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Impact of genotype × environment interaction and stability for seed cotton yield and its component traits in Asiatic cotton (*Gossypium arboreum* L.)

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ABSTRACT : Stability analysis helps in understanding the adaptability of genotypes over different environmental conditions and the identification of adaptable genotypes. To study the magnitude and nature of genotype × environment interaction and to determine stability of yield potentiality in Asiatic cotton was carried out in three different date of sowings (Early, normal and late) during *kharif* seasons of 2015 and 2016. Significant differences were observed among the genotypes and environments for seed cotton yield / plant, lint yield / plant, seed index, lint index, ginning outturn, seeds / boll, boll weight, bolls / plant, monopods / plant, plant height, days to boll bursting and days to first flower indicating presence of variability among genotypes and environments. Mean square due to genotypes x environment (linear) were significant for all the characters indicating the preponderance of linear component of G x E interaction than non linear component hence prediction is possible. The cotton varieties HD 123 and HD 432 were recorded high mean with regression coefficient (b_i) near unity and non significant deviation from regression (S^2d_i) for seed cotton yield / plant, lint yield / plant and monopods / plant indicated that these genotypes had average response and high stability over the environments. The estimation of environmental additive effect (Ij) estimates revealed that environment 4 was best for seed cotton yield (g/plant) and lint yield (g/plant). Hence ex/ imental finding suggests the suitability of genotypes and environmental conditions for the exploitation of different traits of cotton to varying conditions.

Key words : Cotton genotypes, genotype × environment interactions, potentiality, stability parameters

Cotton is one of the most important cash crops of the world. Analysis of genotype (G) x environment (E) interactions and their influence on varieties can help cotton breeders to identify stable cultivars across environments. The adaptability and stability analysis is an important tool to the plant breeders to assess the potentiality of a genotype over multi environment conditions (Meredith *et al.,* 2012). Significant G × E component reduces correlations between genotype and phenotype values (Zeng *et al.*, 2014) and affects breeding for genetic improvement, especially for quantitative traits. The genotypes showing the least genotype × environment interaction are considered desirable for breeding because of their wider adaptability and stability. Mean yield across different environment is an adequate indicator of genotypic /formance, only, in the absence of genotype - environment interaction (Ezzat *et al.,* 2010). Cotton is a sensitive crop to weather fluctuations; it shows higher magnitude of genotype x environment interaction. More knowledge about causes of G x E interaction is needed and would be useful for establishing breeding objectives for optimal cultivar adaptation (Anandan, 2010). Estimation of stability has proven to be a valuable tool in the assessment of varietal adaptability. The major concern of a breeder is to develop stable genotypes that give maximum economic yield / unit area and consistent /formance for productivity across environments. So it becomes im/ative to study the level of impact of G x E interaction over different types of genotypes to identify the best genotypes having better yielding potential across all the environments. The knowledge of buffering capacity of genotypes will be also useful to know whether to use hybrids or varieties for the particular set of environments. The present study aimed to investigate the relative stability /formance of three cotton varieties in six different environments for seed cotton yield and its component traits.

MATERIALS AND METHODS

The study was conducted at the Research Farm of Cotton Section, Department of Genetics and Plant Breeding, Chaudhary Charan Singh Haryana Agricultural University, Hisar. The experimental material for the present study comprised of 3 varieties of *desi* cotton *i.e.* HD123, HD 324 and HD 432. All the experimental material was grown in six environments (Table 1) which comprised of two years (2015 and 2016) and three different dates of sowing (early, normal and late). All the varieties were grown in a randomized block design (RBD) with six replications. There were eight rows of each genotype of six meter length, rows were spaced 67.5 cm apart and plant to plant distance was kept 30 cm. All the recommended agronomical package of practices was followed to raise the good crop. At the time of square initiation five competitive plants were tagged from each treatment and replication for taking the observations for days to first flower, days to boll bursting, plant height (cm), monopods / plant, bolls / plant, boll weight (g), seeds / boll, ginning outturn (%), seed cotton yield / plant (g), lint yield / plant (g), seed index (g) and lint index (g). The averaged data were analyzed for stability.

