster V and X (74.05). This study can well be utilized for selection of divergent genotypes for further crop improvement programme. It is suggested that varietal improvement programme through the hybridization among the genotypes of divergent clusters should be done rather than depending on less divergent clusters. Pod yield per plant had significant positive relationship with number of pods per plant at phenotypic, genotypic and environmental levels. It evinced significant positive phenotypic and genotypic associations with single pod weight. It also showed positive significant association with plant height at genotypic level. Path analysis revealed the importance of number of pods per plant and single pod weight in the pod yield enhancement in okra. Number of pods per plant exerted high positive direct effect towards pod yield plant. It was followed by single pod weight. Moreover, many characters exerted their positive indirect effect towards pod yield per plant through number of pods per plant. The magnitude of genotypic correlations was more than that of phenotypic correlation for all the traits.

Key Words: D^2 Analysis, correlation, path analysis and okra

Genetic improvement mainly depends on the amount of genetic variability present in the population. In any crop, the germplasm serves as a valuable source of base population and provide scope for wide variability. Information on the nature and degree of divergence would help the plant breeder in choosing the right type of parents for future breeding programme to improve the quality characters. Importance of genetic diversity for selecting parents in combination-breeding programme of different autogamous crop to recover transgressive segregates has been emphasized (Singh and Ramanujam, 1981; Cox and Murphy, 1990). Martin *et al.* (1981) observed that in the countries where okra culture is very old such as India, Iran and Turkey varietal groups showed a few or no distinguishing characters. Knowledge of correlation and causation among the yield and yield components is of paramount importance in any crop improvement programme through plant breeding. The present study also brings out the correlation among between 10 yield and yield component characters and the causal basis of such relationship. However in this situation, correlation alone become insufficient to explain relationships among characters and thus, path analysis of economic yield components with yield is important. However, the information on such studies is meager to study the correlation and path analysis in okra for high yield.

Materials and Methods

Thirty five okra cultivars of diverse origin were grown in randomized block design with three replications following a spacing of 45 ´ 30 cm at Plant Breeding Farm, Department of Agricultural Botany, Faculty of Agriculture, Annamalai University during 2008. Need based plant protection measures were given. Observations on days to first flowering, number of nodes to first pod, days to first pod harvest, number of branches per plant, number of pods per plant, single pod weight, length of edible pod, girth of edible pod, plant height and pod yield were recorded on five random plants of each genotype per replication. The data were subjected to Mahalanobis(1936) D^2 statistics to measure genetic divergence as suggested by Rao (1952).

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The phenotypic and genotypic correlation coefficients and path analysis were also computed by using procedure given by Deway and Lu (1959).

Results and Discussion

The analysis of variance revealed significant differences among the genotypes for all the characters except number of branches per plant indicating existence of variability among the characters studies. The mean for pod yield per plant was higher in the genotypes Pusa A4(443.00g)

Table 1. Clustering pattern of 35 okra genotypes on D^2 statistics

Clusters	Number of genotypes	Name of genotypes
I	2	CO 1, Gujurat Bhindi 1
II	2	PB 7, Parbhani Kranti
III	16	OKH 666, NOH 303, Arka Anamika, S51, Lakshmi, Ankur 40, DOV 1, Hissar Unnat, Varsha Uphar, Arya 351, Pusa A4, Indol-03-01, Arka Abhay, DOV 2, Kamini, Harbhajan
IV	2	Selection 2, EMS 8
V	2	MBORH 311, DSN 1
VI	2	DSU 1, Pusa Makhmali
VII	2	P7, PB 266
VIII	4	MBORH 93, AOL-03-01, OKH 333, Bakra
IX	2	Pusa Sawani, MDU 1
X	1	Punjab Padmini

followed by Parbhani Kranti (406.03 g) and Punjab Padmini (378.67 g).Twelve genotypes recorded higher pod yield than general mean (257.13 g).Based on the relative magnitude of D^2 values, 35 genotypes were grouped into ten clusters (Table 1). The maximum number of genotypes (16) was included in cluster III followed by cluster VIII with four genotypes. The genotype fell in one cluster indicating over all genetic similarity among them. Similar findings were made by Gondane and Lal (1993). Cluster I, II, IV, V, VI, VII and IX contained two genotypes and cluster X had only one genotype. Composition of clusters indicated non existence of correspondence between genetic diversity and geographical distribution.

