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RESPONSE OF GROWING SEASON ON SEED YIELD AND ITS ATTRIBUTING TRAITS IN OKRA [*ABELMOSCHUS ESCULENTUS* (L.) MOENCH]

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ABSTRACT

Eight genotypes of okra were grown in randomized block design (RBD) with 03 replications each and the observations were made on seed yield related morphological traits. Data analysis revealed significant genotypic and seasonal difference in most of the seed yield and related attributes. The flowering data considering days to first and 50 percent flower showed significant earliness during pre-*kharif* season. But the rest parameters *viz.* plant height, capsule length and diameter, seeds per capsule, capsules per plant and seed yield recorded significant advanced values during post-kharif. The performance of genotypes was differing significantly for all considerable traits. The interaction of growing season and genotype was found significant positive nature for capsule length, capsule diameter, 100 seed weight and seed diameter. Unlikely to higher seed yield during post-*kharif*, all seed yields related parameters recorded higher percentage of genetic gain during pre-*kharif* than in post-kharif. Similarly, most of the traits showed high broad sense heritability except capsule diameter and capsule per plant during post-*kharif*. Pooled correlation matrix also reported very significant association of seed per capsule with seed yield.

Key words : Okra, Seed yield, Heritability, Genetic advance.

Introduction

Okra [*Abelmoschus esculentus* (L.) Moench] is an important warm season vegetable crop belonging to family *Malvaceae*. Its tender fruit used as vegetable purpose which is commonly known as ladies ‘fingers. The okra capsule or fruit is a good source of vitamins A and B, protein and minerals. It is also an excellent source of iodine and is useful for the treatment of goiter. India is the largest producer of okra globally, with a contribution of more than 72 percent (6.0 million tonnes) from an area of 0.50 million hectares (NHB, 2020). This crop having vast potential for earning foreign exchange as it has a significant share in fresh vegetable export (APEDA, 2020). The availability of quality seed in okra is less due to poor selection of genotype and identification of suitable growing season for a particular region for seed production. Among the available genotype variation in seed yield attributing traits like number of capsules, capsule length, capsule weight and number of seeds per capsule etc., ultimately determine seed yields and which also respond differently to the growing season or environments (Dash and Misra, 1995; Shri-Dhar and Dhar, 1995). Generally, the success of any crop improvement program largely depends on the magnitude of genetic variability, genetic advance, character association, direct and indirect effects on yield and yield attributes (Patro and Ravisankar, 2004). Genetic variability and heritability studies have been done in a wide range of crops in other breeding programs. Determination of heritability estimates will provide information on the proportion of phenotypic variance that is due to genetic factors for different traits but heritability estimate alone is not a sufficient measure of the level of possible genetic progress that might arise not even when the most outstanding individuals are selected in a breeding programme. The value of heritability estimates is enhanced when used together with the selection

differential or genetic advance. Information on the amount and direction of association between yield and yield related characteristics is important for rapid progress in selection and genetic improvement of a crop. This will indicate the interrelationship between two or more plant characters and yield, providing suitable means for indirect selection for yield. In the present study, eight okra cultivars were grown in two different seasons and compared for seed yield and related traits performance.

Materials and Methods

Seed collected for eight genotypes of okra from various sources were grown in Randomized Block Design (RBD) at C-Block Farm (BCKV), Kalyani (Nadia), West Bengal, during pre *kharif* and post *kharif* season of 2021-22 and 2022-23.

Table 1 : List of genotypes and sources for collection of seed.

S. no.	Genotype	Source
1.	Hisar Unnat	CCSHAU, Hisar
2.	Varsha Uphar	CCSHAU, Hisar
3.	Arka Anamika	IIHR, Bangalore
4.	Pusa Bhindi-5	UAS, Raichur
5.	Kashi Kranti	BAU, Sabour
6.	Kashi Pragati	GBPUAT, Pantnagar
7.	Parbhani Kranti	GBPUAT, Pantnagar
8.	Gujrat Okra -5 (Anand Komal)	AAU, Anand

The recommended agronomical package and practices were adopted for maintain the crops during growing period. Observations were recorded on selected plant related to morphological parameters related to flowering, plant height, capsules and seed yield during both growing season. The methodology used for recording of each parameter were described below:

Days to First Flowering (DAS) : The number of days taken from sowing to opening of the first flower was recorded as days to first flowering.

