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RESEARCH ARTICLE

Multivariate analysis of okra [*Abelmoschus esculentus* (L.) Moench] genotypes

■ P.K. AKOTKAR AND D.K. DE

SUMMARY

The present experiment was conducted to estimate the genetic diversity among fifty one genotypes of okra collected from the NBPGR, Regional Station Akola, India in two years. On the basis of D^2 analysis, the genotypes could be grouped into 8 clusters in both the years. Cluster I had the highest number of genotypes (44) and (43) in 2010 and 2011, respectively followed by cluster VI (2) in 2011. Remaining clusters were monogenotypic in both the years. Plant height and fruit weight had the highest contribution towards the total genetic divergence. The highest intra-cluster distances was recorded in cluster I in 2010 and in cluster VI in 2011. The maximum inter cluster distance was observed between VII and III followed by IV and III in the year 2010 whereas, it was between cluster VIII and VI followed by VI and III in the year 2011. Among the 51 genotypes, IC-332453, Parbhani Kranti, IC-342075 and IC-433645 recorded the higher cluster mean for fruit yield per plant and other component characters in both the years. On the basis of grouping of genotypes into different clusters towards contribution of a character to the total genetic divergence, inter-cluster distance and cluster mean, the above genotypes were found promising for using in the hybridization programme.

Key Words : Cluster, Divergence, Multivariate, Okra, Transgressive segregants

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Okra [*Abelmoschus esculentus* (L.) Moench], also called bhindi or lady's finger, is primarily a warm season, annual vegetable crop grown mainly for its tender green fruits. With respect to export potential it stands second after onion which is 60 per cent of the export value of fresh vegetables. The high yielding varieties are generally developed by exploiting the genetic diversity available in the crop. The importance of the genetic diversity for selecting the parents in combination breeding of autogamous crops to obtain transgressive segregants has been well emphasized by Khanna and Mishra (1977), Singh and Ramanujam (1981), Cox and Murphy (1990). Moll *et al.* (1974) opined that the level of heterosis to be exhibited by a hybrid is a function of the genetic divergence between the parents. Hence, estimation of genetic divergence prior to adoption of any breeding programme is necessary. In this respect D^2 statistics which measures the degree of diversification of genotypes and also determines the relative contribution of each component character to the total divergence is a sound statistical procedure. The available literature reveals that breeding programme on the basis of genetic diversity is scanty. Therefore, the present study was undertaken to determine the genetic diversity among 51 genotypes of okra with a view to identifying suitable parents for hybridization.

MEMBERS OF THE RESEARCH FORUM

Author to be contacted :
P.K. AKOTKAR, Anand Niketan College of Agriculture, Warora, CHANDRAPUR (M.S.) INDIA
Email: pradip.akotkar@gmail.com

Address of the Co-authors:
D. K. DE, Department of Plant Breeding, Faculty of Agriculture, Bidhan Chandra Krishi Vishwavidyalaya, Mohanpur, NADIA (W.B.) INDIA

MATERIAL AND METHODS

The material for the present study comprised of 51 genotypes of cultivated okra collected from the National Bureau of Plant Genetic Resources, Regional Station Akola, Maharashtra. The genotypes were evaluated through field experiments conducted in randomised block design with three replications at the Experimental Farm, C Block; B.C.K.V. Kalyani, West Bengal during winter season (September - December) of 2010 and also during rainy season (June - September) of 2011. The soil of the field was sandy clay loam with pH 7.1. Each genotype was planted in a three row plot of 60 m length at spacing of 60 cm between rows and 40 cm between plants. The fertilizer dose and cultural practices followed were as per recommendation for commercial cultivation of the crop. Observations were recorded from five randomly selected competitive plants from the middle row of each genotype in each replication for eleven plant characters *viz.*, days to first flowering, days to 50 per cent flowering, number of fruits/plant, fruit length (cm), fruit diameter (cm), weight/ fruit (g), plant height (cm), number of primary branches/plant, number of nodes on main stem, inter nodal distance, fruit yield/ plant (g). Mean value of the data obtained from five plants in each replication was used for statistical analysis. Following the analysis of variance, the data were subjected to classificatory analysis. The multivariate analysis (D^2 statistic) was carried out following to Mahalanobis (1936). Besides test of significance of multiple measurements from the estimates of variance and covariance using 'V' statistic which in turn utilizes Wilk's criterion, a simultaneous test of differences between mean values of number of correlated variables were done (Rao, 1948). Grouping of genotypes into different clusters was carried out following Tocher's procedure (Rao, 1952) and the relative contribution of different characters towards total divergence was calculated as per Singh and Choudhury (1985). The statistical analysis of present study was carried out by using INDOSTAT software.