RESULTS AND DISCUSSION

Analysis of variance : The analysis of variance (Table 2) showed that mean squares due to genotypes were highly significant for days to first flower, days to boll bursting, plant height, monopods/plant, bolls/plant, boll weight, seeds/boll, ginning outturn, lint index, seed index, seed cotton yield/plant, lint cotton yield/plant indicating sufficient genetic variability present among the genotypes. Environmental mean squares were also highly significant for all the characters which indicated that the environments chosen in the study were highly variable. Environment + genotypes × environment interactions were partitioned into environment (linear), genotypes × environment (linear) interaction (sum of squares due to regression, b_i) and unexplainable deviation from regression (pooled deviation mean squares, S^2d_i).

Mean squares due to environment (linear) and linear interaction genotypes × environment were significantly for all traits studied. This indicated that differences in environments (sowing dates and years) will generate disparities on cultivar responses; while the later effect indicates that there are genetic divergences among cultivars taking into account their responses to variation in environmental conditions. The main cause of the differences among genotypes in their yield stability traits was the wide occurrence of G x E interaction. Similar results were found by (Abdallah *et al.*, 2011; Dewdar, 2013 and Kavithamani *et al.*, 2013).

In other words, pooled of deviation mean squares were significant for all the characters studied indicated that the major components for differences in stability were due to deviation from linear function. In this respect, the investigators proved that the environmental variation can be classified into predictable and unpredictable variation. The predictable once caused by more /manent features, while the unpredictable variations are caused by year to year fluctuations in weather, insect infestation and disease infections. These results were found by Abd El-Moula (2011) and Ghazy *et al.*, (2012).

Stability parameters : Estimates of various stability parameters of three cotton varieties with respect days to first flower, days to boll bursting, plant height (cm), monopods / plant, bolls / plant, boll weight (g), seeds / boll, ginning outturn (%), seed cotton yield / plant (g), lint yield / plant (g), seed index (g) and lint index (g) are presented in (Table 3).

Two varieties namely HD 123 and HD 432 found to be most stable and average response to wider range of environments as they had higher mean, regression coefficient near to unity and least deviation from regression for seed cotton yield / plant (65.13 and 62.05), lint yield / plant (25.95 and 24.65) and monopods / plant (9.80 and 9.86), respectively. The variety HD 324 had high mean and bi>1 for days to boll bursting (118.99), plant height (182.77), boll weight (2.56), seeds / boll (24.66) and ginning outturn (42.39) indicated its suitability for better environment. Similarly; the variety HD 123 was observed to be more adoptive to favorable environment for bolls / plant and seeds / boll. These results were in agreement with findings of Patil and Patel, 2010. The variety HD 432 had response below average (bi<1) for days to boll bursting, plant height and seeds / boll and seed cotton yield indicated its more adoptability to poor environment. For seed index the variety HD 123 showed stable and average responsiveness to wide range of environments, while it showed suitability of boll weight to un favorable conditions and monopods / plant in case of HD 324. These findings were the confirmation of results reported by Patil and Patel (2010).

Table 1. Description of environments

Environment		Date of	Environment
Year	Sowing period	sowing	designation
2015	Early	10-04-2015	E_1
	Normal	15-05-2015	E_2
	Late	5-06-2015	E_3
2016	Early	26-04-2016	E_4
	Normal	5-05-2016	E_5
	Late	2-06-2016	E_6

Estimation of environmental additive effects : The estimation of environmental additive effect (Ij) is presented in Table 4. Perusal of the results revealed that environment four *i.e.* early sowing of the year 2016 was best for

Table 2. Analysis of variance for stability parameter of various traits (Eberhert and Russell, 1966)

S. No.	Sources of variance	d.f	Days to first flower	Days to boll bursting	Plant height (cm)	Mono-pods/ plant	Bolls/ plant	Boll weight (g)	Seeds/ boll	Gin-ning outturn (%)	Lint index (g)	Seed index (g)	Seed cotton yield/ plant (g)	Lint cotton yield/ plant (g)
1	Genotypes	2	71.35*	150.51*	1,407.10*	0.99*	90.92*	0.16**	0.78**	20.25**	0.68*	0.107**	239.23**	29.990**
2	Env. + (G X E)	15	65.77*	16.79*	217.83*	1.85*	23.67*	0.03*	2.43*	1.42*	0.63*	0.08*	254.14*	41.64*
3	Env. (linear)	1	949.91*	226.88*	3,216.90*	11.66*	340.44*	0.62*	35.23*	5.26**	0.36**	0.81**	3,780.16*	621.44*
4	G x E (linear)	2	8.64*	9.83*	213.24*	3.87*	8.06*	3.05*	0.42**	0.39*	0.03*	0.06*	64.82*	0.84*
5	Pooled deviation	12	2.21*	2.58*	51.02*	0.34*	1.98*	0.13*	0.04*	0.029*	0.007*	0.012*	15.85*	0.21*
6	Pooled error	60	3.58	7.40	64.72	0.99	5.72	0.008	0.71	0.40	0.024	0.03	46.613	8.25

