



Assessment of genetic variability and character association in okra genotypes for yield and contributing characters

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Abstract: A study of genetic diversity in 20 okra genotypes for 22 morphological and agronomic traits (13 quantitative and 9 qualitative) was laid out in randomized block design with three replications during 2015-16. The phenotypic and genotypic variances, phenotypic (PCV) and genotypic coefficients of variation (GCV), heritability, genetic advance of the characters were studied. The genotypes demonstrated wide range of variability for all characters. In this study PCV was higher than its corresponding GCV thus revealing the role of environmental factors. High heritability (h^2_b) was recorded for all characters except for days to first flowering (27.76%) and days to 50% flowering (34.67%) which have moderate values. Genetic advance in per cent of mean was high for all the characters except moderate for first flowering node (12.88%), fruit length (17.59%), fruit diameter (13.99%) as well as low for days to first flowering (1.69%) and days to 50% flowering (2.28%). The higher value of genetic advance indicates that selection of genotypes on the basis of these characters is desirable. Fruit yield showed positive and highly significant (at 1% level of significance) genotypic association with fruit diameter, number of fruits per plant, average fruit weight and number of seeds per pod. The genotypes, viz. Kashi Kranti, Kashi Satdhari, VROB-159, Punjab-8 and Kashi Mohini were found promising for most of the yield contributing traits. These genotypes could be used further in hybrid breeding programme.

Keywords: Character association, Genotypes, Heritability, Okra, Variability, Yield

INTRODUCTION

Okra (*Abelmoschus esculentus* L. Moench) commonly known as lady's finger and it belongs to the family Malvaceae. It is one of the oldest cultivated vegetable crops and at present it is one of the most important vegetable crop cultivated in tropical, sub-tropical and warm temperate regions of the world.

However, okra is widely distributed from Africa to Asia, southern Europe and America (Ariyo, 1993). In world, India rank first in okra production with 72.9 % share in world okra production and produces okra in an area of 532.7 thousand hectares with production of 6346.4 thousand tonnes and productivity of 11.9 tonnes/ ha (Anonymous, 2015). Highest productivity is reported from Ghana (20.0 tonnes/ha) followed by Egypt (14.0 tonnes/ha). In India, West Bengal (14% share) is leading okra producer in the country followed by Bihar (12% share), Gujarat (12% share), Andhra Pradesh (10% share) and Odisha (9% share). In Bihar okra is grown in an area of 58.08 thousand hectares with production of 783.54 thousand million tonnes and productivity of 13.5 tonnes/ ha (Anonymous, 2015). In any crop phenotypic and genotypic coefficients of var-

iations are useful in detecting the amounts of variability present in the genotypes. Greater the variability and diversity in the population, more the chances of effective selection for the desirable plant types (Vavilov, 1951).

Okra belongs to the family Malvaceae and having significant variation in chromosome number and ploidy level in different species under the genus *Abelmoschus*. In okra the species *Abelmoschus angulosus*, has lowest number of chromosomes, ($2n = 56$), while in the species *Abelmoschus caillie* has highest chromosomes number ($2n = 200$) (Singh and Bhatnagar, 1975). The cultivated species of okra have somatic chromosome number of 130. Okra appears to have originated in South Africa or Asia as reported by Thompson and Kelley (1957). Genetic variability/ diversity is utmost important component of plant breeding which is a major tool being used to cope with the ever-increasing pressure of an expanding world population on food production (Ariyo, 1990). The high yielding varieties of okra has been primarily developed by exploiting the genetic diversity available in the crop. This information on the nature and degree of genetic divergence is essential for the breeders to choose the promising