Daysto 50 percent Flowering (DAS) : The number of days taken from sowing to opening of at least one flower on 50 percent of plant population in each plot was counted as the days to 50 percent flowering.

Plant height (cm) : The plant height of ten selected plant was measured from ground level to the top of the main stem at harvest maturity and its average was calculated.

Capsule length (cm) : Length of ten individual capsule from selected plant were measured in centimeters and the average was calculated for further statistical analysis.

Capsule diameter (cm) : Same capsule as taken for measuring capsule length were taken for capsule diameter. The diameter of capsule was measured at middle portion with a vernier calliper. The average diameter of capsule was calculated.

Capsule per plant : Total number of capsules from ten randomly selected plants was counted and the average was calculated for further statistical analysis

Seeds per capsule : Seeds extracted from ten capsules of randomly selected plant were collected and counted separately. The mean value was noted as number of seeds capsules per plant.

100 seed weight (g) : A random sample from pure seed fraction was used for estimating 100 seed weight. Eight replicates of 100 seed were weighted for each seed of each harvesting stage. The mean value was expressed in grams.

Seed diameter (mm) : A random seed sample of mature seed was used for estimating its diameter. Four replicates of 10 seed were measured by using digital vernier calliper. The mean value was expressed in mm.

Seed yield per plant (g) : The weight of seed extracted from all capsules of ten randomly selected plants at harvest maturity was measured in gram and average was calculated for computation of seed yield per plant.

Seed yield (kg/ha) : Data from seed yield per plant was used for calculation of seed yield (kg/ha) after multiplying it with total number of plant per hectare at a considered plant to plant and row to row spacing.

Data were collected from replicated trial for each parameter during both growing season and subjected to statistical analysis using analysis of variance (ANOVA) approach as given by Panse and Sukhatme (1985). The genetic parameters such as heritability and genetic advance were performed using approach described by Johnson *et al*. (1955 a). The analyzed data were classified and tabulated for interpretation of result.

Results and Discussion

Genotypes were raised during pre *kharif* and post *kharif* for assessing the variability in seed yield related morphological traits. The effect of growing season on days to first flowering was found significant demarcation. The mean ranges of days to first flowering during pre *kharif* was 38.33 (Hisar Unnat) to 46.33 (Gujarat Okra-5) and post *kharif* was 42.67 (Hisar Unnat) to 49.67 (Gujarat Okra-5) *i.e.* longer period of expression. Genotypes also differed significantly for days to first flowering. The days to first flowering was reported earliest in Hisar Unnat (40.50), whereas Gujarat Okra-5 taken 48.00 days from its sowing to gives first flower.

Table 2 : Effect of growing season on days to first flowering, days to 50 percent flowering and plant height of okra.

Genotype (G)	Days to first flowering (DAS)			Days to 50 percent flowering (DAS)			Plant height (cm)		
	Season (S)		Mean(G)	Season (S)		Mean(G)	Season (S)		Mean(G)
	Pre *Kharif*	Post *Kharif*		Pre *Kharif*	Post *Kharif*		Pre *Kharif*	Post *Kharif*	
G_1 (Hisar Unnat)	38.33	42.67	**40.50**	42.00	46.67	**44.33**	89.67	99.27	**94.47**
G_2 (Varsha Uphar)	39.33	43.67	**41.50**	43.33	48.67	**46.00**	87.00	96.07	**91.53**
G_3 (Arka Anamika)	41.67	46.33	**44.00**	46.33	53.00	**49.67**	95.00	107.87	**101.43**
G_4 (Pusa Bhindi-5)	42.33	47.00	**44.67**	45.33	52.00	**48.67**	101.67	113.13	**107.40**
G_5 (Kashi Kranti)	41.33	45.00	**43.17**	44.33	51.00	**47.67**	90.67	101.00	**95.83**
G_6 (Kashi Pragati)	42.33	47.33	**44.83**	46.67	50.00	**48.33**	108.67	118.20	**113.43**
G_7 (Parbhani Kranti)	40.68	44.33	**42.50**	44.33	50.33	**47.33**	102.00	113.00	**107.50**
G_8 (Gujarat Okra-5)	46.33	49.67	**48.00**	48.67	52.33	**50.50**	107.67	120.27	**113.97**
	Mean (S)	**41.54**	**45.75**		**45.13**	**50.50**		**97.79**	**108.60**
	G	**S**	**G X S**	**G**	**S**	**G X S**	**G**	**S**	**G X S**
SE (m)	**0.43**	**0.21**	**0.60**	**0.48**	**0.24**	**0.68**	**0.51**	**0.25**	**0.72**
C.D. (P=0.05)	**1.24**	**0.62**	**NS**	**1.39**	**0.70**	**NS**	**1.48**	**0.74**	**NS**
Heritability	**96.70**	**62.60**		**84.70**	**74.80**		**98.10**	**96.60**	
GA over Mean (%)	**11.62**	**7.40**		**8.54**	**6.98**		**17.39**	**16.73**	