* Significant at 5 % level ** Significant at 1% level

Table 3. Estimates of stability parameters of individual genotypes

S. No.	Characters	Varieties	Mean($\bar{X}$)	b_i	S^2_{di}
1	Days to first flower	HD 123	66.64	0.92*	0.09
		HD 324	73.52	1.13*	3.54*
		HD 432	69.57	0.88*	0.28
		Mean	**69.93**		
2	Days to boll bursting	HD 123	109.03	0.80*	-0.89
		HD 324	118.99	1.39*	-0.12
		HD 432	113.99	0.79*	-0.93
		Mean	**113.71**		
3	Plant height (cm)	HD 123	152.12	1.06*	-47.17
		HD 324	182.77	1.05*	-47.93
		HD 432	168.34	0.87*	-46.24
		Mean	**167.76**		
4	Monopods /plant	HD 123	9.81	1.01	-0.09
		HD 324	9.99	0.85*	-0.14
		HD 432	9.86	1.03	-0.14
		Mean	**9.80**		
5	Bolls/ plants	HD 123	28.90	1.13*	-0.51
		HD 324	25.31	0.75*	-0.56
		HD 432	33.02	1.11*	-0.63
		Mean	**28.85**		
6	Boll weight (g)	HD 123	2.49	0.91	-0.000
		HD 324	2.56	1.16*	-0.001
		HD 432	2.25	0.92	0.001
		Mean	**2.4**		
7	Seeds/boll	HD 123	24.88	1.16*	-0.11
		HD 324	24.66	1.05*	-0.06
		HD 432	24.59	0.79*	-0.07
		Mean	**24.58**		
8	Ginning outturn (%)	HD 123	38.83	0.53*	-0.02
		HD 324	42.39	1.48*	-0.04
		HD 432	39.83	0.98	-0.06
		Mean	**40.35**		
9	Lint index (g)	HD 123	3.30	0.70*	0.003
		HD 324	3.90	1.55*	0.009*
		HD 432	3.34	0.74*	-0.003
		Mean	**3.52**		
10	Seed index (g)	HD 123	5.17	1.04	0.001
		HD 324	5.29	1.18	0.011*
		HD 432	5.03	0.77*	0.000
		Mean	**5.17**		
11	Seed cotton yield/ plant (g)	HD 123	65.13	1.02	-5.76
		HD 324	55.90	0.92*	-6.92
		HD 432	62.09	1.04	-5.06
		Mean	**61.05**		
12	Lint yield/ plant (g)	HD 123	25.95	0.99	-1.23
		HD 324	23.71	0.97	-1.26
		HD 432	24.65	1.04	-0.98
		Mean	**24.61**		

