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Research Article

Genotype x Environment interaction for seed cotton yield and component traits in upland cotton (*Gossypium hirsutum* L.)

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Abstract
The present investigation was carried out to assess the stability of three lines, twelve testers, thirty six hybrids and one check (PKV Hy 2) over three locations in Maharashtra *viz.,* Akola, Amravati and Nagpur using Eberhart and Russell Model. Pooled analysis of variance over the environments revealed that the genotypes, environments and genotypes x environments interaction were highly significant for all the characters indicating a considerable extent of interaction between the genotypes and environments. Environmental indices revealed that Nagpur was the most favourable location in an expression of most of the yield component traits. Eight hybrids *viz.,* AKH 84635 x AKH 11-7, AKH 84635 x AKH 9916, AKH 8828 x AKH 2012-8, AKH 8828 x AKH 2006-2, AKH 8828 x SURAJ, AKH 081 x AKH 10-2, AKH 081 x DHY 286, AKH 081 x AKH 10-5 and two parents *viz.,* AKH 081 and AKH 2012-8 found to be stable for seed cotton yield and most of the other traits over the location.

Key words: Stability, regression coefficient, environmental indices, genotype x environment interaction

INTRODUCTION

Cotton (*Gossypium spp.*) is the world's leading natural textile fibre, also known as 'King of fibres'. Cotton is providing livelihood directly and indirectly to over 60 million people and accounting for about 16 per cent of India's export earnings. Stability is one of the most desirable properties of a genotype to be released as a variety/ hybrid for commercial cultivation or use as a parent in crop improvement programmes. The stable genotype/ hybrid is the one, which has the buffering capacity against the changes in environmental conditions. Stability analysis is an important tool in predicting the response of various genotypes over changing environments. Breeding efforts are made to identify a stable genotype in a given environment to realize the potential yield. Thus, a proper understanding of the magnitude and nature of G x E interaction and stability of complex traits like yield and yield components in cotton would be useful. In the present scenario of global warming and climatic changes, considerable attention is needed to estimate the effect of G x E interaction in the plant breeding programmes especially in developing countries (Ghazy *et al.,* 2012).

The phenotypic performance of a genotype is not necessarily the same under diverse agro-ecological conditions and all genotypes may not reach the same level of phenotypic expression under all environmental conditions. The interaction between genetic and non-genetic effects reduces the correlation between the genotype and phenotype, which in turn reduces the accuracy with which the environmental data can be interpreted. Thus, the genotype-environment interaction is of major concern to plant breeders, because such interactions limit the selection of superior cultivars by altering their relative productiveness in different environments. The lower the G x E interaction, the lesser is the chance of progress under selection. Similarly, the low G x E interaction over the group of environments gives information on the stability of the particular variety/hybrid across the environments. The stable genotypes should have the ability to show minimum interaction with the environments in which they are grown. Eberhart and Russell (1966) defined a stable variety as one with regression coefficient as unity (bi=1) and a minimum deviation from the regression line (S^2di = 0). Using their definition a breeder would usually desire to develop a variety with a high mean satisfying the above requirements for stability. Therefore, this experiment was carried out to identify stable cotton genotypes for seed cotton yield and its component traits by assessing the G × E interaction in stratified environments.

MATERIALS AND METHODS

In the present study, three lines *viz.,* AKH 84635, AKH 8828 and AKH 081 were crossed with twelve testers *viz.,* AKH 10-2, AKH 10-5, AKH 10-10, AKH 11-7, AKH 2006-2, AKH 2012-8, AKH 2012-9, AKH 09-5, AKH 976, AKH 9916, DHY 286 and SURAJ in a line x tester mating design (Kempthorne, 1957) to develop 36 hybrids during *kharif*, 2016 at Cotton Research Unit, Dr. PDKV, Akola. The 15 parents and the 36 hybrids along with a check (PKV Hy 2) were evaluated to study the genotype x environment (G x E) interaction in randomized block design with three replications across three environments at Cotton Research Unit, Dr. PDKV, Akola (lat. 20.41^{0}N and Long. 77.3^{0}E), Regional Research Centre, Amravati (lat. 20.96^0 N and long. 77.85^0 E) and ICAR-Central Institute for Cotton Research, Nagpur (lat. 23.03^0 N and long. 72.40^0 E) during *kharif,* 2017. The spacing of 60 x 60 cm for hybrids and parents was a dopted at all the three environments. The observations in each genotype per replication were recorded for the number of bolls per plant, boll weight (g), ginning percentage (%), seed index (g), lint index (g), seed cotton yield per plant (g), 2.5 % span length (mm), fibre strength (g/tex), fibre fineness (µg/inch), uniformity index (%) and elongation percentage (%). Pooled data from all three locations were subjected to statistical analysis (INDOSTAT 8.1 software) followed by the Eberhart and Russell model (1966) to study the stability performance of genotypes over locations/environments.

