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Assessment of Genotype x Environment Interaction and Stability Analysis in Okra [*Abelmoschus esculentus* (L.) Moench] Genotypes for Growth and Yield Components

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ABSTRACT

Keywords

Okra, Yield components, Regression, GXE interaction, Stability analysis.

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The phenotypic stability of sixteen genotypes of okra was tested for growth and yield components by growing them in three different environments. The results revealed significant difference among the genotypes all the traits studied except for plant height at 90 days after sowing and number of fruits per plant. Significant difference among the environments was observed for almost all the characters except for plant height at 90 days after sowing (DAS), number of fruits per plant. GxE interaction was significant for plant height at 45 days after sowing and total yield per plant. The genotypes L5, L8, L9 and L15 were found stable and predictable with high mean value for fruit yield per plant as indicated by regression coefficient approaching unity and non-significant deviation from regression and were stable across different environments

Introduction

Okra [*Abelmoschus esculentus* (L) Moench] is an important vegetable crop grown in tropical and sub-tropical regions for its tender green fruits. It has high nutritive value and export potential. Okra has multiple uses. Tender fruits are used as vegetable, eaten boiled, in culinary preparations as sliced and fried pieces. It is also used in thickening of soups and gravies because of its high mucilage content. India is the largest producer of okra in the world with an annual production of 6346.4 thousand million tons from an area of 532.7 thousand hectares (Anon., 2016). Yield stability is one of the most desirable properties of the genotypes to be released as new variety. Great fluctuations in the crop yield are observed due to the non-adaptability of varieties to variable agro-climatic conditions.

Gene expression is subject to modification by the environment; therefore, genotypic expression of the phenotype is environmentally dependent (Kang, 1998).

Inconsistent genotypic responses to environmental factors such as temperature, soil moisture, soil type or fertility level from location to location and year to year are a function of genotype x environment (GE) interactions. Genotype x environment interactions has been defined as the failure of genotypes to achieve the same relative performance in different environments (Baker, 1988). A breeding programme aimed at developing phenotypically stable varieties needs information on the extent of GXE interaction for growth, yield and its component characters. Genotype × Environment (GE) interaction is useful for explaining adaptation patterns, as only this interaction can be exploited by selecting for specific adaptation or by growing specifically adapted genotypes. To avoid genetic vulnerability associated with the narrowing of the genetic base of any crop, the GXE interactions of the germplasm are important (Kang, 1998). Therefore, in the present investigation an attempt has been made to evaluate superior okra genotypes for yield and its component characters under different environments to identify stable genotypes.

Materials and Methods

Fifty six genotypes of okra, which were collected from different sources were evaluated in field along with check variety for various productivity related traits. Based on the growth, yield and resistance against YVMV, top sixteen superior genotypes were selected form fifty six genotypes (Table 1) and used in the present investigation for stability analysis. These sixteen superior okra genotypes were evaluated along with check in randomized block design (RBD) at three different locations (environments) namely, horticulture research station Devihosur, horticulture research station, Kumbhapur Farm, Dharwad and college of horticulture, Bagalkot, Haveli farm in two replications during *Kharif* 2016. In each replication, each genotype was represented by plot of one row of ten plants. Recommended package of practices were followed to raise good crop. Five plants in each genotype of two replications were randomly chosen to record the observations on plant height (cm), number of leaves at 45 and 90 days after planting, number of fruits per plant and total fruit yield per plant (g). Mean data obtained was statistically analyzed and the genotypes were assessed for their stability of performance across environments following the method described by Eberhart and Russell (1966)

Results and Discussion

The results of analysis of variance for six growth and yield traits are summarized in table 1. The results revealed significant difference among the genotypes for all the characters studied expect for plant height at 90 days after sowing (DAS) and number of fruits per plant. Significant variation among the environments was observed for almost all the characters except for plant height at 90 days after sowing (DAS) and number of fruits per plant. Higher magnitude of mean squares due to environments for plant height at 45 days after sowing (DAS) and total fruit yield per plant indicates considerable differences between environments for these characters and these characters were greatly influenced by environments; thereby suggesting the large differences between environments along with greater part of genotypic response was a linear function of environments.

Significant genotype x environment interaction led to the identification of stable genotypes. The stable genotype is one, which interact less with the environments, giving a near consistent performance across the environments. According to Eberhort and Russell (1966) model, an ideal genotype is defined as the one possessing high mean performance with regression coefficient around unity, *i.e.*, bi=1 with non-significant deviation from regression coefficient, *i.e.*, (S^2_{di}) as close to zero as possible. The linear regression is recorded as a measure of response to a particular genotype to changing environments. If regression coefficient (bi) is greater than unity, the genotype is said to be highly sensitive to environmental changes and adapted to favorable environments. If regression coefficient (bi) is equal to unity, it indicates average sensitivity to environmental changes and coefficient is less than unity. bi ≤ 1 indicates less sensitivity to environmental changes and if it shows a higher mean value, then the genotype was adapted to widely differing conditions. If the mean is low, the genotype is considered to be poorly adapted to all environments.

