IJPS INTERNATIONAL JOURNAL OF PLANT SCIENCES
Volume **9** | Issue 1 | January, 2014 | 35-39

RESEARCH ARTICLE

Stability analysis for fruit yield and its attributing characters in okra [*Abelmoschus esculantus* (L.) Moench]

R.M. JAVIA

SUMMARY

Stability performance of 49 okra entries including 13 genetically diverse parents and 36 crosses were compared by using stability analysis for fruit yield and its yield attributing characters such as days to flowering, number of nodes per plant, inter-nodal length (cm), plant height (cm), branches per plant, fruit length (cm), fruit girth (cm), number of fruits per plant and fruits yield per plant (g) in three consecutive seasons. The analysis of variance for stability revealed that the differences among the genotypes were highly significant for all the characters when tested against the pooled error, pooled deviation and G x E interaction indicating the presence of variability among the genotypes under all the environments. The fruit yield per plant was higher in two female and five male parents and in sixteen hybrids than average. However, none of the parents and crosses was considered stable. None of the parents or hybrids exhibited average stability for all the characters. Thus, any generalization regarding stability of genotypes for all the characters is too difficult since the genotypes may not simultaneously exhibit uniform responsiveness and stability patterns for all the characters. On the basis of overall yield performance, D-1-87-5 was observed to be highest yielder and deserves merit as high yielding variety for *Kharif* season. The cross combination HRB-55 x D-1-87-5 can be considered as an elite cross as it was highest yielder across the environments and was also superior with respect to most of the other characters.

Key Words : G x E interaction, Stability, Okra, Fruit yield

How to cite this article : Javia, R.M. (2014). Stability analysis for fruit yield and its attributing characters in okra [*Abelmoschus esculantus* (L.) Moench]. *Internat. J. Plant Sci.*, **9** (1): 35-39.

Article chronicle : Received : 30.07.2013; **Revised :** 21.09.2013; **Accepted :** 06.10.2013

Okra [*Abelmoschus esculentus* (L.) Moench] is an important vegetable crop grown throughout the country both as summer as well as rainy season crop for its green fruits. Okra fruit is a good source of nutrients and minerals. Mature fruits and stems are used in paper industry; root and stems are used for cleaning the cane juices (Singh, 1989). Apart from its commercial uses, it is very useful against genito-urinary disorders, spermatorrhoea and chronic dysentery (Krishnamurthy, 1994). Environment plays an important role in the final phenotypic expression of a character. A genotype is known to show a differential phenotypic response in development when introduced in different environments. The genotype x environment interaction plays an important role in the expression of quantitative characters controlled by polygenic systems and are greatly modified by the environmental influences.

AUTHOR FOR CORRESPONDENCE

R.M. JAVIA, Krishi Vigyan Kendra (J.A.U.), Nana-Kandhasar, SURENDRANAGAR (GUJARAT) INDIA
Email: rmjavia@gmail.com

The knowledge of nature and relative magnitude of various types of G x E interactions is useful in making decisions concerning breeding methods, selection of programmes and testing procedures in crop plants. Breeding genotypes with only high fruits yield is not enough because the effect of diverse environments on genotypic expression is a major problem. G x E interaction measures the differences in response of genotype to changing environments, thus, information on stability of fruits yield and its components characters is essential to understand diverse mechanism to yield stability. Therefore, an attempt was made to identify stable okra genotypes for fruits yield and yield attributing traits.