RESULTS AND DISCUSSION

The analysis of variance showed that the genotypes under study differed significantly among themselves for all the eleven characters suggesting considerable genetic variability. On the basis of Mahalanobis D^2 analysis, the genotypes could be grouped into 8 clusters in the years 2010 and 2011 (Table 1). The clustering pattern was found to be consistent with regard to the entries included into various clusters formed in the two years. Very less inter-cluster cross over or exchange of genotypes into various clusters was noticeable. Interestingly, as many as 44 and 43 genotypes belonged to cluster I in the respective years whereas cluster II, III, IV, V, VI (except in 2011), VII and VIII exhibited to be monogenotypic. Results obtained with respect to inter- and intra-cluster divergences indicated variations in the parameters (Table 2 and 3).

The values of average intra-cluster distance varied from 0.00 to 7.92 and from 0.00 to 78.98 in the year 2010 and 2011, respectively (Table 2 and 3). Clusters having intra-cluster distance of 0.00 are monogenotypic in both the years.

Table 1: Grouping of 51 genotypes of okra into different clusters in the year 2010 and 2011

Sr. No.	Year-2010			Year-2011		
	Clusters	Number of genotypes	Genotypes	Clusters	Number of genotypes	Genotypes
1.	I	44	IC-433690,IC-433718,IC-331047IC-331026, IC-331034, IC-433640,IC-27831,IC-433721, IC-331217, IC-332217, IC-42491, IC-433637, IC-7952, IC-433675, IC-433670, IC-433672, IC-1543, IC-433641, IC-427732, IC-27875,IC-433720, IC-332455, IC-328942,IC-332232,IC-3753,IC-326893,IC-89819, IC-9856B, IC-4378,IC-22285,IC-427732, IC-89879, IC-332454, IC-22237, IC-433664, IC-7452, IC-433695, IC-43736, IC-89712, IC-89835, IC-8991, IC-89899, IC-433638, IC-331157	I	43	IC-342075,IC-433690,IC-433718,IC-331026, IC-331034, IC-433640,IC-27831,IC-433721, IC-331217, IC-332217, IC-42491, IC-433652,IC-433637,IC-7952,IC-433675,IC-433670, IC-1543, IC-433641,IC-427732,IC-27875, IC-433720, IC-332455, IC-328942, IC-331067,IC-332232,IC-3753,IC-326893,IC-89819, IC-9856B, IC-4378,IC-22285,IC-427732, IC-89879, IC-332454, IC-22237, IC-433664, IC-7452, IC-433695, IC-89712, IC-89835, IC-89899, IC-433638, IC-331157.
2.	II	1	IC-43652	II	1	IC-433645
3.	III	1	IC-3307	III	1	IC-8991
4.	IV	1	IC-331067	IV	1	IC-433672
5.	V	1	Parbhani Kranti	V	1	IC-3307
6.	VI	1	IC-342075	VI	2	Parbhani Kranti, IC-332453
7.	VII	1	IC-332453	VII	1	IC-43736
8.	VIII	1	IC-433645	VIII	1	IC-331047