The significant effect on growing season was also exposed for character. In pre *kharif* the flowering was found earlier than the post *kharif*. The interaction effect of the season and genotype showed a non-significant difference for days to first flower. These results were also in accordance with finding of Dash and Misra (1995), who reported that okra cultivars differed significantly in all the parameter including the days taken to first flowering. Likely days to 50 percent flowering was differed significantly among genotypes. The days to 50 percent flowering was reported earliest in Hisar Unnat (44.33) and very late in Gujarat Okra-5 (50.50). There was a significant effect of growing season on days to 50 percent flowering. The mean value expressed during pre *kharif* and post *kharif* were 45.13 and 50.50 days after sowing (DAS), respectively. The interaction effect on growing season and genotype indicated non-significant demarcation highlighting a cumulative role in expression for the characters. The results are consistent with earlier finding (Dash and Misra, 1995), which found that okra cultivars varied significantly for days to flowering. Several other workers have also reported that days to flowering varied significantly among the okra genotypes (Subrata *et al*., 2004; Divya and Sreenivasan, 2010; Medagam *et al*., 2013).

Variations in plant height was found significantly among genotype. The mean value showed plant height of Gujarat okra-5 (113.97cm) and Kashi Pragati (113.43cm) were at par and it was significantly highest among the other genotype. There was also significant effect on growing season for plant height. The mean plant height of genotypes was significantly shorter during pre *kharif* (97.79cm) in contrast to the post *kharif* (108.60cm). The season and genotype interaction on plant height was found non-significant indicating no specific

Table 3 : Effect of growing season on Capsule related parameters of okra.