MATERIAL AND METHODS

The experimental material, comprised of 49 entries including 13 genetically diverse parents collected from the different parts of the country *viz.*, GO-2, Parbhani Kranti, JOL-1 and HRB-55 as female parents and Pusa Sawani, TC-17, HRB-107-4, VRO-6, Pant Bhindi-1, JO (2000K)-15, NDO-10, NOL-101 and D-1-87-5 as male parents and their 36 crosses generated by using line x tester mating design. The trial was raised in a randomized block design with three replications during three consecutive seasons *viz.*, early summer (E_1), late summer (E_2) and *Kharif* (E_3) at Instructional Farm, Junagadh Agricultural University, Junagadh. Each entry was planted by a single-row plot of ten plants, spaced at 45 x 30 cm. Five competitive plants were selected randomly for recording the different characters *viz.*, days to flowering, number of nodes per plant, inter-nodal length (cm), plant height (cm), branches per plant, fruit length (cm), fruit girth (cm), number of fruits per plant and fruits yield per plant (g). The recommended cultural practices and plant protection measures were followed uniformly in all the three environments to raised good crop. The pooled analysis of variance over the three seasons was also done to test the interaction of genotypes and sub-divisions with environments given by Comstock and Robinson (1952). The statistical analysis for genotype-environment (G×E) interaction and stability was carried out according to Eberhart and Russel (1966) for fruit yield and its component characters.

RESULTS AND DISCUSSION

The analysis of variance representing the mean squares due to different sources of variation following Eberhart and Russell (1966) stability model is presented in Table 1. The analysis of variance for stability revealed that the differences among the genotypes were highly significant for all the characters when tested against the pooled error, pooled deviation and G x E interaction indicating the presence of variability among the genotypes under all the environments. The differences among the environments (testing seasons) were also highly significant when tested against the pooled error, pooled deviation as well as against G x E interaction for all the characters. The difference due to genotype x environment were highly significant when tested against pooled error for all the characters. The mean square due to environments (linear) was higher in magnitude and were essentially linear for all the characters since differences were highly significant when tested against pooled error and against pooled deviations indicated that environments created by various seasons was justified and had linear effect. The genotype x environment component of variation was significant for all the characters when tested against pooled error, but was only significant for number of nodes per plant, internodal length, branches per plant and fruit girth when tested against pooled deviation. The genotype x environment (linear) component was highly significant for all the characters when tested against pooled error but non-significant for plant height, fruit length and fruits per plant when tested against pooled deviation.

The estimates of stability parameters were computed to evaluate relative stability of different genotypes over a range of environments and is presented in Table 2. A variety or genotype is considered to be stable over environments if it has higher mean value (Xi), unit regression (bi=1) non-significant deviation from regression ($S^2di=0$) (Eberhart and Russel, 1966).

For days to flowering, five parents and eleven hybrids indicated g x e interaction of predictable type (only b_i significant), while one parent and hybrid exhibited presence of linear and non-linear portion of g x e interaction (only b_i and S^2d_i significant). Stability parameters of the parents indicated that female parents HRB-55 (45.67 days) and JOL-1 (46.89 days) were earlier in flowering, poor responsive (b<1) and stable (S^2d_i=0). Out of thirty-six hybrids, four hybrids GO-2 x JO (2000 K)-15; P. Kranti x VRO-6; JOL-1 x P. Sawani and JOL-1 x TC-17 exhibited low mean, regression co-efficient near unity and non-significant deviation from regression indicated good stability with respect to flowering. Among the parents, P. Kranti; VRO-6; JO (2000 K)-15 and D-1-87-5 exhibited more number of nodes, regression co-efficient near unit value and non-significant deviation from regression indicating good stability associated with them. Five hybrids *viz.*, GO-2 x P. Sawani; P. Kranti x VRO-6; P. Kranti x Pant Bhindi-1; P. Kranti x NDO-10 and HRB-55 x NDO-10 had

Table 1 : Pooled analysis of variance for stability parameters for fruit yield and its components in okra

Source of variation	d.f.	Days to flowering	Number of nodes/plant	Internodal length	Plant height	Branches/ plant	Fruit length	Fruit girth	Fruits / plant	Yield / plant
Genotypes (G)	48	12.205*+	5.27*+	0.77*+	377.36*+	0.11*+	1.40*+	0.25*+	12.11*+	1478.38*+
Environments (E)	2	173.141*+	1623.62*+	126.11*+	66751.60*+	6.72*+	13.06*+	0.27*+	19.41*+	5876.34*+
G x E	96	4.286*	1.70*+	0.39*+	117.71*	0.02*+	0.37*	0.02*+	0.71*	168.81*
Environments (Linear)	1	346.017*+	3247.23*+	252.21*+	133503.70*+	13.45*+	26.11*+	0.54*+	38.81*+	11753.80*+
G x E (Linear)	48	6.604*+	2.42*+	0.63*+	135.52*	0.04*+	0.43*	0.03*+	0.72*	211.91*+
Pooled deviations	49	2.932*	0.96*	0.14*	97.85*	0.01*	0.29*	0.01*	0.69*	123.13*
Pooled Error	288	1.848	0.38	0.04	0.83	0.01	0.01	0.00	0.04	7.30