RESULTS AND DISCUSSION

Pooled analysis of variance over three environments revealed that the source of variation due to environment showed highly significant differences for all the characters indicating the validity of conduct of experiment in the selected environments. There was a highly significant

Table 1. Pooled analysis of variance for experimental design over the three environments for various traits in cotton

Sources of variation	d.f.	Mean sum of squares										
		Number of bolls/ plant	Boll weight	Ginning percentage	Seed index	Lint index	Seed cotton yield/plant	2.5 % Span length	Fibre strength	Fibre fineness	Uniformity index	Elongation percentage
Environments	2	33217.83**	9.47**	204.60**	25.36**	4.25**	334810.34**	90.57**	892.63**	50.62**	118.44**	24.74**
Genotypes	50	127.87**	0.74**	41.23**	3.44**	2.44**	1906.78**	12.41**	20.20**	0.99**	10.54**	1.22**
Parents	14	58.28**	0.71**	60.23**	3.42**	2.92**	796.64**	12.63**	14.06**	1.31**	15.22**	2.22**
Crosses	35	118.59**	0.75**	32.23**	3.33**	2.32**	1749.83**	11.73**	20.65**	0.63**	7.44**	0.85**
Parents Vs crosses	1	1427.03**	0.68**	90.07**	7.33**	0.06	22941.98**	33.06**	90.49**	9.16**	53.25**	0.02
Environments x genotypes	100	63.56**	0.40**	10.04**	1.20**	0.54**	1107.42**	4.91**	9.69**	0.55**	5.93**	0.81**
Environments x parents	28	47.30**	0.55**	7.91**	1.17**	0.46**	797.85**	4.12**	12.68**	0.67**	7.03**	0.59**
Environments x crosses	70	70.34**	0.34**	10.75**	1.20**	0.57**	1187.45**	4.84**	7.40**	0.49**	5.15**	0.90**
Environments x parent Vs crosses	2	53.84	0.23	14.73**	1.19*	0.54*	2640.26**	18.10**	47.99**	1.20**	17.60**	0.79**
Error	300	23.29	0.08	1.75	0.26	0.12	216.79	0.1	0.24	0.01	0.76	0.01

** Significant at 1 % level

difference among genotypes for all the characters indicating the presence of variability in the material under study. The variance due to genotypes x environments interaction was found significant for all the characters which indicated a considerable amount of interaction between the genotypes and environments (**Table 1**). Pooled analysis of variance for stability revealed significant differences among the genotypes for all the traits studied except for fibre elongation. Significant differences among genotypes and environments suggested the presence of variability both among genotypes and environments. The mean squares due to genotypes x environments interaction were found significant for seed cotton yield/ plant indicating the differential response of genotypes to different environments (**Table 2**). Jamwal *et al.* (2016) also reported the significant genotype, environment and genotypes x environments interaction for all traits in their studies.

The variance due to environments + (genotypes x environments) revealed the relative complex type of interaction among the characters studied. Significant mean sum of squares due to environments (linear) indicated considerable differences among environments and their predominant effects on all the traits. Pooled deviations indicated the importance of non-linear components in the manifestation of genotypes x environments interaction for these significant traits. Significant genotypes x environments interaction (linear) component against pooled deviation for most of the traits revealed that linear regression was the major component responsible for differences in stability, thereby the performance can be predicted for these traits could be made more meaningful. However, for the unpredictable traits, prediction can be made by considering the stability parameters of individual traits. The above results are in accordance with the findings of earlier workers in cotton *viz.,* Riaz *et al.* (2013), Gul *et al.* (2016), and Patil *et al.* (2017) and Vavdiya *et al.* (2021). Mean performance and environmental indices study revealed that the environment had a profound influence on some characters, while, their influences on other characters were not so high. Among the three environments, Nagpur was most favourable in the expression of most of the traits while Amravati was best for seed index, 2.5% span length, fibre strength and uniformity index (**Table 3**).

The three stability parameters *viz.,* mean (x), regression coefficient (bi) and deviation from linear regression (S^2di) indicated that total of 17 genotypes recorded higher seed cotton yield/plant than the population mean (77.98 g) with non-significant deviation from regression. The hybrid AKH 081 x AKH 10-5 recorded average stability (bi≅1.00) with an average mean (89.48 g) for seed cotton yield/plant and showed general adaptability to all the environments. Fifteen genotypes recorded below average stability (bi>1.00) with a high mean indicating responsiveness to the high yielding environment. The hybrids AKH 8828 x AKH 2006-2 and AKH 8828 x SURAJ showed 'bi' value more than unity (1.14 and 1.06, respectively) with a high mean (101.04 and 82.45 g, respectively) with non-significant deviation from regression. Nineteen genotypes recorded above average stability (bi<1) indicating non responsiveness to favourable environments with high mean. The cross AKH 8828 x AKH 2012-8 exhibited a 'bi' value less than unity (0.89) with an average mean

Table 2. Pooled analysis of variance for stability for various yields and its contributing traits and fibre quality parameters in cotton

Sources of variation	d.f.	Mean sum of squares										
		Number of bolls/ plant	Boll weight	Ginning per-centage	Seed index	Lint index	Seed cotton yield/ plant	2.5 % span length	Fibre strength	Fibre fineness	Uniformity index	Elongation percentage
Genotypes (G)	51	41.966**	0.244**	13.487**	1.133**	0.800**	628.321**	4.063**	6.664**	0.326 *	3.544 *	0.399
Environments + (G X E interaction)	104	235.313**	0.188 *	4.534**	0.558	0.205	2522.231**	2.176	8.830**	0.512**	2.736	0.425 *
Environments	2	11151.790**	3.133**	65.734**	8.932**	1.432**	112505.900**	28.066**	290.092**	17.410**	37.553**	8.141**
Genotypes X environments	102	21.265	0.13	3.334	0.394	0.181	365.689**	1.668	3.315	0.181	2.054	0.274
Environments (linear)	1	22303.570**	6.267**	131.469**	17.864**	2.865**	225011.700**	56.133**	580.184**	34.820**	75.107**	16.282**
Genotypes X environments (linear)	51	25.746	0.138	4.150 *	0.334	0.166	585.037**	1.65	3.414	0.186	2.201	0.29
Pooled deviation	52	16.461**	0.119**	2.469**	0.445**	0.193**	143.527**	1.654**	3.155**	0.172**	1.870**	0.253**
Pooled Error	312	7.699	0.027	0.596	0.088	0.039	72.844	0.036	0.081	0.004	0.251	0.005
Total	155	171.696	0.206	7.479	0.747	0.401	1899.074	2.797	8.117	0.451	3.002	0.417