The estimates of intra and inter cluster D^2 and D values have been presented in Table 2. The intra cluster distance ranged from 0.00 for cluster X to 29.20 for cluster III. The inter cluster distance was observed to be the highest between cluster VII and X (83.25), indicating that genotypes of these two clusters were genetically more diverse. The minimum diversity was observed between cluster IV and VI (15.45). The greater the distance between two clusters wider is the genetic diversity among the parents, to be included in hybridization programme.

Among the different characters, the trait pod yield (31.26%) contributed maximum towards genetic divergence followed by plant height (29.92%) and

Table 2. Average intra and inter cluster D^2 and D values for 35 okra genotypes

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X
Days to first flowering	19.27 (4.39)	445.26 (21.10)	1026.04 (32.03)	760.84 (27.58)	1868.57 (43.23)	655.38 (25.60)	2975.88 (54.55)	890.76 (29.85)	1356.81 (36.84)	1043.18 (32.30)
Number of nodes to first pod		54.19 (7.36)	1980.79 (44.51)	2138.57 (46.25)	3869.30 (62.20)	1749.56 (41.83)	5098.42 (71.40)	904.67 (30.08)	2827.57 (53.18)	245.53 (15.67)
Days to first pod harvest			852.56 (29.20)	677.06 (26.02)	1113.37 (33.37)	470.73 (21.70)	1515.48 (38.93)	1400.24 (37.42)	798.65 (28.26)	3095.26 (55.64)
Number of branches per plant				75.96 (8.72)	372.08 (19.29)	238.56 (15.45)	943.68 (30.72)	1728.74 (41.58)	422.60 (20.56)	3339.61 (57.79)
Number of pods per plant					79.55 (8.92)	599.84 (24.49)	335.02 (18.30)	2983.29 (54.62)	434.17 (20.84)	5483.76 (74.05)
Single pod weight (g)						133.88 (11.57)	1097.83 (33.13)	1151.36 (33.93)	339.21 (18.42)	2937.01 (18.42)
Length of edible pod (cm)							220.32 (14.84)	3755.30 (61.28)	781.99 (27.96)	6929.72 (39.65)
Girth of edible pod (cm)								679.27 (83.25)	1964.61 (26.06)	1571.92 (44.32)
Plant height (cm)									773.20 (27.81)	4294.31 (65.53)
Pod yield (g)										0.00 (0.00)

length of edible pod (25.38%) as shown in Table 3. The other characters contributed comparatively less towards genetic divergence. The cluster mean for various traits (Table 4) revealed that genotypes included in cluster II were early flowering types (38.00) followed by cluster X (41.33) and cluster VII (42.17). Cluster II recorded minimum number of nodes to first pod (1.83), maximum number of pods per plant (25.00), highest mean for girth of edible pod (6.38 cm) and maximum pod yield (383.53 g). Cluster IV recorded minimum days to first pod harvest (6.50) and cluster V recorded minimum plant height (69.00 cm). Cluster X recorded the highest number of branches per plant (3.67), single pod weight (17.50 g) and length of edible pod (18.40 cm).