* Significant against pooled error at 5 % level, + Significant against pooled deviation at 5 % level

Table 2 : Estimates of stability parameters for different genotypes for fruit yield and its components in okra

Genotypes	Days to flowering			Number of nodes per plant			Internodal length			Plant height			Branches per plant		
	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$
GO-2	48.56	5.41*	22.05**	14.98	0.37**	0.56	8.18	1.37*	0.11**	84.00	1.07	4.80**	1.67	1.25	0.00
Parbhani Kranti	47.89	1.38**	-1.83	16.74	1.06	-0.12	8.93	0.58	0.00	110.74	0.87**	1.74	1.51	0.83	0.00
JOL-1	46.89	0.57**	-1.84	16.02	1.20	1.42*	8.62	1.37	0.00	111.58	0.93	2.85*	1.36	0.26	0.00
HRB-55	45.67	0.52	-0.23	13.21	1.05**	-0.38	7.76	-0.08**	0.14**	76.89	1.02*	-0.52	1.73	1.26	0.02*
Pusa Sawani	50.33	0.56	-1.19	15.72	1.15	-0.38	7.88	0.76	0.66**	99.94	0.99	7.74**	1.47	1.09	0.00
TC-17	46.22	1.52	1.63	14.52	1.03	-0.32	8.32	0.71	0.71**	85.74	0.97	20.21	1.76	1.05	0.00
HRB-107-4	49.00	0.39	-0.94	14.72	1.09	0.51	8.13	0.92	0.00	88.73	0.89	314.31**	1.59	0.50	0.00
VRO-5	49.00	1.71**	-1.78	16.40	1.07	-0.38	8.46	0.81	0.22**	99.23	0.82	171.91**	1.38	0.69	0.01*
Pant Bhindi-1	49.78	1.59	0.31	15.81	0.79	0.57	8.47	1.03	0.02**	103.62	0.84	94.03**	1.36	0.72*	0.01
JO (2000K)-15	48.56	1.38**	-1.83	15.90	1.02	-0.30	8.29	1.20**	0.41**	91.30	0.95	31.75**	1.69	0.88	0.00
NDO-10	48.67	0.64**	-1.84	14.86	1.33	3.12**	8.28	1.42**	0.22**	82.70	1.04	146.14**	1.71	0.83	0.00
NOL-101	49.78	-0.35	-0.84	14.54	0.97	0.28	8.89	1.33**	0.00	91.57	0.92	176.46**	1.71	0.99	0.00
D-1-87-5	49.11	1.79	1.32	15.48	1.02	0.45	9.11	1.47	0.00	97.17	0.99	70.11**	2.02	1.20	0.00
GO-2 x NDO-10	48.56	1.23	2.85	15.74	0.85	0.07	8.19	0.61**	0.12**	99.83	0.90	239.78**	1.71	0.82	0.01
GO-2 x NOL-101	50.44	1.78	-1.85	15.04	1.28**	-0.20	8.09	0.43**	0.13**	88.28	1.41**	19.56**	1.98	1.14	0.00
GO-2 x D-1-87-5	48.67	2.01**	-1.65	14.96	0.77	0.58	7.70	0.45**	0.05**	92.67	0.96	87.39	2.02	1.20	0.00
Parbhani Kranti x D-1-87-5	50.33	0.68	-1.53	14.86	1.01	-0.35	8.41	0.77	0.00	99.91	1.13	18.52**	1.84	0.52	0.00
JOL-1 x D-1-87-5	47.00	0.85	-1.35	15.53	0.87	0.90	8.64	1.13	0.02**	104.10	0.72**	18.91**	1.96	1.34**	0.01*
HRB-55 x JO (2000K)-15	47.89	0.14**	-1.69	13.01	1.07	-0.38	7.68	1.22**	0.01*	73.61	1.12**	-0.79	1.76	1.35	0.00
HRB-55 x NOL-101	45.78	0.41**	-1.62	13.17	1.05	-0.38	8.28	1.14	0.00	75.14	1.07**	-0.55	2.02	1.98	0.00
HRB-55 x D-1-87-5	46.22	0.52*	-0.54	14.96	0.82**	-0.25	7.94	1.24	0.17**	90.09	0.61**	32.46**	2.18	1.76	0.00