Plant height differed in the genotypes at all the stages of crop growth. Difference in plant height among the genotypes is by virtue of their growth habit. At 45 days after sowing (DAS), the genotypes L7, L10, L11 and L12 were found to be stable with respect to plant height as indicated by their high mean values, regression coefficient approaching unity and non-significant deviation from regression (Table 3), hence these genotypes are specifically adapted to favorable environment. Such varied responsiveness of genotypes to changing environments for plant height was also reported by Tomar and Singh (1992).

Table.1 List of okra genotypes used in the present study for stability analysis

Okra Genotype	Genotype Code
MHO-1	L1
MHO-2	L2
MHO-3	L3
MHO-4	L4
MHO -5	L5
MHO -6	L6
MHO -7	L7
MHO -8	L8
MHO -9	L9
MHO -10	L10
MHO -11	L11
MHO -12	L12
MHO -13	L13
MHO -14	L14
MHO -15	L15
MHO-16	L16

Table.2 Analysis of variance (mean squares) for stability for growth and yield parameters of okra genotypes

Sl. No.	Character	Genotypes	Environment	Genotypes x Environments	Environments + (Genotypes x Environments)	Environment (Linear)	Genotypes x Environments (linear)	Pooled deviation	pooled error
	Degrees of freedom	**15**	**2**	**30**	**32**	**1**	**30**	**16**	**45**
1	Plant height (cm) (45 DAS)	11.316**	15.974*	3.563*	4.339**	31.948**	5.814**	1.23	6.244
2	Plant height (cm) (90 DAS)	41.674	0.545	32.099	30.127	1.09	20.217	41.232*	6.384
3	Number of leaves per plant (45 DAS)	5.928*	0.139*	0.073	0.077	0.278	0.095	0.048	0.114
4	Number of leaves per plant (90 DAS)	11.80**	0.149*	0.221	0.216	9.49**	5.86**	1.835**	0.241
5	Number of fruits per plant	1.604	0.85	1.974	1.904	1.7	1.684	2.123	1.248
6	Total yield per plant (g)	1669.5**	115.14**	576.48**	547.652**	230.291**	633.415	487.08**	423.66

Table.3 Stability parameters for plant height and number of leaves per plant (at 45 and 90 DAS) in okra genotypes

	Plant height at 45 DAS			Plant height at 90 DAS			Number of leaves per plant at 45 DAS			Number of leaves per plant at 90 DAS		
Genotypes	**Mean**	**Regression co efficient (bi)**	**Deviation from regression (S^2di)**	**Mean**	**Regression co efficient (bi)**	**Deviation from regression (S^2di)**	**Mean**	**Regression co efficient (bi)**	**Deviation from regression (S^2di)**	**Mean**	**Regression co efficient (bi)**	**Deviation from regression (S^2di)**
L1	41.5	1.7	0.7	85.8	20.8	4	11.7	-9.8	7.642*	22.8	-2.5	5.0851 **
L2	42.6	1.7	-3.2	85.8	14.5	60.67**	11.1	8.0	-1.2	22.5	1.8	1.1
L3	39.9	0.8	-1.9	92.4	0.9	44.7 **	12.7	3.7	-0.9	22.4	1.1	-0.6
L4	43.0	2.3	-3.2	91.0	-17.5	49.43 **	11.1	5.6	0.0	20.3	-0.5	-0.6
L5	38.8	3.3	-3.0	88.3	-20.0	89.61**	12.3	3.074*	-1.3	21.2	-0.6	-0.6
L6	40.1	0.2	-1.2	82.9	-15.8	45.03**	10.4	-25.3	-1.1	22.9	0.6	-0.6
L7	38.8	1.2	-3.0	80.3	17.1	-2	11.3	5.5	0.5	22.2	3.6	-0.5
L8	42.4	0.4	0.1	91.2	22.7	26.32**	15.6	15.4	-0.5	26.3	8.4	12.3 **
L9	45.8	2.9	-2.5	91.9	21.43*	-3	14.2	20.3	5.65 *	28.2	7.3	5.43**
L10	41.5	1.5	-2.1	87.9	-22.9	197.3**	11.4	-4.9	-0.7	21.0	-1.8	0.4
L11	41.8	1.4	-2.5	86.5	-2.3	21.08 **	10.8	3.074*	-1.3	21.3	-0.7	-0.3
L12	40.7	1.6	-2.1	93.2	-1.3	23.50 **	12.7	7.4	0.0	23.4	1.2	-0.6
L13	44.0	1.8	-3.0	93.6	-11.9	2	11.1	-16.0	4.784*	22.4	-1.55*	-0.6
L14	43.7	3.0	-3.0	88.6	19.2	50.32 **	13.3	1.2	-0.8	23.9	2.14*	-0.6
L15	43.3	2.1	-0.2	86.5	11.7	-2	10.8	-3.1	-0.3	22.3	-1.8	0.4
L16	43.3	1.9	-1.3	88.3	-20.6	0	12.2	1.9	-1.2	21.9	-0.7	-0.2
Mean	**41.9**			**88.4**			**12.0**			**22.8**		
S. E m±	**0.8**			**4.5**			**1.0**			**1.0**		
S.E.of bi		**0.8**			**24.6**			**8.5**			**1.8**	