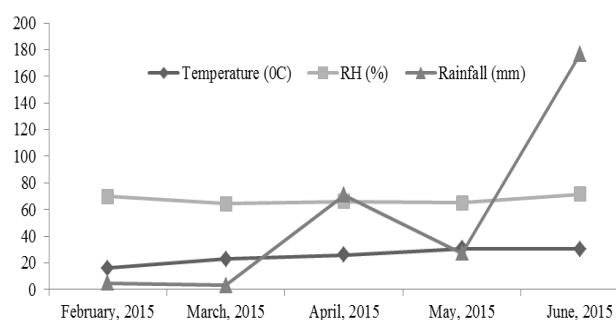


Fig. 1. Meteorological data recorded during crop growing season, 2015-16.

parents for purposeful hybridization in heterosis breeding and in order to benefit transgressive segregations (Khodadabi, 2011). As per the view of Ariyo (1993), vegetative traits of okra are positively correlated with yield and thus traits such as fruit size must be given prime attention in the selection of okra species for breeding programmes to improve yield. Moreover, the average weight and number of fruits/plant have been consistently identified as critical determinants of fruit yield (Saifullah and Rabbani, 2009). As we know that India is the richest country for diverse genotypes of okra. Geographically separation, genetic barriers to crossability, and different parents of evolution are the main reason of genetic diversity (Kumar *et al.* 2015). As well as success of the hybridization followed by selection depends largely on the selection of parents with high genetic diversity for traits of interest (Solanki *et al.*, 2013). The present investigation therefore undertaken to evaluate genetic diversity among the 20 okra genotypes to find out promising genotypes for different traits for enhancing the fruit yield.

MATERIALS AND METHODS

The experiment was conducted using 20 okra genotypes including 4 checks i.e. Kashi Pragati (VRO 6), Kashi Kranti (VRO-22), Kashi Lalima and Arka Anamika collected from Indian Institute of Vegetable Research (IIVR), Varanasi and Indian Institute of Horticulture Research (IIHR), Bengaluru. They were evaluated in a randomized complete block design at Department of Horticulture (Vegetable and Floriculture), Bihar Agricultural University (B.A.U.), Sabour, Bhagalpur (Bihar), during summer season, 2015 - 16. This place comes under subtropical region and it is slightly semi-arid in nature and is characterized by dry summer, moderate rainfall and cold winter. The rainfall of this region is mainly distributed between middle of June to middle of October. The meteorological observations of present investigation were collected from the Meteorological unit of the Department of Agronomy, B.A.U., Sabour. The total rainfall received during the crop period was 282.57 mm. The maximum temperature ranged from 23.9°C - 35°C during the plant growth and development phase (Fig. 1).

The recommended package of cultural practices was adopted for raising the crop (Fageria *et al.*, 2003). Observations were recorded on 22 economically important traits (13 quantitative), viz. days to 50% flowering, first flowering node, plant canopy width (cm), number of primary branches per plant, plant height (cm), fruit length (cm), fruit diameter (cm), number of fruits per plant, average fruit weight (g), number of seeds per pod, yield per plant (kg), fruit yield (q/ha) and (9 qualitative traits) fruit: number of ridges (5, 6, 7, 8), leaf blade: depth of lobbing (shallow, medium, deep), fruit: constriction of basal part (absent, weak,

Table 1. Specific qualitative morphological traits of 20 okra genotype.

Sl. No.	Genotypes	Specific qualitative morphological traits
1	BO-13	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
2	Pusa Makhmali	Five ridges, light green fruited, weak fruit pubescence and yellow petal colour
3	VRO-6	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
4	Kashi Mohini	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
5	Pusa Sawani	Five ridges, light green fruited, weak fruit pubescence and yellow petal colour
6	Punjab-8	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
7	Kashi Lalima	Five ridges, red fruited, medium fruit pubescence and red petal colour
8	VROB-159	Five ridges, red fruited, medium fruit pubescence and red petal colour
9	SB-2	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
10	307-10-1	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
11	Kashi Kranti	Five ridges, dark green fruited, weak fruit pubescence and yellow petal colour
12	Kashi Satdhari	Seven ridges, green fruited, strong fruit pubescence and yellow petal colour
13	CO-3	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
14	IC-14909	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
15	VROB-178	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
16	Arka Anamika	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
17	IBS-02	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
18	VRO-109	Five ridges, light green fruited, medium fruit pubescence and yellow petal colour
19	Azad Bhindi-1	Five ridges, green fruited, medium fruit pubescence and yellow petal colour
20	VRO-106	Five ridges, dark green fruited, medium fruit pubescence and yellow petal colour

Table 2. Mean performance of 20 okra genotype for 13 quantitative morphological characters.