Table 2. Contd.....

Genotypes	Fruit length			Fruit girth			Fruits per plant			Yield per plant		
	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$	Mean	b_i	$S^2 d_i$
GO-2	10.65	0.41	0.07**	5.26	1.24	0.00	10.20	-0.15	1.91**	131.38	0.35	299.34**
Parbhani Kranti	11.13	0.08**	0.02	4.67	-1.54	0.03**	11.67	0.82	3.01**	136.07	-0.60	317.68**
JOL-1	9.60	1.31	0.07**	4.74	3.19	0.00	12.27	0.87	0.45**	128.36	0.94	17.56
HRB-55	11.99	1.17**	0.01	5.11	-2.22	0.01*	12.80	2.46**	-0.02	153.93	2.40	398.92**
Pusa Sawani	10.71	2.64*	0.31**	5.27	-2.52	0.00	10.13	2.37**	0.11	128.78	4.11**	9.04
TC-17	10.82	1.55	0.04*	4.86	2.21	0.00	12.73	1.05	-0.03	125.20	0.60	15.27
HRB-107-4	10.95	0.29	1.25**	5.23	0.31	0.00	12.93	0.93	0.79**	140.93	0.55	54.86**
VRO-5	10.57	-0.13**	0.00	4.98	8.05**	0.04**	9.80	-0.45	0.48**	115.51	-0.44	51.62**
Pant Bhindi-1	10.23	3.30**	0.00	5.33	0.77	0.00	9.73	1.02	0.12*	120.00	0.06**	-1.71
JO (2000K)-15	10.81	0.66	0.04*	4.98	2.12	0.00	14.27	-0.01	0.21**	143.51	0.41**	-7.27
NDO-10	10.60	0.23	0.17**	5.33	0.12	0.01*	12.80	-0.17**	0.02	138.89	0.84	8.17
NOL-101	11.86	0.64	0.43**	5.42	3.04	0.00	14.47	1.58	0.37**	139.00	1.59**	-7.24
D-1-87-5	12.41	0.21**	0.00	5.44	0.57	0.00	15.00	1.66	-0.03	163.49	0.87**	-7.27
GO-2 x NDO-10	11.49	1.38	0.24**	5.71	0.79	0.00	13.93	2.10**	0.20*	162.31	3.07	314.06**
GO-2 x NOL-101	11.02	-1.35*	0.00	5.48	-0.28	0.01**	15.13	-0.49	0.43**	171.78	1.80	791.37**
GO-2 x D-1-87-5	11.57	0.33*	0.03*	5.64	0.41	0.02**	15.20	0.98	-0.03	173.51	1.88**	11.09
Parhani Kranti X D-1-87-5	11.64	1.01	0.65**	5.66	1.01	0.00*	16.40	1.07	0.13*	184.27	1.40**	-1.09
JOL-1 x D-1-87-5	12.02	0.87	-0.01	5.21	2.09	0.03**	14.20	2.46	0.53**	161.96	2.55**	73.26**
HRB-55 x JO (2000K)-15	11.78	1.55	0.29**	5.19	-1.69	0.00	15.00	1.89**	0.03	164.33	1.97**	25.39*
HRB-55 x NOL-101	10.87	-0.85	0.01	5.57	0.83	0.03**	14.00	1.39	1.37**	157.73	1.17	120.71**
HRB-55 x D-1-87-5	12.54	0.94	-0.01	5.49	1.61	0.00	16.87	1.87*	0.08	188.44	1.41	47.46**