Genotypes (G)	Capsule length (cm)			Capsule diameter (mm)			Seed per capsule			Capsule per plant		
	Season (S)		Mean(G)	Season (S)		Mean(G)	Season (S)		Mean(G)	Season (S)		Mean(G)
	Pre *Kharif*	Post *Kharif*		Pre *Kharif*	Post *Kharif*		Pre *Kharif*	Post *Kharif*		Pre *Kharif*	Post *Kharif*	
G_1 (Hisar Unnat)	13.80	17.18	**15.48**	18.72	19.05	**18.88**	42.77	43.50	**43.13**	7.13	7.80	**7.47**
G_2 (Varsha Uphar)	17.70	18.81	**18.25**	18.24	19.38	**18.81**	39.70	40.46	**40.08**	7.87	8.00	**7.93**
G_3 (Arka Anamika)	18.20	20.31	**19.25**	19.32	19.57	**19.44**	43.80	43.80	**43.80**	7.07	7.53	**7.30**
G_4 (Pusa Bhindi-5)	15.30	17.55	**16.42**	18.06	18.60	**18.33**	32.20	34.20	**33.20**	7.00	7.07	**7.03**
G_5 (Kashi Kranti)	16.30	17.71	**17.00**	19.40	20.45	**19.93**	36.80	38.80	**37.80**	7.40	7.73	**7.57**
G_6 (Kashi Pragati)	17.30	18.27	**17.78**	18.85	19.05	**18.95**	35.93	37.50	**36.72**	8.00	8.27	**8.13**
G_7 (Parbhani Kranti)	18.40	19.21	**18.80**	18.25	18.34	**18.30**	40.17	40.67	**40.42**	8.33	8.37	**8.35**
G_8 (Gujarat Okra-5)	16.40	17.91	**17.15**	18.40	18.58	**18.49**	30.30	31.20	**30.75**	7.86	8.17	**8.02**
Mean (S)	**16.67**	**18.36**		**18.66**	**19.13**		**37.71**	**38.77**		**7.13**	**7.80**	
	G	**S**	**G X S**	**G**	**S**	**G X S**	**G**	**S**	**GX S**	**G**	**S**	**G X S**
SE (m)	**0.01**	**0.004**	**0.01**	**0.08**	**0.04**	**0.12**	**0.511**	**0.255**	**0.722**	**0.19**	**0.09**	**0.27**
C.D. (P=0.05)	**0.02**	**0.01**	**0.03**	**0.23**	**0.12**	**0.33**	**0.15**	**0.74**	**NS**	**0.55**	**0.27**	**NS**
Heritability	**99.90**	**99.90**		**90.40**	**57.70**		**94.90**	**84.00**		**59.20**	**10.00**	
GA over Mean (%)	**19.32**	**11.56**		**5.27**	**4.97**		**25.36**	**21.10**		**9.40**	**1.74**	

Table 4 : Effect of growing season on seed related parameters of okra.

Genotypes (G)	100 Seed weight (g)			Seed diameter (mm)			Seed Yield per plant (g)			Seed yield (kg/ha)		
	Season (S)		Mean(G)	Season (S)		Mean(G)	Season (S)		Mean(G)	Season (S)		Mean(G)
	Pre *Kharif*	Post *Kharif*		Pre *Kharif*	Post *Kharif*		Pre *Kharif*	Post *Kharif*		Pre *Kharif*	Post *Kharif*	
G_1 (Hisar Unnat)	5.51	7.01	**6.26**	4.11	5.02	**4.57**	16.86	23.63	**20.24**	936.5	1312.6	**1124.5**
G_2 (Varsha Uphar)	5.14	6.56	**5.85**	4.55	5.17	**4.86**	16.06	20.73	**18.40**	892.5	1151.4	**1021.9**
G_3 (Arka Anamika)	5.73	7.62	**6.68**	4.59	5.14	**4.87**	17.74	25.13	**21.44**	985.7	1396.2	**1190.9**
G_4 (Pusa Bhindi-5)	4.93	7.60	**6.27**	4.17	5.03	**4.60**	11.14	18.23	**14.68**	618.7	1012.8	**815.8**
G_5 (Kashi Kranti)	5.49	6.82	**6.16**	4.61	5.05	**4.83**	14.97	20.42	**17.70**	831.8	1134.4	**983.1**
G_6 (Kashi Pragati)	4.67	5.93	**5.30**	4.27	5.03	**4.65**	13.43	18.17	**15.80**	746.2	1009.6	**877.9**
G_7 (Parbhani Kranti)	5.70	6.88	**6.29**	4.30	5.04	**4.67**	19.07	23.40	**21.23**	1059.3	1299.9	**1179.6**
G_8 (Gujarat Okra-5)	5.76	7.24	**6.50**	4.72	5.43	**5.07**	13.76	18.46	**16.11**	764.7	1025.7	**895.2**
Mean (S)	**5.37**	**6.96**		**4.41**	**5.12**		**16.86**	**23.63**		**854.4**	**1167.8**	
	G	**S**	**G X S**	**G**	**S**	**G X S**	**G**	**S**	**G X S**	**G**	**S**	**G X S**
SE (m)	**0.02**	**0.01**	**0.03**	**0.04**	**0.02**	**0.05**	**0.53**	**0.27**	**0.75**	**29.5**	**14.7**	**41.7**
C.D. (P=0.05)	**0.06**	**0.03**	**0.09**	**0.11**	**0.06**	**0.16**	**1.54**	**0.77**	**NS**	**85.5**	**42.8**	**NS**
Heritability	**96.60**	**81.30**		**77.60**	**69.60**		**80.80**	**83.70**		**80.80**	**83.70**	
GA over Mean (%)	**15.23**	**14.07**		**9.78**	**4.34**		**29.84**	**23.73**		**29.84**	**23.73**	