Genotypes	Days to first flowering	Days to 50% flowering	First flowering node	Plant canopy width (cm)	Number of primary branches per plant	Plant Height (cm)	Fruit length (cm)	Fruit diameter (cm)	Number of fruits/plant	Average fruit weight (g)	Number of seeds per pod	Fruit yield per plant (g)	Fruit yield (q/ha)
BO-13	42.00	45.00	6.33	59.44	1.90	69.89	11.97	1.48	11.44	13.29	52.00	151.98	151.98
Pusa Makhmali	42.00	44.33	5.63	63.11	3.27	69.00	9.28	1.35	16.33	10.83	35.33	176.81	176.81
VRO-6	43.00	45.33	6.30	62.33	2.93	76.67	8.88	1.65	13.69	11.76	41.67	161.22	161.22
Kashi Mohini	41.67	44.00	6.57	85.44	2.73	91.00	8.94	1.67	17.29	11.63	55.67	200.75	200.75
Pusa Sawani	44.00	47.33	6.90	71.22	2.90	87.11	9.13	1.47	13.22	10.37	36.33	136.93	136.93
Punjab-8	43.67	46.67	6.17	72.66	3.67	75.33	9.97	1.67	17.25	11.96	48.00	206.40	206.40
Kashi Lalima	44.00	47.00	6.33	69.44	2.70	71.33	10.53	1.56	17.78	10.72	33.67	191.06	191.06
VROB-159	44.00	48.00	5.60	42.66	4.50	58.33	10.24	1.65	15.92	13.19	64.67	209.86	209.86
SB-2	43.00	46.33	5.67	40.25	3.60	56.33	9.03	1.59	11.03	10.73	47.33	118.33	118.33
307-10-1	42.00	45.33	7.40	98.44	3.27	96.67	9.83	1.46	16.25	9.39	29.33	152.67	152.67
Kashi Kranti	42.00	46.67	5.80	52.88	2.73	60.67	10.83	1.47	18.58	13.63	45.33	253.25	253.25
Kashi Satdhari	43.33	46.00	6.67	92.55	2.93	93.67	8.77	1.91	17.11	13.86	66.33	237.12	237.12
CO-3	42.67	44.67	7.33	61.77	4.13	68.33	9.81	1.44	15.25	11.46	55.00	174.83	174.83
IC-14909	44.00	46.00	6.67	101.77	3.67	117.33	11.33	1.43	15.80	10.39	41.33	164.38	164.38
VROB-178	44.00	47.00	6.43	93.88	2.70	73.33	9.83	1.65	16.36	12.10	50.67	197.97	197.97
Arka Anamika	43.67	46.00	6.67	91.55	3.17	71.00	9.30	1.49	15.73	10.63	38.33	167.03	167.03
IIBS-02	44.00	46.67	7.33	77.55	2.57	86.67	9.90	1.60	16.37	10.22	47.00	167.36	167.36
VRO-109	44.00	46.67	6.50	62.66	2.53	73.00	10.97	1.52	16.33	10.59	46.00	173.01	173.01
Azad Bhindi-1	44.67	47.33	6.33	76.27	1.97	74.67	9.27	1.53	17.56	9.23	45.33	161.96	161.96
VRO-106	44.00	46.67	6.67	94.10	3.77	101.33	9.77	1.60	13.51	9.30	41.00	125.75	125.75
General Mean	43.28	46.15	6.47	73.50	3.08	78.58	9.88	1.56	15.64	11.26	46.02	176.43	176.43
C.V. (%)	2.51	2.58	5.41	1.51	9.10	3.76	2.14	3.74	6.53	2.92	5.39	7.26	7.26
SEm±	0.63	0.69	0.20	0.65	0.16	1.72	0.12	0.03	0.59	0.19	1.43	7.39	7.39
C.D. 5%	1.79	1.96	0.58	1.86	0.46	4.91	0.35	0.10	1.69	0.54	4.10	21.16	21.16