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

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Table 3. Mean performance and environmental indices values in respect of different quantitative traits across environments

S. No.	Characters	Mean			Environmental Indices		
		AKL	AMT	NGP	AKL	AMT	NGP
1	Number of bolls/plant	23.04	22.00	47.87	-7.93	-8.97	16.90
2	Boll weight (g)	3.03	3.19	3.51	-0.21	-0.06	0.27
3	Ginning percentage (%)	35.44	33.73	35.86	0.43	-1.28	0.85
4	Seed index (g)	7.62	8.45	8.08	-0.43	0.40	0.03
5	Lint index (%)	4.18	4.34	4.51	-0.17	0.00	0.17
6	Seed cotton yield/plant (g)	55.61	46.88	131.45	-22.37	-31.10	53.47
7	2.5% span length (mm)	28.09	29.47	28.35	-0.55	0.84	-0.29
8	Fibre strength (g/tex)	23.96	28.65	26.83	-2.52	2.17	0.35
9	Fibre fineness (µg/inch)	3.53	4.67	4.29	-0.63	0.51	0.13
10	Uniformity index (%)	83.51	84.64	82.97	-0.19	0.93	-0.74
11	Elongation percentage (%)	5.65	5.55	6.28	-0.18	-0.27	0.45

AKL-Akola AMT-Amravati NGP-Nagpur

(78.81 g). The check PKV Hy 2 exhibited above average stability with 'bi' value less than unity but it had lower seed cotton yield/plant i.e. 68.68 g (**Table 4**). Patil *et al.* (2018) also reported high yielding stable hybrids for seed cotton yield in their studies.

Among the other characters studied, the hybrid AKH 84635 x AKH 10-2 exhibited average stability (0.98) for the number of bolls/plant with a high mean (33.71) and non-significant S^2di indicating adaptability to all the environments. Ten genotypes exhibited below average stability (bi>1.00) for the number of bolls/plant with non-significant deviation from regression indicating responsiveness to favourable environments with high mean. Eighteen genotypes exhibited high mean than the population mean (3.25 g) for boll weight. The hybrid AKH 081 x SURAJ showed average stability (bi≅1.00) with an average mean (3.45 g). Whereas, the parent AKH 10-5 recorded above average stability (bi<1) with a high mean (3.48 g). Similarly, AKH 10-10 exhibited below average stability (bi=1.15) with a high mean (3.41 g). Two parental lines and two hybrids *viz.,* AKH 2012-8, AKH 09-5, AKH 8828 x AKH 2006-2 and AKH 081 x AKH 2012-8 exhibited below average stability with a high mean indicating responsiveness to favourable environments. A total of 16 genotypes recorded a higher mean for seed index than the population mean (8.05 g) with non-significant S^2di values. Only one genotype SURAJ exhibited average stability (bi≅1.04) with an average mean (9.01 g) indicating general adaptability to all the environments. Similarly, eight genotypes exhibited below average stability with a high mean. A total of 23 genotypes recorded a higher mean value than population mean (35.01 %) for ginning percentage with non-significant S^2di values. The parent AKH 10-2 and hybrid AKH 081 x AKH 2012-9 exhibited above average stability (0.97 and 0.91) with a high mean (35.06 and 37.33 %). Three hybrids *viz.,* AKH 84635 x AKH 10-2, AKH 84635 x AKH 976 and AKH 081 x AKH 2012-8 exhibited high mean and below average stability for ginning percentage. Eighteen genotypes recorded significantly higher lint index than the average mean. The parent AKH 8828 exhibited above average stability (0.90) with a high average mean (4.92 %). The hybrid, AKH 8828 x AKH 2006-2 exhibited a high mean (4.57 %) with below average stability.

One genotype *viz.,* AKH 09-5 and the hybrid AKH 8828 x AKH 9916 recorded below average stability (1.40 and 1.66) with a high mean (28.78 and 28.38 mm) for 2.5 % span length. AKH 09-5, AKH 8828 x AKH 2006-2 and AKH 081 x AKH 2012-8 exhibited below average stability, while five genotypes exhibited above average stability with high mean. Only five genotypes showed high fibre strength in comparison to the population mean (26.48 g/tex). The genotype AKH 8828 exhibited average stability (bi=1.08) with average mean, while, AKH 2006-2 exhibited above average stability with 'bi' value less than unity (0.93), high mean (28.33 g/tex) and non-significant S^2di values. Six genotypes recorded less micronaire value than the population mean (4.16 µg/inch) with non-significant deviation from regression. AKH 8828 x AKH 2006-2 recorded average stability (bi≅1.01) with average mean (4.12 µg/inch). Singh *et al.* (2014) also reported the stable hybrids for this trait. None of the genotypes recorded average stability with an average mean for uniformity index. Thirteen genotypes exhibited non-significant deviation from regression for elongation percentage. Only two genotypes exhibited high fibre elongation than the population mean (5.83 %) with non-significant deviation from regression. Two genotypes *viz.,* AKH 09-5 and AKH 9916 exhibited an average mean and 'bi' value more than one with non-significant deviation from regression indicating sensitiveness to environmental fluctuations but adaptation to highly favourable environment. Jamwal *et al.* (2016) and Vavdiya *et al*. (2021) also reported similar findings in their studies.