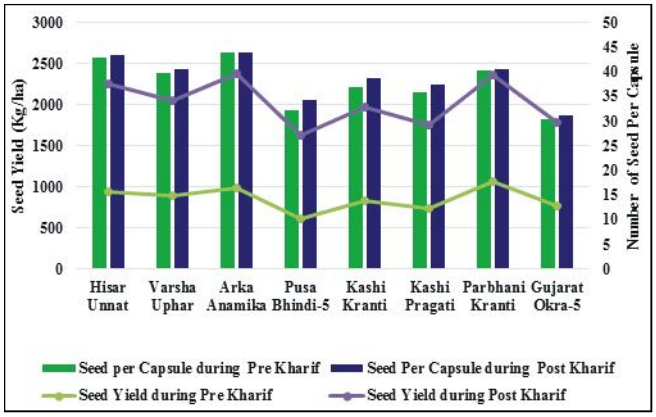

Fig. 1 : Seasonal influence on seed yield and its main determinants in okra.

interaction effect in individual case. Similar evidence was also reported by Simon *et al.* (2013) in okra genotypes based on variability in plant height.

Genotypic and seasonal difference was found significant for capsule parameters such as length, diameter, seed per capsule and capsule per plant. The performance of all capsule parameters was found significantly higher in post kharif. The interaction effect was found significant for capsule length and diameter only. Longest capsule was recorded in Arka Anamika (20.31 cm). Similarity, Kashi Kranti showed maximum in diameter (20.45 mm). Gondane and Bhattia (1995) also found significant and marked variation in capsule length among the fifty cultivars of okra, which is consistent with present finding. Similar variation in capsule diameter of okra based on genotypes and further influenced by growing season were also noticed by Bisaria and Shamshery (1979). The performance was superior during post *kharif* might due to favourable environmental conditions.

Seasonal and genotypic variation in seed related traits such as 100 seed weight, seed diameter and seed yield were found significant. The mean data showed that seed weight was recorded significantly highest in Arka Anamika (6.68 g) and the lowest was in Kashi Pragati (5.30 g). It was also observed that 100 seed weight was higher during post *kharif* (6.93 g) than pre *kharif* (5.37 g) in significant manner. The interaction effect of growing season and genotypes was also showed significant where topmost value was found in Arka Anamika during post *kharif*. Whereas, mean range of seed diameter was 4.11 mm (Hisar Unnat) to 4.72 mm (Gujarat Okra-5) and 5.02 mm (Hisar Unnat) to 5.43 mm (Gujarat Okra-5) during pre *kharif* and post *kharif*, respectively. Similar result was reported earlier by Wood *et al.* (1977) and Sankar and Mani (2015). This difference in 100 seed weight is possibly due to the genetic variation among the genotypes and their interaction with the environment. The interaction

Table 5 : Pearson correlation matrix of seed yield related phenotypic characters based on pooled mean of okra.