Table 3. Independent character contribution towards divergence in 10 characters of 35 okra genotypes

Characters	Times ranked	Contribution (%)
Days to first flowering	0	0.01
Number of nodes to first pod	0	0.01
Days to first pod harvest	0	0.01
Number of branches per plant	0	0.01
Number of pods per plant	2	0.34
Single pod weight (g)	27	4.54
Length of edible pod (cm)	151	25.38
Girth of edible pod (cm)	51	8.57
Plant height (cm)	178	29.92
Pod yield (g)	186	31.26
Total	595	100

Cluster III comprises of 16 genotypes. Among 16, five genotypes *viz.,* Arka Anamika (287.03 g), Hissar Unnat (304.33 g), Varsha Uphar (371.43 g), Pusa A4 (443.00 g) and Harbhajan (305.60 g) which recorded higher pod yield than general mean compared with CD value. Similarly cluster II had two genotypes, *viz.,* PB 7 (361.33 g) and Parbhani Kranti (406.03 g) and also cluster I contained two genotypes *viz.,* CO 1 (295.40 g) and Gujarat Bhindi 1 (286.83 g) which showed higher mean value. The cluster IV and VII consisted of two genotypes each. Among the two genotypes one genotype from each cluster *viz.,* EMS 8 (296.67 g) and PB 266 (304.70 g) which recorded higher mean value. Similarly cluster X contained only one genotype Punjab Padmini (378.67 g) which also recorded higher mean value than general mean when compared with CD value (282.11 g). Above mentioned 12 genotypes fell in six different clusters. The genotypes with higher mean value on different cluster can either straight away be used for adoption or can be used in hybridization programme for yield improvement. The hybrids developed from the selected genotypes of these clusters may produce desirable transgressive segregates that would be productive in okra breeding programme. Similar studies also made by Hazra *et al.* (2002).

Table 4. Cluster mean for different characters of 35 okra genotypes

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X
I	44.167	2.000	8.500	2.500	18.667	15.583	16.083	5.833	107.167	291.117
II	38.000	1.833	6.833	2.500	25.000	15.333	17.433	6.383	135.833	383.533
III	44.979	3.438	7.375	2.333	18.813	13.677	12.967	5.602	108.312	258.063
IV	44.500	3.333	6.500	2.833	18.833	14.533	12.900	4.633	85.833	274.150
V	45.333	4.000	7.833	2.167	13.333	14.783	11.267	5.100	69.000	196.883
VI	46.000	4.167	8.167	2.833	15.833	13.333	13.283	5.683	97.500	212.167
VII	42.167	3.833	8.500	3.167	18.167	14.283	9.200	4.883	83.167	261.917
VIII	44.000	4.167	7.750	3.000	20.417	10.708	15.717	5.800	125.917	216.250
IX	44.333	3.500	7.333	2.500	14.833	13.033	12.283	5.633	83.167	193.533
X	41.333	3.000	7.000	3.667	21.667	17.500	18.400	6.167	160.667	378.667

The estimates of phenotypic and genotypic correlation coefficients (Table 5) depicted that genotypic correlation were higher than phenotypic correlations for all the character combinations,

Table 5. Phenotypic (P) and Genotypic (G) correlation coefficient among yield and its components in okra

S. No.	Characters	Type of correlation	Number of nodes to first pod	Days to first pod harvest	Number of branches per plant	Number of pods per plant	Single pod weight	Length of edible pod	Girth of edible pod	Plant height	Pod yield per plant
1.	Days to first flowering	(P)	0.258	0.095	-0.204	-0.469**	0.056	-0.177	0.054	-0.285	-0.374
		(G)	0.667**	0.114	-0.459**	-0.511**	0.067	-0.195	0.060	-0.304	-0.395*
2.	Number of nodes to first pod	(P)		0.042	0.006	-0.308	-0.287	-0.206	-0.132	-0.091	-0.424**
		(G)		0.184	0.542**	-0.496**	-0.625**	-0.411**	-0.276	-0.254	-0.789**
3.	Days to first pod harvest	(P)			0.132	0.023	0.136	-0.027	-0.034	-0.093	0.061
		(G)			0.163	0.051	0.190	-0.051	-0.027	-0.132	0.103
4.	Number of branches per plant	(P)				0.119	-0.082	0.205	0.130	0.058	0.024
		(G)				0.313	-0.153	0.509**	0.194	0.141	0.096
5.	Number of pods per plant	(P)					0.046	0.324	0.239	0.562**	0.814**
		(G)					0.061	0.340*	0.255	0.595**	0.810**
6.	Single pod weight	(P)						0.083	0.116	-0.012	0.603**
		(G)						0.085	0.120	-0.019	0.621**
7.	Length of edible pod	(P)							0.544**	0.328*	0.298
		(G)							0.554**	0.332*	0.308
8.	Girth of edible pod	(P)								0.071	0.242
		(G)								0.076	0.255
9.	Plant height	(P)									0.457
		(G)									0.469**