strong), fruit: shape of apex (narrow acute, acute, blunt), fruit colour (light green, green, light red, red, purple), flower petal colour (cream, yellow, purple), Flower petal base colour (inside only, both side), stem pubescence (absent, weak, medium, strong), fruit: pubescence (absent, weak, medium, strong). The soil of plot was sandy loam in texture having good fertility, properly leveled and well drained. Five plants in each genotype were selected randomly and were tagged and used for recording observations for the above characters. The morphological observations were taken with the help of Guidelines for the Conduct of Test for Distinctiveness, Uniformity and Stability (DUS) on okra by Protection of Plant Varieties and Farmers' Rights Authority (Plant Protection Variety and Farmers Right Authority), Government of India. Phenotypic and Genotypic variance was calculated as per the formula suggested by Comstock and Robinson (1948). The genotypic and phenotypic co-efficients of variation were calculated in accordance to the procedure outlined by Burton (1952). Heritability in broad sense was calculated as per the formula suggested by Burton and Devane (1953) moreover, genetic advance by Johnson *et al.* (1955). Phenotypic and genotypic correlation coefficients were calculated as per formula suggested by Al-Jibouri *et al.* (1956).

RESULTS AND DISCUSSION

In the present study a wide range of variation in mean performance of genotypes were observed for all the characters. There was uniform yellow petal colour for all genotypes expect Kashi Lalima and VROB-159 i.e. red petal colour as well as these genotypes have red fruit colour while rest of the genotypes have green fruit colour (Table 1).

The genotype, Kashi Kranti, gave significantly highest yield per plant (253.25g), compared to other okra genotypes (Table 2 and 3). The earliest flowering (days to

first flowering and days to 50% flowering) was observed in the variety Kashi Mohini. However, VROB-159 has lowest value for the first flowering node which is at par with the genotypes, Pusa Makhmali, Punjab-8, SB-2 and Kashi Kranti. The phenotypic coefficient of variation (PCV) for all characters was higher than the genotypic coefficient of variation (GCV). Kumar *et al.* (2015) also reported higher PCV (26.25%) than GCV (23.71%) for fruit yield in okra. Similar trend for GCV and PCV was also reported by Koundinya *et al.* (2013) and Khajuria (2016). In present study, the phenotypic coefficient of variation ranged from 2.95% (days to first flowering) to 27.13% (Plant canopy width). The phenotypic coefficient of variability expressed in terms of percentage was comparatively high for plant canopy width, number of primary branches per plant, plant height, number of seeds per pod, fruit yield per plant; moderate for number of fruits/ plant and average fruit weight; moreover, low for days to first flowering, days to 50% flowering, first flowering node, fruit length and fruit diameter (Table 2). Kumar *et al.* (2015) also reported low PCV for days to first flowering, days to 50% flowering and moderate for number of branches, number of fruits and fruit yield in okra. In any crop species, higher the coefficient of genetic variation greater will be the chances of improvement in that character.

In this study genotypic coefficient of variation was higher for plant canopy width. However, moderate value of PCV and GCV was observed for plant height (PCV= 21.60%, GCV= 21.27%).