Parameters	Days to first flowering	Days to 50 % flowering	Plant height	Capsule length	Capsule diameter	Seed per capsule	Capsule per plant	100 seed weight	Seed diameter	Seed yield
Days to First flowering	1	**0.915****	**0.809***	0.089^{NS}	-0.182^{NS}	**-0.797***	0.085^{NS}	0.140^{NS}	0.558^{NS}	-0.585^{NS}
Days to 50 % flowering	**0.915****	1	**0.709***	0.383^{NS}	-0.024^{NS}	-0.572^{NS}	-0.023^{NS}	0.286^{NS}	0.574^{NS}	-0.356^{NS}
Plant height	**0.809***	**0.709***	1	0.126^{NS}	-0.474^{NS}	-0.643^{NS}	0.321^{NS}	-0.089^{NS}	0.090^{NS}	-0.453^{NS}
Capsule length	0.089^{NS}	0.383^{NS}	0.126^{NS}	1	0.080^{NS}	0.296^{NS}	0.396^{NS}	0.044^{NS}	0.354^{NS}	0.430^{NS}
Capsule diameter	-0.182^{NS}	-0.024^{NS}	-0.474^{NS}	0.080^{NS}	1	0.379^{NS}	-0.270^{NS}	-0.010^{NS}	0.207^{NS}	0.207^{NS}
Seed per capsule	-0.797*	-0.572^{NS}	-0.643^{NS}	0.296^{NS}	0.379^{NS}	1	-0.077^{NS}	0.095^{NS}	-0.311^{NS}	**0.872****
Capsule per plant	0.085^{NS}	-0.023^{NS}	0.321^{NS}	0.396^{NS}	-0.270^{NS}	-0.077^{NS}	1	-0.411^{NS}	0.209^{NS}	0.119^{NS}
100 Seed weight	0.140^{NS}	0.286^{NS}	-0.089^{NS}	0.044^{NS}	-0.010^{NS}	0.095^{NS}	-0.411^{NS}	1	0.350^{NS}	0.416^{NS}
Seed size	0.558^{NS}	0.574^{NS}	0.090^{NS}	0.354^{NS}	0.207^{NS}	-0.311^{NS}	0.209^{NS}	0.350^{NS}	1	-0.045^{NS}
Seed yield	-0.585^{NS}	-0.356^{NS}	-0.453^{NS}	0.430^{NS}	0.207^{NS}	**0.872****	0.119^{NS}	0.416^{NS}	-0.045^{NS}	1

Note: * at 0.01 percent, ** at 0.05 percent.

effect of growing season and genotype was found significant 100 seed weight and seed diameter, whereas, it was found non-significant for seed yield. The performance of genotypes was differing significantly for all considerable traits. The pooled seed yield value of Arka Anamika (1190.9 kg/ha) followed by Parbhani Kranti (1179.6 kg/ha) was highest comparing the least value of Kashi Kranti (877.9kg/ha). The most prominence performance was observed in seed yield indicating 854.4kg/ha and 1167.8kg/ha for during pre *kharif* and post *kharif*, respectively. In the present investigation, we have observed that most of the phenotypic traits recorded higher during post *kharif* season might be due to favorable growing conditions. This finding was also evident from the work of Wang *et al.* (2012).

All the above mentioned character was also recorded for heritability and genetic advance over mean. A joint consideration of broad-sense heritability (H_2%) and genetic advance (GA %) during pre *kharif* revealed the number of seed per capsule (94.85, 25.35 percent, respectively) exposed heritability and high genetic advance, whereas the capsule length (99.9, 9.32 percent, respectively) expressed with high heritability and moderate level of genetic advance. Similarly, the post *kharif* indicated same fashion on, broad-sense heritability (H_2%) and genetic advance (GA %) considering the characters, where the number of seed per capsule (84.00, 21.10 percent, respectively) showed the topmost in consideration of these. The plant height also indicated superior mutual effect having high heritability with moderate genetic advance indicating the values 96.60, 16.73 percent, respectively. Pooled correlation matrix also reported very significant association (0.872) of seed per capsule with seed yield. These results were in harmony with those previously obtained by Rambabu *et al.* (2019) and Ranga *et al.* (2021).

Conclusion

The genotypic difference was found significant for all phenotypic traits except per capsule weight. Similarly, effect of growing season was found significant higher for all traits except per capsule weight, during post kharif. Interaction effect of genotype and growing season was found significant for only capsule length, capsule diameter and physiological maturity. Based for early anthesis, early maturity and seed yield genotype Hisar Unnat (1124.50 kg/ha) was good performer, even though highest seed yield was recorded in genotype Arka Anamika (1190.90 kg/ha). Seed yield was recorded significantly highest during post kharif over pre *kharif*. The genotypes under present investigation differed significantly for seed yield attributing traits, where significant influence of post *kharif* was prominent. On considering the data of heritability, genetic advance and correlation simultaneously, it is reasonable to infer that improvement of seed per capsule itself will results in much higher seed yield.

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