Table 4. Mean performance and stability parameters in respect of different quantitative traits in cotton

S. No.	Genotypes	Number of bolls/plant			Boll weight			Seed index			Ginning percentage		
		Mean	Bi	S^2di	Mean	Bi	S^2di	Mean	Bi	S^2di	Mean	Bi	S^2di
1	AKH 84635	28.67	0.84	-7.43	2.92	0.42	0.01	7.88	1.06	2.25**	32.95	0.49	-0.57
2	AKH 8828	31.56	1.05	-3.31	3.62	0.43	-0.01	7.79	0.91	0.15	38.78	-0.33	0.54
3	AKH 081	25.47	0.98	2.39	3.30	1.82	0.76**	7.78	-0.07	-0.01	35.97	0.37	0.00
4	AKH 10-2	24.77	0.86	4.35	3.01	-0.53	0.01	8.25	1.46	0.24	35.06	0.97	-0.60
5	AKH 10-5	27.20	0.97	0.35	3.48	0.98	0.01	8.63	0.68	0.07	32.37	0.40	0.57
6	AKH 10-10	28.11	0.9	7.67	3.41	1.15	0.02	9.52	3.30	0.02	34.52	0.75	-0.45
7	AKH 11-7	25.69	0.78	11.86	3.30	-0.22	0.41**	8.76	1.97	1.51**	35.10	0.53	-0.33
8	AKH 2006-2	29.13	0.67	10.9	2.98	0.35	0.13*	8.20	0.80	0.12	28.39	4.07*	-0.59
9	AKH 2012-8	29.78	1.16	-7.62	3.28	3.19	0.03	8.61	0.78	0.01	33.96	0.39	-0.01
10	AKH 2012-9	30.92	0.88	-6.28	3.09	-0.38*	-0.03	7.85	0.95	0.49**	36.14	-0.42	-0.37
11	AKH 09-5	27.06	1.25*	-7.62	3.90	3.21	-0.01	8.73	1.35	0.11	32.66	0.43	4.47**
12	AKH 976	27.69	1.24	-5.78	3.30	1.59	0.89**	7.33	-0.27	0.85**	32.23	2.48	8.83**
13	AKH 9916	34.16	0.71	149.68**	2.98	2.06	0.01	7.40	0.28	0.01	36.37	0.60	1.45
14	DHY 286	26.01	0.94	-5.79	3.32	2.62	0.09*	8.08	1.28	0.88**	32.53	1.92	5.81**
15	SURAJ	27.91	0.94	1.31	3.63	0.58	-0.03	9.01	1.04	0.02	37.66	-0.64*	-0.57
	Mean	28.27			3.30			8.25			34.31		
	Crosses												
16	AKH 84635 X AKH 10-2	33.71	0.98	-7.28	3.24	1.18	0.09*	8.51	0.05	0.10	38.19	1.40	1.20
17	AKH 84635 X AKH 10-5	29.60	0.83	-7.06	3.15	-0.53	-0.02	7.81	0.27*	-0.09	35.66	1.83	13.69**
18	AKH 84635 X AKH 10-10	30.40	1.06	17.99	3.06	-0.39	0.06	8.07	-0.51	0.36*	36.35	-0.29	0.93
19	AKH 84635 X AKH 11-7	33.78	0.77	71.8**	3.43	0.97	0.01	8.57	1.30*	-0.09	36.30	1.12	8.29**
20	AKH 84635 X AKH 2006-2	29.56	0.87	-6.24	3.11	0.19	-0.02	7.73	0.91	-0.07	33.59	3.89	0.27
21	AKH 84635 X AKH 2012-8	33.33	1.16	-3.76	3.53	1.62	0.19**	8.70	2.83	0.50*	37.91	-0.90	0.33
22	AKH 84635 X AKH 2012-9	35.22	1.55	27.47*	3.12	0.36	-0.03	7.54	1.44	-0.03	33.35	2.43	4.78**
23	AKH 84635 X AKH 09-5	26.83	0.72	-1.5	3.20	1.36	0.10*	7.57	1.71	0.08	32.25	2.66	9.51**
24	AKH 84635 X AKH 976	31.12	0.76	41.66*	3.21	1.41	0.22**	7.02	0.67	-0.07	36.08	2.36	0.15
25	AKH 84635 X AKH 9916	31.96	0.35	18.96	2.75	1.46	0.01	7.71	0.58	0.11	36.90	1.94	13.41**
26	AKH 84635 X DHY 286	34.63	1.46	-1.15	3.31	-0.01	0.04	8.05	0.86	0.38*	29.93	0.98	0.62
27	AKH 84635 X SURAJ	35.47	1.31*	-7.57	3.57	0.94	-0.02	9.12	1.62*	-0.09	33.95	2.08	-0.16
28	AKH 8828 X AKH 10-2	26.42	1.05	6.77	2.64	0.76	-0.03	7.50	-0.49	0.23	33.76	3.12	0.16
29	AKH 8828 X AKH 10-5	29.70	0.99	-4.56	3.02	-0.81	0.05	7.67	-0.02	0.30*	34.32	1.66	0.41
30	AKH 8828 X AKH 10-10	35.52	0.96	-7.13	3.29	1.71	0.03	8.25	1.75	0.15	34.82	0.58	1.21
31	AKH 8828 X AKH 11-7	31.51	0.81	66.24**	3.29	1.63	0.61**	8.26	2.19	0.71**	33.89	4.59	0.20
32	AKH 8828 X AKH 2006-2	40.08	1.03	55.17**	3.66	4.62	0.01	8.21	2.02	0.12	35.86	0.61	2.97*
33	AKH 8828 X AKH 2012-8	32.08	0.81	0.41	3.00	0.60	0.01	7.70	3.23	0.15	37.17	0.06	0.02
34	AKH 8828 X AKH 2012-9	34.64	1.58**	-7.7	3.30	0.60	-0.01	7.25	0.31	0.98**	35.60	0.50	-0.36
35	AKH 8828 X AKH 09-5	33.02	1.11	2.71	3.55	-1.01	0.14*	8.00	-0.68	0.33*	36.83	0.91	0.11
36	AKH 8828 X AKH 976	34.90	1.23	-1.96	3.68	-0.34	0.08*	6.95	2.22	0.05	33.73	1.75	0.09
37	AKH 8828 X AKH 9916	36.14	1.11**	-7.7	3.13	1.53	0.11*	7.55	1.10	-0.06	37.17	0.29	0.08
38	AKH 8828 X DHY 286	39.81	1.22	-6.08	3.11	1.41	0.01	8.07	-1.05	0.02	35.76	1.53	5.13**
39	AKH 8828 X SURAJ	31.08	1.03	-6.18	3.12	1.58	0.31**	7.60	2.26	-0.03	35.43	0.71	4.87**
40	AKH 081 X AKH 10-2	31.21	0.91	-2.84	3.22	2.02	0.12*	8.71	1.03	2.20**	37.27	-1.87	7.75**
41	AKH 081 X AKH 10-5	30.37	0.81	-6.65	3.53	0.10	-0.01	7.88	1.05	0.33*	35.07	1.19	0.77
42	AKH 081 X AKH 10-10	28.13	0.89	31.63*	3.23	0.33	0.32**	8.77	2.46	-0.05	37.61	-0.51	0.78
43	AKH 081 X AKH 11-7	27.78	1.24	-6.06	3.09	0.63	0.07	7.35	0.11	-0.05	32.17	0.42	-0.20
44	AKH 081 X AKH 2006-2	27.40	0.65	10.66	3.05	1.63	-0.02	7.70	0.17	-0.02	35.94	0.75	1.76*
45	AKH 081 X AKH 2012-8	28.27	1.21	-7.29	3.43	1.47	-0.02	8.64	0.60	0.03	35.79	1.15	-0.18
46	AKH 081 X AKH 2012-9	26.36	0.91	8.85	2.78	1.44	-0.02	7.63	1.95	-0.08	37.33	0.91	0.15
47	AKH 081 X AKH 09-5	33.87	1.39	10.59	3.93	0.80	-0.02	9.50	0.92	0.94**	35.13	0.20	-0.47
48	AKH 081 X AKH 976	36.74	1.3	25.6*	2.63	1.51	0.02	6.98	0.59	1.38**	34.97	1.16	-0.59
49	AKH 081 X AKH 9916	30.66	1.24	-0.64	3.05	2.13	-0.02	7.73	-0.42	-0.07	35.80	-0.80	0.86
50	AKH 081 X DHY 286	37.44	1.13	19.87	2.91	0.49	0.10*	8.96	-0.02	2.94**	31.60	1.92	0.58
51	AKH 081 X SURAJ	28.43	0.74	-5.41	3.45	1.00	0.03	7.93	1.60	0.34*	36.81	0.09	0.64
52	PKV Hy 2	29.26	0.69	-0.65	3.46	0.32	0.01	7.66	1.90	-0.05	35.49	-0.45	-0.51
	Mean	32.07			3.22			7.97			35.29		
	Population Mean	30.97			3.25			8.05			35.01		