Bagwale *et al.* (2016) found highest PCV for number of branches (69.72) followed by fruit yield per plant (46.17). While moderate PCV was observed for traits plant height (27.30) while lowest PCV was observed in number of seeds per fruit (dry fruit) (11.76), length of fruit (9.49), girth of fruit (8.28), number of ridges on fruit (9.36), days to initiation of flowering (6.68) and days to 50 % flowering (6.60).The similar results in

Table 3. Estimates of variability parameters for 13 characters in okra.

Characters	General Mean	Range		GCV (%)	PCV (%)	h ² b (%)	G.A. % of Mean (5%)
		Lowest	Highest				
Days to first flowering	43.28	41.67 (Kashi Mohi-	44.67 (Azad Bhindi-	1.55	2.95	27.76	1.69
Days to 50 % flowering	46.15	44.00 Kashi Mohini	48.00 VROB-159	1.88	3.19	34.67	2.28
First flowering node	6.47	5.60 VROB-159	7.40 (307-10-1)	7.66	9.38	66.69	12.88
Plant canopy width (cm)	73.50	40.25 SB-2	101.77 IC-14909	27.09	27.13	99.69	55.72
Number of primary branches per plant	3.08	1.90 BO-13	4.50 VROB-159	20.97	22.86	84.16	39.63
Plant Height (cm)	78.58	56.33 SB-2	117.33 (IC-14909)	21.27	21.60	96.97	43.15
Fruit length (cm)	9.88	8.77 Kashi Satdhari	11.97 BO-13	8.79	9.04	94.41	17.59
Fruit diameter (cm)	1.56	1.35Pusa Makhmali	1.91 Kashi Satdhari	7.58	8.45	80.38	13.99
Number of fruits/ plant	15.64	11.03 SB-2	18.58 Kashi Kranti	12.58	14.17	78.77	22.99
Average fruit weight (g)	11.26	9.23 Azad Bhindi-1	13.86 Kashi Satdhari	12.37	12.70	94.72	24.79
Number of seeds per pod	46.02	29.33 (307-10-1)	66.33 (Kashi Satdhari)	20.70	21.39	93.64	41.27
Fruit yield per plant (g)	176.43	118.33 SB-2	253.25 Kashi Kranti	18.96	20.30	87.23	36.49
Fruit yield (q/ha)	176.43	118.33 SB-2	253.25 Kashi Kranti	18.96	20.30	87.23	36.49

Table 4. Phenotypic (rp) and genotypic (rg) correlation coefficients for 13 characters in 20 okra genotypes.

Charac- ters		DFF	D50%F	FFN	PCW	PBPP	PH	FL	FD	FPP	AFW	NSPP	YPP	FY
DFF	rp	0.804**	0.162	0.144	0.075	0.128	0.012	0.165	0.057	-0.187	0.018	-0.074	-0.074	
	rg	0.784**	-0.007	0.283*	0.012	0.178	-0.035	0.273*	0.111	-0.520**	-0.011	-0.262*	-0.262*	
D50%F	rp		-0.024	-0.075	0.089	-0.081	0.118	0.182	0.113	-0.004	0.069	0.094	0.094	
	rg		-0.295**	-0.125	-0.011	-0.184	0.146	0.286*	0.110	-0.099	0.059	0.034	0.034	
FFN	rp			0.505**	-0.108	0.486**	-0.044	-0.091	0.044	-0.342**	-0.145	-0.193	-0.193	
	rg			0.617**	-0.076	0.598**	-0.055	-0.027	0.024	-0.441**	-0.185	-0.285*	-0.285*	
PCW	rp				-0.046	0.851**	-0.035	0.078	0.216*	-0.364**	-0.226*	-0.073	-0.073	
	rg				-0.043	0.869**	-0.035	0.081	0.247*	-0.376**	-0.238*	-0.077	-0.077	
PBPP	rp					0.050	-0.118	0.034	-0.024	0.015	0.127	0.028	0.028	
	rg					0.036	-0.149	-0.002	-0.152	0.005	0.162	-0.056	-0.056	
PH	rp						0.053	0.048	0.083	-0.354**	-0.189	-0.158	-0.158	
	rg						0.046	0.049	0.056	-0.373**	-0.197	-0.200	-0.200	
FL	rp							-0.337**	-0.002	0.195	-0.027	0.093	0.093	
	rg							-0.413**	-0.012	0.185	-0.039	0.081	0.081	
FD	rp								0.140	0.426**	0.568**	0.386**	0.386**	
	rg								0.117	0.423**	0.684**	0.379**	0.379**	
FPP	rp									0.084	0.023	0.770**	0.770**	
	rg									0.094	0.060	0.747**	0.747**	
AFW	rp										0.658**	0.694**	0.694**	
	rg										0.706**	0.726**	0.726**	
NSPP	rp											0.434**	0.434**	
	rg											0.504**	0.504**	
YPP	rp												1.000**	
	rg												1.000**	
FY	rp													rp
	rg													rg