more number of nodes per plant, regression co-efficient around unity and non-significant deviation from regression which revealed that these hybrids were more stable for increased number of nodes per plant across environments. For internodal length only one male parent HRB-107-4 depicted shorter internodes, regression co-efficient near unity and non-significant deviation from regression indicating stable male parent for shorter internodal length. Three hybrids *viz*., JOL-1 x P. Sawani; JOL-1 x TC-17 and HRB-55 x TC-17 displayed low mean, non-significant deviation from regression and regression co-efficient less than unity which indicated above average stable. Moreover, the internodal length of hybrids was not predictable because their deviation from regression were away from zero. Only one male parent P. Kranti registered higher plant height ($\overline{X}$=110.74) coupled with unit regression co-efficient (b_i=0.87) and non-significant deviation from regression (S^2d_i=1.74) indicating the stable male parent for tallness. Two hybrids such as GO-2 x HRB-107-4 and P. Kranti x VRO-6 recorded tall plant height, regression co-efficient near unity and non-significant deviation from regression indicating stable hybrids for tall plant type. High mean for branches per plant, unit regression co-efficient and non-significant deviation from regression were displayed by two male parents (TC-17 and NOL-101) and were considered stable for number of branches per plant.

In case of fruit length, eight parents deviated significantly from regression suggesting that its performance over environments was unpredictable. Only single female parent HRB-55 was considered as stable for fruit length because high fruit length ($\overline{X}$=11.99 cm), regression co-efficient near unit value (b_i=1.17) and non-significant deviation from regression (S^2d_i=0.01). Only one hybrid HRB-55 x D-1-87-5 recorded longer fruits ($\overline{X}$=12.54 cm), regression co-efficient near unity (b_i=0.94) and non-significant deviation from regression (S^2d_i=0.01) suggesting stability for fruit length. The male parents P. Sawani; HRB-107-4; Pant Bhindi-1; NDO-10 and D-1-87-5 had high mean for fruit girth response less than unity (bi<1) and non-significant deviation from regression thereby indicating above average stable for thicker fruits while hybrid GO-2 x VRO-6 had thicker fruits ($\overline{X}$=5.24 cm) was considered stable as its regression co-efficient was near unity (b_i=0.99) and non-significant deviation from regression (S^2d_i=0). Male parent TC-17 and hybrids GO-2 x D-1-87-5 and P. Kranti x P. Sawani manifested more number of fruits, regression co-efficient near unity and non-significant deviation from regression and were considered as stable for number of fruits per plant.

The fruit yield per plant was higher in two female and

Table 3 : Distribution of parents and hybrids on the basis of individual g x e interaction components for various characters

Characters	Predictable				Unpredictable (g x e present)			
	g x e absent (both bi and S2di n.s.)		g x e present (only bi significant)		Both bi and S2di significant		Only S2di significant	
	Parents	Hybrids	Parents	Hybrids	Parents	Hybrids	Parents	Hybrids
Days to flowering	7	24	5	11	1	1	0	0
Number of nodes per plant	9	15	2	14	0	0	2	7
Internodal length	4	7	1	3	4	7	4	11
Plant height	1	2	2	6	0	8	10	20
Branches per plant	10	26	1	2	0	5	2	3
Fruit length	0	6	5	5	1	4	7	21
Fruit girth	9	20	0	0	1	0	3	16
Fruits per plant	2	5	3	7	0	2	8	22
Yield per plant	3	5	5	8	0	4	5	19

Table 4 : Estimates of environmental index (I_j) for various characters under different environments