However, the maximum intra-cluster distance was recorded in cluster I in the year 2010 and in cluster VI in 2011. When the clusters were compared for divergence, maximum inter-cluster distance was observed between clusters VII and III followed by IV and III in the year 2010 and between clusters VIII and VI followed by VI and III in the year 2011. The above results further reveal that most of the genotypes under study were highly variable considering individual character but considering constellation of characters, they belonged to the same group. Similar observation has been reported by Martin *et al*. (1981). Further, the genotype IC-332453 belonging to cluster VII in 2010 and IC-330147, Parbhani Kranti and IC-332453 belonging to cluster VIII and cluster VI were most divergent in 2011, respectively. These were followed by the genotypes IC- 331067 and IC-342075 belonging to cluster IV and cluster VI in the year 2010 and IC-8991 belonging to cluster III and IC-3307 belonging to cluster V, respectively in the year 2011. Therefore, the genotype IC-332453 was consistently divergent in two years.

Since improvement in economic yield and other related traits is a basic objective in any breeding programme, cluster means for fruit yield per plant and its associated desirable components need to be taken care during selection of genotypes. Accordingly, in the present experiment considering cluster mean, the genotype IC-332453 of cluster VII recording highest mean for fruit yield per plant followed by the genotypes IC-342075 and Parbhani Kranti belonging to cluster VI and V for fruit yield per plant and fruit weight per plant, respectively in the year 2010 (Table 4) and in 2011, Parbhani Kranti and IC-332453 of cluster VI recorded highest cluster mean for fruit yield per plant and number of fruits per plant followed by IC- 433645 of cluster II produced higher cluster mean for fruit yield per plant and highest for fruit length, fruit weight per plant, plant height and number of nodes on main stem per plant (Table 4) should be considered while selecting parents for hybridization. Interestingly, the genotypes such as IC-332453 and Parbhani Kranti recorded higher mean for fruit yield per plant in both the years.

The relative contribution of different characters toward the expression of total genetic divergence revealed that plant height and fruit weight in both the years (Table 5) contributed maximum. Abdul *et al*. (1994) also reported similar contribution of the two characters to the total genetic diversity of okra. The principle components corresponding to the two largest *eigen* values supplied by the two best orthogonal vectors indicated that plant height and fruit weight) were the most important primary causes of divergence, recording high linear functions in the first component in the two years (Table 5) and revealed that these are the basic common attributes of plant architecture. De *et al.* (1988) proposed that characters contributing maximum toward the D^2 values need to be given more emphasis for the purpose of further selection and choice of parents for hybridization. Apart from high degree of divergence, the performance of

Table 2 : Intra (diagonal) and inter cluster distance in 51 genotypes of okra in the year 2010

Clusters	I	II	III	IV	V	VI	VII	VIII
I	7.92							
II	10.87	0.00						
III	11.68	19.04	0.00					
IV	11.74	5.86	19.79	0.00				
V	11.63	8.86	18.92	5.09	0.00			
VI	12.87	11.87	19.31	8.25	5.58	0.00		
VII	15.10	11.81	21.76	8.00	6.10	6.15	0.00	
VIII	11.44	8.84	18.73	8.14	9.13	9.45	13.03	0.000

Table 3: Intra (diagonal) and inter cluster distance in 51 genotypes of okra in the year 2011

Clusters	I	II	III	IV	V	VI	VII	VIII
I	40.44							
II	73.29	0.00						
III	74.69	174.63	0.00					
IV	71.65	115.61	162.61	0.00				
V	93.65	213.47	41.33	114.11	0.00			
VI	290.90	228.88	481.47	234.60	480.75	78.98		
VII	122.18	191.91	118.32	172.73	166.77	444.37	0.00	
VIII	147.80	204.83	141.57	230.49	193.10	520.67	204.84	0.000

genotypes *vis-à-vis* the characters with maximum contribution towards divergence might be given due consideration for yield improvement of okra.

Since considerable diversity, both within and between clusters, revealed that fruit weight and plant height had been the highest contributors to the total genetic divergence in both the years. Selection of divergent parents based on these characters might be useful for heterosis breeding as well as to obtain large number of useful segregants in the subsequent generations. Thus, on the basis of intercluster distance, cluster mean and magnitude of D^2 value, the genotypes *viz*., IC-332453, Parbhani Kranti, IC-342075 and IC-433645 emerged as superior parents for future breeding programme.