* - Significant at 5% level b_i – Regression coefficient

** - Significant at 1% level S^2_{di} – Deviation from regression

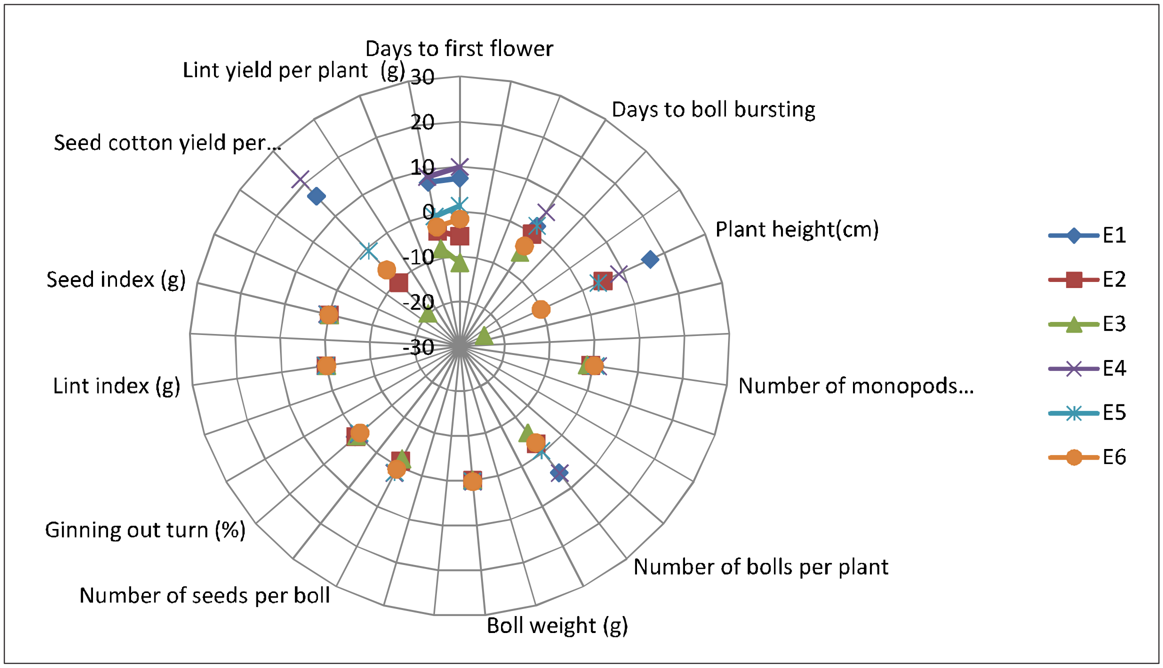

Fig 1. Radar showing environmental indices for different characters in *desi* cotton (Environmental additive effects)

seed cotton yield (g/plant), days to first flower, plant height, lint yield (g/plant), bolls /plant, seeds/boll, monopods /plant, seed index, boll weight and lint index. The environment one *i.e.* early sowing of the year 2015 was found to be favorable for plant height while second best for seed cotton yield (g/plant), days to first flower, lint yield (g/plant), bolls /plant and lint index. The dak in Table clearly showed that during the year 2015 environmental index values were much higher than 2016 in their respective environments for ginning out turn trait mainly

Table 4. Environmental indices for different characters in *desi* cotton in different environments expressed as deviation from grand mean (Environmental additive effects)

S.N	Characters	Environmental index						**Grand**
		E_1	E_2	E_3	E_4	E5	E6	**mean** ($\bar{X}$)
1.	Days to first flower	7.39	-5.47	-11.37	9.90	1.25	-1.71	**69.93**
2	Days to boll bursting	1.69	-0.29	-5.21	5.46	1.83	-3.48	**113.71**
3	Plant height(cm)	16.49	5.01	-24.03	8.85	3.86	-10.19	**167.76**
4	Monopods/plant	0.32	-0.58	-1.44	1.01	0.55	0.13	**9.84**
5	Bolls/plant	5.72	-2.53	-5.64	5.84	-0.58	-2.80	**28.85**
6	Boll weight (g)	0.09	-0.15	-0.23	0.21	0.08	0.10	**2.4**
7	Seeds/boll	0.47	-1.38	-2.00	1.73	1.50	0.61	**24.58**
8	Ginning outturn (%)	0.73	0.49	0.31	-0.28	-0.56	-0.68	**40.35**
9	Lint index (g)	0.16	-0.03	-0.16	0.18	0.02	-0.17	**3.52**
10	Seed index (g)	0.06	-0.14	-0.31	0.32	0.17	-0.09	**5.17**
11	Seed cotton yield/plant (g)	16.11	-10.44	-19.80	21.37	-0.74	-6.48	**61.05**
12	Lint yield/plant (g)	7.06	-3.98	-7.87	8.37	-0.60	-2.98	**24.61**

due to very poor seed development during *kharif*, 2015 and ultimately resulted in reduced seed index and poor seed cotton yield also. The environment three *i.e.* late sowing of 2015 was the poorest environment for all the traits. When we compare the different environments of a particular year, it clearly showed that early sowing was most favorable, followed by normal sowing and late sowing resulted in poorest / formance for most of the traits and similar observations were during the year 2016 shown in Fig.1. Among the years, 2016 was the favorable one.

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