*- Significant at 5 % level , **- Significant at 1 % level

Table 4. Cont..

S. No.	Genotypes	Seed cotton yield/plant			Lint index			2.5 % span length			Fibre strength		
		Mean	Bi	S^2di	Mean	Bi	S^2di	Mean	Bi	S^2di	Mean	Bi	S^2di
1	AKH 84635	63.03	0.58	88.34	3.87	-1.91	0.24**	29.16	-1.13	4.95**	24.96	0.45	7.88**
2	AKH 8828	58.58	0.89	13.80	4.92	0.90	0.01	26.66	0.57	2.58**	26.41	1.08*	-0.08
3	AKH 081	81.65	1.58	48.38	4.37	0.02*	-0.04	27.92	2.06	2.85**	25.30	0.84	0.90**
4	AKH 10-2	56.81	0.63	-14.26	4.45	0.17	0.02	30.28	0.44	0.10	27.93	0.19	7.76**
5	AKH 10-5	64.86	0.92	241.10*	4.13	0.73	-0.01	29.57	-0.74	1.62**	28.06	0.08	3.75**
6	AKH 10-10	73.37	0.94	271.45*	5.01	1.71	0.40**	30.38	0.08	0.31**	28.40	0.66	-0.02
7	AKH 11-7	64.03	0.50	32.55	4.73	-0.53	0.50**	30.82	0.96	1.10**	27.99	1.48	10.34**
8	AKH 2006-2	62.79	0.74	-30.16	3.26	0.63	0.48**	29.04	0.85	3.95**	28.33	0.93	0.17
9	AKH 2012-8	87.07	1.46*	-70.38	4.42	0.58	-0.04	28.39	-0.36	2.95**	28.57	-0.71	0.28*
10	AKH 2012-9	55.25	0.70	-21.93	4.44	1.74	-0.02	29.37	1.98	6.12**	28.49	1.21	5.15**
11	AKH 09-5	75.90	1.11	-37.81	4.25	3.56	-0.03	28.78	1.40	0.08	26.42	1.58	4.08**
12	AKH 976	58.79	0.65	1.85	3.47	0.65	0.06	28.59	1.25	3.48**	26.24	1.54	9.54**
13	AKH 9916	75.29	0.84	349.18*	4.23	0.83	-0.04	27.62	0.50	0.93**	25.72	0.43	5.58**
14	DHY 286	64.54	0.73**	-72.80	3.93	5.02	0.17*	28.54	0.60	0.28**	26.96	0.03	0.41*
15	SURAJ	66.18	0.82	-14.30	5.45	1.23	0.15*	30.73	0.76	0.02	28.03	0.50	0.06
	Mean	67.21			4.33			29.06			27.19		
	Crosses												
16	AKH 84635 X AKH 10-2	72.03	0.52	-66.41	5.18	-1.33	0.05	27.48	3.04	0.64**	25.67	1.58	5.96**
17	AKH 84635 X AKH 10-5	69.49	0.71	59.79	4.23	-1.81	0.16	27.49	-0.90	0.17*	26.09	0.88	0.47**
18	AKH 84635 X AKH 10-10	71.09	0.61*	130.82	4.69	-2.81	0.03	27.56	-0.91	0.05	24.31	0.79	0.64**
19	AKH 84635 X AKH 11-7	94.75	1.37	176.98	4.85	-1.02	-0.03	27.93	3.11	0.89**	27.36	1.33	6.81**
20	AKH 84635 X AKH 2006-2	62.95	0.62	-69.65	3.91	1.06	0.47**	26.87	1.08	0.77**	24.00	0.56	0.02
21	AKH 84635 X AKH 2012-8	99.11	0.78	349.38*	5.31	2.91	0.75**	29.67	0.11	-0.01	26.82	0.05	9.14**
22	AKH 84635 X AKH 2012-9	88.32	1.73	47.53	3.76	3.98	0.05	26.39	1.92	1.77**	26.39	1.50	0.07
23	AKH 84635 X AKH 09-5	67.76	0.90	-63.07	3.58	3.20	-0.03	30.33	-1.97*	-0.03	24.89	1.53	3.97**
24	AKH 84635 X AKH 976	98.40	1.42	50.49	3.92	0.55	0.12*	29.14	-0.45*	-0.03	24.03	1.12	7.10**
25	AKH 84635 X AKH 9916	99.72	1.34	-3.20	4.56	-3.15	0.06	27.40	0.58	0.57**	26.71	1.79	0.22
26	AKH 84635 X DHY 286	83.05	1.40*	-70.38	3.47	0.37	0.01	26.23	1.58	-0.02	26.52	1.35	5.24**