Table 6. Direct and indirect effects of various characters on pod yield per plant as partition by path analysis

S. No.	Characters	Days to first flowering	No.of nodes to first pod	Days to first pod harvest	No. of branches per plant	No.of pods per plant	Single pod weight	Length of edible pod	Girth of edible pod	Plant height	Genotypic correlation with yield
1.	Days to first flowering	**-0.016**	-0.040	-0.002	0.009	-0.376	0.036	0.003	-0.000	-0.008	-0.395*
2.	Number of nodes to first pod	-0.011	**-0.059**	-0.003	-0.010	-0.365	-0.340	0.006	0.001	-0.007	-0.789**
3.	Days to first pod harvest	-0.0019	-0.011	**-0.019**	-0.003	0.037	0.103	0.001	0.000	-0.003	0.103
4.	Number of branches per plant	0.007	-0.032	-0.003	**-0.019**	0.230	-0.083	-0.007	-0.001	0.004	0.096
5.	Number of pods per plant	0.008	0.030	-0.001	-0.006	**0.736**	0.033	-0.005	-0.001	0.016	0.810**
6.	Single pod weight	-0.001	0.037	-0.004	0.003	0.044	**0.543**	-0.001	-0.000	-0.000	0.621**
7.	Length of edible pod	0.003	0.024	-0.001	-0.001	0.250	0.046	**-0.013**	-0.003	0.009	0.308
8.	Girth of edible pod	-0.001	0.016	-0.001	-0.004	0.188	0.065	-0.007	**-0.005**	0.002	0.255
9.	Plant height	0.005	0.015	0.002	-0.003	0.438	-0.010	-0.004	-0.000	**0.026**	0.469**

establishing predominant role of heritable factors. The study revealed that the pod yield per plant had high significant positive association with number of pods per plant at phenotypic (0.814) and genotypic (0.810) levels and single pod weight at phenotypic (0.603) and genotypic (0.621) levels and also plant height at genotypic level (0.469) (Table 6). It was noted that days to first flowering and number of nodes to first pod were negatively correlated with pod yield per plant. These results are in conformity with Patel and Dalal (1994), Mandal and Dana (1994), Kolra and Rastogi (1978) and Singh and Singh (2006). Path coefficient analysis (Table 6) revealed that number of pods per plant (0.736) exerted its high positive direct effects towards pod yield per plant followed by single pod weight (0.543) and plant height (0.026) Plant height exerted its high positive indirect effect (0.438) towards pod yield per plant through number of pods per plant. Similarly, girth of edible pod (0.188), length of edible pod (0.250) and number of branches per plant (0.230) exhibit moderate positive indirect effect towards pod yield per plant through number of pods per plant. The characters like days to first flowering (0.036), days to first pod harvest (0.103), number of pods per plant (0.033), length of edible pod (0.046) and girth of edible pod (0.065) exerted its negligible positive indirect effects towards pod yield per plant through single pod weight. Similar reports were made earlier by Shukla (1990) and Subhashini *et al.* (1996). The study amply indicated that pod yield is influenced by number of pods per plant and single pod weight. They may be declared as choice of characters for yield improvement programme in okra through plant breeding.

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