*, ** Significant at 5 % and 1 % probability level, respectively. Where, DFF=Days to first flowering, D50%F=Days to 50 % flowering, FFN=First flowering node, PCW=Plant canopy width (cm), PBPP=Number of primary branches per plant, PH=Plant Height (cm), FL=Fruit length (cm), FD=Fruit diameter (cm), FPP=Number of fruits/ plant, AFW=Average fruit weight (g), NSPP=Number of seeds per pod, YPP=Fruit yield per plant (g), FY=Fruit yield (q/ha).

okra were also described by other workers (Dhall *et al.*, 2003; Singh *et al.*, 2006; Jaiprakashnarayan *et al.*, 2006, Yadav *et al.*, 2010 and Koundinya *et al.*, 2013). High heritability estimates coupled with high genetic advancement in per cent of mean were observed for plant canopy width, plant height, number of seeds per pod and for fruit yield per plant (Table 3). This indicates substantial contribution of additive genetic variance for these characters. These results are in consonance with the earlier workers (Indurani and Veerarantham, 2005; Mehta *et al.*, 2006; Karri and Acharyya, 2012; Koundinya *et al.*, 2013). Therefore, improvement in these traits would be more effective by selection.

The correlation studies indicate that days to first flowering have positive and highly significant association with days to 50% flowering (rp = 0.804, rg = 0.784) (Table 4). First flowering node exerted positive and highly significant association with plant canopy width (rp= 0.505, rg= 0.617) and plant height (rp= 0.486, rg= 0.598) while, negative and highly significant association with average fruit weight (rp =-0.342, rg =-0.441). Plant canopy width expressed positive and highly significant association with plant height (rp = 0.851, rg = 0.869). Fruit diameter have positive and highly signifi-

cant association with average fruit weight (rp= 0.426, rg= 0.423), number of seeds per pod (rp = 0.568, rg = 0.684). Average fruit weight have positive and highly significant association with number of seeds per pod (rp= 0.658, rg= 0.706). Plant height have negative and highly significant association with average fruit weight (rp = -0.354, rg = -0.373). Similar pattern of correlation in okra were also reported by Balai *et al.* (2014), Solankey *et al.* (2014), Ahamed (2015) and Binalfew and Alemu (2016).Fruit yield showed positive and significant association with fruit diameter, number of fruits per plant, average fruit weight, number of seeds per pod. These findings of character association are in close conformity with the findings of Balai *et al.* (2014) and Binalfew and Alemu (2016).

Conclusion

The variability parameters of the present study indicate that optimum variability was present in the research work. On the basis of performance the genotype Kashi Kranti was the best performer for most of the morphological quantitative traits followed by Kashi Satdhari. Likewise, VROB-159, Punjab-8 and Kashi Mohini also showed better performance. Fruit yield showed positive and significant

association with fruit diameter, number of fruits per plant, average fruit weight, number of seeds per pod and first flowering node. These characters and genotypes can be very much useful in future hybrid breeding programme of okra for higher yield and quality.

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