27	AKH 84635 X SURAJ	101.48	1.04	238.38*	4.64	1.55	0.03	28.78	1.28	2.10**	28.71	1.20	0.90**
28	AKH 8828 X AKH 10-2	73.13	1.17	-62.28	3.87	-1.40	0.58**	26.99	0.58	-0.03	25.31	1.25	0.01
29	AKH 8828 X AKH 10-5	61.17	0.45*	-71.80	4.00	-0.13	0.02	26.42	0.65	0.03	24.37	1.21	0.17
30	AKH 8828 X AKH 10-10	88.50	1.11	312.79*	4.42	3.48	-0.02	29.80	0.91	2.03**	24.64	1.55	2.53**
31	AKH 8828 X AKH 11-7	70.33	0.60	113.89	4.20	0.31	0.36**	28.68	3.43	4.07**	26.57	1.23	0.90**
32	AKH 8828 X AKH 2006-2	101.04	1.14	-70.05	4.57	1.13	-0.01	29.49	3.07	0.08	26.38	2.13	1.64**
33	AKH 8828 X AKH 2012-8	79.81	0.89	-65.68	4.55	3.06	0.49**	27.53	3.56	0.94**	25.94	1.66	0.00
34	AKH 8828 X AKH 2012-9	87.51	1.66*	-72.17	4.01	1.97	0.12*	28.03	0.86	3.70**	24.03	0.97	0.27*
35	AKH 8828 X AKH 09-5	69.53	0.93	-68.56	4.67	-0.95	0.01	29.72	1.43	-0.02	26.59	1.61	0.37*
36	AKH 8828 X AKH 976	72.93	0.87	-42.28	3.52	0.79	-0.01	28.61	2.62	1.98**	25.59	0.81	-0.07
37	AKH 8828 X AKH 9916	110.09	1.15	617.51**	4.47	1.98	0.02	28.38	1.66	0.03	28.12	1.41	0.08
38	AKH 8828 X DHY 286	100.13	1.46	-45.78	4.50	0.92	0.26**	28.19	1.52	1.50**	26.96	0.60	2.00**
39	AKH 8828 X SURAJ	82.45	1.06	140.53	4.19	3.13	0.25**	29.60	1.36	3.33**	24.50	1.30	4.65**
40	AKH 081 X AKH 10-2	88.65	1.22	205.52	5.11	0.36	0.12*	29.98	1.75	4.16**	26.57	0.67	0.31**
41	AKH 081 X AKH 10-5	89.48	1.00	-55.78	4.27	3.23	0.02	28.87	-0.51	0.48**	28.52	1.27	1.07**
42	AKH 081 X AKH 10-10	78.09	0.93	499.86**	5.29	1.25	0.61**	30.36	0.58	0.04	29.51	1.25	20.29**
43	AKH 081 X AKH 11-7	74.33	1.11	-46.65	3.48	0.24*	-0.04	28.18	0.76	0.32**	27.16	1.01	2.85**
44	AKH 081 X AKH 2006-2	62.68	0.27	485.09**	4.31	0.81	-0.04	27.89	0.65	5.47**	23.89	0.66	3.10**
45	AKH 081 X AKH 2012-8	81.79	1.20*	-71.92	4.71	-0.28	-0.04	28.84	1.78**	-0.04	28.48	1.27	1.13**
46	AKH 081 X AKH 2012-9	62.52	0.71	-9.69	4.47	1.56	0.08	29.76	1.21	5.21**	27.41	1.28	2.91**
47	AKH 081 X AKH 09-5	105.80	2.05	23.96	5.13	3.22	-0.02	28.82	2.34	2.76**	28.71	1.13	5.49**
48	AKH 081 X AKH 976	91.78	1.60	428.57**	3.77	3.12	0.23**	28.43	2.14	5.97**	24.89	0.65	2.55**
49	AKH 081 X AKH 9916	66.67	1.03	3.84	4.32	0.16	0.02	28.26	2.09*	-0.04	26.07	0.63	1.48**
50	AKH 081 X DHY 286	93.76	1.23	5.34	4.17	2.55	1.05**	28.73	1.10	1.61**	26.16	1.48	1.21**
51	AKH 081 X SURAJ	77.78	0.92	14.82	4.61	1.78	0.02	30.00	0.18	2.20**	25.81	1.15	8.58**
52	PKV Hy 2	68.68	0.71	-59.23	4.21	0.85	0.45**	28.28	-1.41	0.17*	25.47	-0.15*	-0.06
	Mean	82.35			4.35			28.46			26.19		
	Population Mean	77.98			4.34			28.63			26.48		