Table 4: Cluster mean for different characters in 51 genotypes of okra in the year 2010 and 2011

Clusters	Year	Days to 1st flowering	Days to 50% flowering	No. of fruits / plants	Fruit length (cm)	Fruit diameter (mm)	Fruit weight (g)	Plant height (cm)	No. of primary branches / plant	No. of nodes on main stem	Inter node length (cm)	Fruit yield / plant (g)
I	2010	36.83	40.10	12.72	9.87	12.05	10.49	64.68	1.84	14.85	4.40	133.39
	2011	33.68	36.79	13.01	10.02	12.99	10.44	70.20	1.89	15.67	4.52	135.83
II	2010	28.00	31.33	14.23	11.59	12.31	10.90	77.10	2.23	18.83	4.10	155.03
	2011	34.00	37.00	12.40	13.17	14.50	15.23	92.33	2.67	20.47	4.53	188.33
III	2010	45.00	48.33	9.50	9.70	11.79	8.39	50.20	1.2	11.60	4.30	79.80
	2011	37.33	40.33	12.33	7.85	11.31	7.06	67.97	1.97	12.87	5.27	87.07
IV	2010	32.67	34.67	14.17	9.53	13.67	13.09	85.03	1.67	18.20	4.67	185.47
	2011	37.67	40.67	12.80	10.06	13.15	11.37	52.90	1.80	14.93	3.50	144.90
V	2010	35.00	37.00	15.23	10.00	11.99	13.57	84.13	2.10	14.80	5.70	206.50
	2011	40.67	42.00	9.50	9.35	12.01	8.46	53.50	1.53	12.17	4.40	80.30
VI	2010	41.00	43.67	13.53	10.60	12.80	16.79	82.4	2.23	16.87	4.87	226.80
	2011	35.11	38.33	17.81	10.94	14.45	14.92	86.72	2.18	17.71	4.94	263.06
VII	2010	36.67	40.00	16.40	10.78	13.30	15.17	84.17	2.23	17.50	4.80	248.83
	2011	28.67	32.33	12.37	4.57	19.63	9.92	71.83	2.10	16.17	4.47	122.13
VIII	2010	37.33	39.67	10.10	13.17	12.60	14.80	85.23	2.17	18.50	4.60	149.37
	2011	34.33	38.00	13.80	10.50	12.67	8.41	66.20	2.30	16.90	3.90	115.97

Table 5: Contribution of individual characters towards total genotypic divergence in 51 genotypes of okra in the year 2010

Sr. No.	Characters	Year-2010				Year-2011			
		Number of times appearing as first in rank	Per cent contribution towards divergence D^2 statistics	Canonical vectors		Number of times appearing as first in rank	Per cent contribution towards divergence D^2 statistics	Canonical vectors	
				Vector I	Vector II			Vector I	Vector II
1.	Days to 1st flowering	121	9.49	0.16	0.57	129	10.12	0.02	0.52
2.	Days to 50% flowering	1	0.08	0.06	0.15	11	0.86	-0.01	0.47
3.	No. of fruits / plants	53	4.16	-0.18	0.05	37	2.90	-0.46	-0.08
4.	Fruit length (cm)	61	4.78	-0.13	0.04	33	2.59	-0.19	0.10
5.	Fruit diameter (mm)	10	0.78	-0.11	0.005	47	3.69	-0.09	-0.04
6.	Fruit weight (g)	255	20.00	-0.51	0.40	524	41.10	0.50	-0.07
7.	Plant height (cm)	524	41.10	-0.70	0.01	196	15.37	0.35	-0.13
8.	No. of primary branches / plant	21	1.65	-0.14	0.07	47	3.69	-0.25	-0.17
9.	No. of nodes on main stem	169	13.25	-0.29	-0.61	73	5.73	0.30	-0.31
10.	Inter node length (cm)	1	0.08	-0.01	0.06	2	0.16	0.04	0.35
11.	Fruit yield / plant (g)	59	4.63	-0.18	0.30	70	5.49	-0.42	0.17

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