Characters	Environmental index		
	E_1	E_2	E_3
Days to flowering	1.3606	0.5443	-1.9047
Number of nodes per plant	-3.9340	-2.7807	6.7145
Internodal length (cm)	-1.1413	-0.6930	1.8342
Plant height (cm)	-20.1086	-22.4882	42.5968
Branches per plant	-0.1952	-0.2320	0.4272
Fruit length (cm)	-0.2715	-0.3237	0.5952
Fruit girth (cm)	-0.0563	-0.0276	0.0839
Fruits per plant	-0.5918	-0.2082	0.6381
Yield per plant (g)	-8.7536	-3.5270	12.2805

five male parents and in sixteen hybrids than average. However, none of the parents and crosses was considered stable. The male parents *viz.*, JO (2000 K)-15; NDO-10 and D-1-87-5 had high mean yield, regression co-efficient significantly less than unity and non-significant deviation from regression suggesting that these parents were considered as above average stable. In case of hybrids, GO-2 x D-1-87-5 ($\overline{X}$=173.51 g, b_i=1.88, S^2d_i=11.09); P. Kranti x D-1-87-5 ($\overline{X}$=184.27 g, b_i=1.40, S^2d_i=-1.09) were considered as below average stable since they had regression co-efficient greater than unity, while hybrid GO-2 x P. Sawani ($\overline{X}$=138.60 g, b_i=-0.88, S^2d_i=-6.69) was considered as above average stable since they had regression co-efficient less than unity. The highest yielding hybrid HRB-55 x D-1-87-5 ($\overline{X}$=188.44 g) as well as 22 other hybrids were found to be unpredictable across the environments as it displayed significant deviation from regression for fruit yield per plant.

The summarized information on g x e interaction of individual genotypes is presented in Table 3. It showed that days to flowering, number of nodes per plant, branches per plant and fruit girth recorded higher number of predictable genotypes, whereas plant height and fruit length expressed with lowest number of predictable genotypes. Two characters *viz.*, days to flowering and number of nodes per plant also recorded greater number of stable genotypes among the characters under study.

None of the parents or hybrids exhibited average stability for all the characters. Thus, any generalization regarding stability of genotypes for all the characters is too difficult since the genotypes may not simultaneously exhibit uniform responsiveness and stability patterns for all the characters. (Singh and Singh, 1980).

Simultaneous consideration of mean, regression co-efficient and deviation from regression of the individual genotype for yield per plant revealed that none of the parents and hybrid showed the stability for this trait, but the parents D-1-87-5, NDO-10 and JO (2000K)-15 and hybrid GO-2 x Pusa Sawani exhibited above average stability for yield per plant which suggested that these parents and hybrid would do well even under poor environments. Similar finding were also reported by Ariyo (1987) and Desai (1990).

Looking to the environmental indices for various characters (Table 4), it was observed that *Kharif* (E_3) was found most favourable for majority of characters, while early summer ($E_{1)}$ and late summer ($E_{2)}$ were poor for all the characters except for internodal length.

Looking to the yield in three environments, D-1-87-5 was observed to be highest yielder though it had above average stability. This variety deserves merit as high yielding variety for *Kharif* season. The cross combination HRB-55 x D-1-87-5 can be considered as an elite cross as it was highest yielder across the environments and was also superior with respect to most of the other characters.

REFERENCES

Ariyo, O.J. (1987). Stability of performance of okra as influenced by planting date. *Theoretical & Appl. Genet.*, **74** (1): 83-86.

Comstock, R.E. and Robinson, H.F. (1952). Estimation of average dominance of genes in "Heterosis" Edn. G. W. Gowen. Iowa State College Press, Ames, Iowa, pp. 494-516.

Desai, D.T. (1990). Genetic analysis of some quantitative characters in okra [*Abelmoschus esculentus* (L.) Moench]. Ph.D. Thesis, Mahatma Phule Krishi Vidyapeeth, Rahuri, AHMEDNAGAR (M.S.) INDIA.

Eberhart, S.A. and Russell, W.A. (1966). Stability parameters for comparing varieties. *Crop. Sci*., **6** : 26-40.

Krishnamurthy, K.H. (1994). Okra In : *Vegetable health series, traditional family medicine*. Publ. by Books for all, Ashok Vihar, Delhi, pp.12-15.

Singh, S.V. and Singh, R.B. (1980). Stability of components characters in relation with the stability of yield. *Indian J. Genet*., **40** : 93-98.

Singh, S.P. (1989). Okra In : Production technology of vegetable crops. Publ. by Agril. Research Communication Centre, Sardar, Karnal (India), p. 70.