*- Significant at 5 % level , **- Significant at 1 % level

Table 4. Cont..

S. No.	Genotypes	Fibre fineness			Uniformity index			Elongation percentage		
		Mean	Bi	S²di	Mean	Bi	S²di	Mean	Bi	S²di
1	AKH 84635	4.51	1.10	0.19**	82.56	0.81	-0.24	5.66	0.56	0.01
2	AKH 8828	4.22	1.86	0.01	82.56	0.17	-0.22	5.78	0.67	0.04**
3	AKH 081	4.00	0.62	0.03	83.00	1.55	4.26**	5.52	0.21	0.04**
4	AKH 10-2	3.39	0.54	0.10**	85.00	2.31	0.06	5.32	0.34	0.65**
5	AKH 10-5	4.00	-0.11	0.53**	84.67	-0.27	2.31**	5.97	0.35	0.06**
6	AKH 10-10	4.33	0.75	0.08**	85.56	2.86	0.43	5.70	0.24	0.66**
7	AKH 11-7	3.74	2.01	1.44**	84.33	0.64	-0.18	4.67	2.32	0.04**
8	AKH 2006-2	3.91	2.23	0.01	87.11	0.21	-0.24	6.04	2.19	0.61**
9	AKH 2012-8	4.34	0.84	0.02	83.22	0.83	6.39**	6.42	1.45	0.32**
10	AKH 2012-9	3.72	0.86	0.04**	84.11	-2.09	0.16	5.90	1.61	0.13**
11	AKH 09-5	3.39	0.99	0.01	84.56	2.88	8.25**	6.70	1.10**	0.01
12	AKH 976	3.50	0.96	0.12**	84.22	-0.09	0.03	5.41	1.21	0.18**
13	AKH 9916	4.18	1.46	0.03	82.56	-0.08	0.26	6.18	2.04*	0.02
14	DHY 286	4.38	0.51	0.32**	84.11	-1.72	0.24	6.10	1.98	0.13**
15	SURAJ	3.53	0.74	0.24**	85.56	0.18	0.89*	6.21	0.98	0.33**
	Mean	3.94			84.21			5.84		
	Crosses									
16	AKH 84635 X AKH 10-2	4.42	0.31	0.34**	83.22	2.36**	0.67	5.48	2.10	0.09
17	AKH 84635 X AKH 10-5	4.81	0.86	0.12**	83.78	1.10	2.96**	5.98	1.07	0.14**
18	AKH 84635 X AKH 10-10	4.12	0.79	0.42**	82.89	1.46	-0.13	5.73	0.32	0.01
19	AKH 84635 X AKH 11-7	3.94	1.27	0.43**	84.22	3.00**	-0.25	5.79	0.86	0.04**
20	AKH 84635 X AKH 2006-2	4.60	0.92	0.09**	81.78	-0.95	0.53	5.67	0.49	0.01
21	AKH 84635 X AKH 2012-8	4.11	1.10	0.01	84.00	-0.66	7.34**	6.02	0.61	0.48**
22	AKH 84635 X AKH 2012-9	4.43	1.60	0.02	84.22	2.48	0.29	5.80	1.28	0.05**
23	AKH 84635 X AKH 09-5	3.82	1.13	0.68**	84.89	0.16	1.78**	6.12	3.96	0.72**
24	AKH 84635 X AKH 976	4.27	0.60	0.01	83.78	0.98	-0.24	5.48	0.41	0.16**
25	AKH 84635 X AKH 9916	4.67	0.79	0.06**	82.56	1.85	1.99**	5.77	0.35	0.06**
26	AKH 84635 X DHY 286	4.83	0.64	0.01	82.56	1.33	0.37	6.16	2.24	0.08**
27	AKH 84635 X SURAJ	4.31	1.04	0.03**	85.00	2.31	0.06	5.83	0.65	0.08**
28	AKH 8828 X AKH 10-2	4.44	0.67	0.02*	82.78	-0.31	3.24**	5.54	0.37	0.35**
29	AKH 8828 X AKH 10-5	4.20	1.92	0.03**	81.56	-0.35	0.54	5.86	2.80	0.60**
30	AKH 8828 X AKH 10-10	4.42	0.39	0.08**	84.33	2.95	-0.17	5.66	1.81	0.06**
31	AKH 8828 X AKH 11-7	4.31	0.87	0.22**	84.00	1.66	4.01**	5.90	0.47	0.03**
32	AKH 8828 X AKH 2006-2	4.12	1.01	0.02	84.00	2.58	5.01**	6.86	2.82	0.10**
33	AKH 8828 X AKH 2012-8	4.12	1.29	0.26**	83.33	1.28	0.27	6.00	0.46	0.91**
34	AKH 8828 X AKH 2012-9	4.06	1.37	0.70**	83.33	1.15	-0.17	5.77	0.54	0.87**
35	AKH 8828 X AKH 09-5	4.34	0.50	0.14**	84.00	0.12	2.62**	5.52	0.61*	0.02
36	AKH 8828 X AKH 976	4.31	1.10	0.00	84.22	1.19	1.33*	5.34	0.71	0.14**
37	AKH 8828 X AKH 9916	4.36	0.86	0.02**	83.56	2.74	0.50	6.04	-0.08	0.37**
38	AKH 8828 X DHY 286	4.28	0.97	0.01*	82.67	1.15	-0.17	6.41	-0.38	0.18**
39	AKH 8828 X SURAJ	3.91	1.78	0.17**	83.00	0.64	0.72	5.80	-0.56	0.23**
40	AKH 081 X AKH 10-2	4.08	0.80	0.27**	84.33	1.92	2.67**	5.99	0.75	0.54**
41	AKH 081 X AKH 10-5	4.46	0.01	0.02	84.33	1.28	0.27	5.98	0.52	0.02*
42	AKH 081 X AKH 10-10	4.13	1.89	0.04**	84.67	2.06	2.26**	6.37	3.86	0.03*
43	AKH 081 X AKH 11-7	3.97	1.62	0.43**	83.56	0.67	3.61**	5.90	1.36	0.03*
44	AKH 081 X AKH 2006-2	4.56	0.52	0.22**	81.78	-0.95	0.53	5.77	0.29*	0.01
45	AKH 081 X AKH 2012-8	4.06	0.35	0.01*	83.89	1.20*	-0.25	5.52	0.59	0.01
46	AKH 081 X AKH 2012-9	3.87	1.06	0.14**	83.89	1.60	5.47**	5.41	0.51	0.01
47	AKH 081 X AKH 09-5	4.10	0.49	0.04**	84.33	1.80*	-0.25	5.86	0.11	1.22**
48	AKH 081 X AKH 976	3.82	0.67	0.54**	82.33	1.16	0.69	5.63	0.97	0.02
49	AKH 081 X AKH 9916	4.01	0.53	0.01	82.78	1.76	0.68	5.72	0.65	1.53**
50	AKH 081 X DHY 286	4.63	1.60	0.01	82.11	2.03	6.33**	5.47	0.52	0.02
51	AKH 081 X SURAJ	4.23	2.00	0.12**	82.89	-0.21*	-0.24	5.57	0.53	0.01
52	PKV Hy 2	4.30	1.30	0.02	85.00	-0.75	6.93**	5.72	0.18	0.59**
	Mean	4.25			83.50			5.82		
	Population Mean	4.16			83.71			5.83		