Table.4 Stability parameters for number of fruit per plant and fruit yield per plant in okra genotypes

Number of fruits per plant					Fruit yield per plant (g)		
Sl. No.	**Genotypes**	**Mean**	**Regression co efficient (bi)**	**Deviation from regression (S^2di)**	**Mean**	**Regression co efficient (bi)**	**Deviation from regression (S^2di)**
1	L1	22.2	3.683	0.04	268.6	1.54	156.5
2	L2	22.2	1.062	-0.07	283.6	-1.1	131.5
3	L3	21.2	0.692	3.995**	281.7	-3.7	-197
4	L4	20.1	-0.46	2.0632 *	265.7	1.12	-181
5	L5	21.1	3.441	-0.48	321.8	9.83	59.83
6	L6	20.7	0.415	0.039	266.3	-0.5	338.2
7	L7	20.5	-5.36	0.992	303.2	9.36	2057.1**
8	L8	21.6	-0.95	-0.42	346.6	2.3	-91.3
9	L9	21.3	0.994	6.2719**	304.2	16.1	935.23 *
10	L10	20.3	5.547	3.2769 *	272.9	-10	887.11 *
11	L11	20.3	1.989	7.126 **	254.8	-4.3	229.1
12	L12	22.1	10.11	0.413	274.4	-1.6	-95.5
13	L13	22.5	1.964	-0.53	289.5	-2.6	-112
14	L14	21.3	-1.62	1.268	280.5	-2.7	585.2
15	L15	21.3	1.55	-0.36	304.3	-4.7	-46.5
16	L16	21.4	-7.06	0.436	281.6	7.1	-93.7
	Mean	**21.3**			**287.5**		
	S. E m±	**1.03**			**15.61**		
	S.E.of bi		**4.47**			**5.82**	

Other genotypes, L3, L6 and L8 having regression coefficient below the unity and can perform marginally well in unfavorable environments, L 9 and L13 had higher mean value and regression coefficient above the unity with non-significant deviation from regression, indicating slightly better performance of this genotypes in favorable environments.

The genotype L3 was found stable and predictable with high mean value for plant height at 90 DAS as indicated by non-significant regression coefficient approaching unity and non-significant deviation from regression. The genotypes L14 and L16 were found stable and predictable with high mean value for number of leaves at 45 DAS as indicated by non-significant regression coefficient approaching unity and non-significant deviation from regression. In contrary to the finding of present investigation, Babu *et al.,* (1983) reported consistence performance of genotypes for number of leaves in okra with different set of genotypes.

For number of leaves at 90 DAS, GX E interaction was not significant. Similar results were obtained by Babu *et al.,* (1983) in okra and Cuartero and Cubero (1982) in tomato. This indicated that all the genotypes were stable. The genotype L9 exhibited maximum number of leaves at 90 DAS (28.17) followed by L8 (26.33), L14 (23.89) and L12 (23.39). With respect to number of fruits per plant, the genotypes L2 and L15 were found stable and average responsive with regression coefficient approaching unity and non-significant deviation from regression and hence regarded as stable genotypes for this trait (Table 4). The other genotypes L9, L10 and L11 with high mean values were found to be unstable because of significant regression coefficient above unity and are suited to favorable environments. Such varied response of genotypes for stability parameters have been reported for number of fruits per plant by Babu *et al.,* (1983) in okra, Rai *et al.,* (2000) in Brinjal and Harrer *et al.,* (2000) in cowpea.

The genotypes L1 and L4 were found stable for total yield per plant. The average responsive with regression coefficient approaching unity and non-significant deviation from regression makes them as stable genotypes for this trait. The genotypes L5, L8, L9 and L15 were found stable and predictable with high mean value fruit yield per plant as indicated by regression coefficient approaching unity and non-significant deviation from regression. Difference among the genotypes tested with respect to stability parameters were also reported in tomato for yield per plant (Pandy, 1983). Among the stable genotypes for yield, the genotype L8 was highest yielder and it was also found stable for number of leaves at 90 DAS, number of branches at 90 DAS, number of fruits per plant. It also had least number of ridges, which is desirable. The next highest yielder among the stable genotypes was L5, which was also found stable for plant height at 45 DAS, number of fruits per plant. The third highest stable yielding genotypes for total yield per plant was L 9 and it was also found stable for plant height at 45 and 90 DAS, number of fruits per plant. The genotype L15 was the fourth highest yielding among the stable genotypes.

Generally, genotypes with high mean yield over the environments and high stability are preferred, but in practice, such genotypes are rarely available. Therefore, identification of stable genotypes with high mean yield suited to poor environments and favorable environments separately is inevitable. The present study outstandingly brought out of the fact that, advantages of genotypes may not only in the area of increased yield but also for greater stability in production across the environments (Poshiya and Vashi, 1997). In the present investigation, among the stable genotypes for total fruit yield per plant, the genotypes L5, L8, L9 and L15 were found stable and predictable with high mean value for fruit yield per plant as indicated by regression coefficient approaching unity and non-significant deviation from regression and they were stable across the environments.

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