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

Table 5. Promising stable hybrids and parents selected for seed cotton yield, yield contributing traits and fibre properties across the environments

S. No.	Stable genotypes/ hybrids	Stability for characters under study
1	AKH 84635 x AKH 11-7	Seed cotton yield/plant, boll weight, seed index and uniformity index
2	AKH 84635 x AKH 9916	Seed cotton yield/plant, number of bolls/plant and fibre strength
3	AKH 8828 x AKH 2012-8	Seed cotton yield/plant, number of bolls/plant and ginning percentage
4	AKH 8828 x AKH 2006-2	Seed cotton yield/plant, boll weight, seed index, lint index, 2.5 % span length and fibre fineness
5	AKH 8828 x SURAJ	Seed cotton yield/plant and number of bolls/plant
6	AKH 081 x AKH 10-2	Seed cotton yield/plant, and number of bolls/plant
7	AKH 081 x DHY 286	Seed cotton yield/plant and number of bolls/plant
8	AKH 081 x AKH 10-5	Seed cotton yield/plant, boll weight, ginning percentage, and uniformity index
9	AKH 081	Seed cotton yield/plant, lint index, fibre fineness and ginning percentage
10	AKH 2012-8	Seed cotton yield/plant, boll weight, seed index and lint index

From the stability study, it can be concluded that most of the hybrids and parents were considered as responsive for most of the traits studied as they had non-significant regression coefficient (bi) and deviation from the regression line (S^2di). These hybrids and parents had better adaptability for different environmental conditions with predictable performance. Out of thirty six hybrids, only eight hybrids *viz.,* AKH 84635 x AKH 11-7, AKH 84635 x AKH 9916, AKH 8828 x AKH 2012-8, AKH 8828 x AKH 2006-2, AKH 8828 x SURAJ, AKH 081 x AKH 10-2, AKH 081 x DHY 286, AKH 081 x AKH 10-5 were found promising stable hybrids for seed cotton yield, yield contributing traits and fibre properties across the environments (**Table 5**).

The hybrid, AKH 8828 x AKH 2006-2 exhibited superior mean performance for boll weight, seed cotton yield/ plant, seed index, lint index, 2.5 % span length and fibre fineness and was identified as promising for the favourable environment based on stability parameters. Similarly two parents *viz.,* AKH 081 and AKH 2012-8 were found to be stable for seed cotton yield/plant with other yield contributing and fibre quality traits. Parents AKH 081 was found stable for lint index, fibre fineness, ginning percentage, whereas parent AKH 2012-8 for boll weight, seed index and lint index including seed cotton yield/plant. Several other workers *viz*., Satish *et al.* (2009), Dewdar (2013), Singh *et al*. (2014), Patel *et al.* (2015) and Maleia *et al.* (2017) also reported similar results *i.e.,* average stability for yield, its contributing traits and fibre properties in parents and hybrids in cotton. Importantly the above suggested genotypes have desirable stability features for seed cotton yield, its components and fibre quality parameters. Therefore, these genotypes may be exploited at the commercial level after thorough multilocation testing in given environments and as promising parents for developing still better genotypes through a breeding programme.

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