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EVALUATING THE STABILITY OF SEED COTTON YIELD AND ITS KEY COMPONENTS OVER ENVIRONMENTS

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ABSTRACT

The stability analysis for seed cotton yield and its attributing traits was performed as per Eberhart and Russell (1966) in 45 crosses developed through line x tester mating design (nine lines and five testers) along with 14 parents grown under three dates of sowing (environments) E_1, E_2 and E_3. The stability analysis indicated significant differences among the genotypes (G) and environments (E) indicating variable response of different genotypes for various traits under varied environmental conditions. The G × E interaction was significant for most traits, except for plant height and boll weight, when tested against pooled error. When considering the combined effect of E + (G × E), significant impacts were observed across all traits against pooled error and pooled deviation. A very high proportion of total variance was accounted for the environment (linear) component. This indicated that environments created by various sowing dates were justified and had mostly linear effect. The stability parameters *viz*., overall mean (X), regression coefficient (bi) and deviation from regression (S^2di) revealed that, top five crosses identified on the basis of seed cotton yield per plant *viz*., GJHV-522 × GJHV-503, GJHV-548 × GJHV-585, TCH-1828 × GJHV-503, GBHV-187 × GJHV-503 and GISV-365 × GJHV-503 were the most widely adapted and stable crosses for seed cotton yield per plant and its components. The parents, GBHV-187, GJHV-548 and GJHV-585 were identified as the stable genotypes for seed cotton yield and its components and hence, they may be utilized in breeding programmes for incorporation of stability in cotton.

Keywords: Cotton, Eberhart and Russell Model, Environments, G × E interaction, Stability

Introduction

Cotton (*Gossypium* spp.), popularly known as "King of Fiber'' or "White Gold" holds a prominent position as one of the world's primary agricultural crops. It plays a crucial role in the economic, political and social spheres worldwide, cultivated in tropical and sub-tropical regions of about 80 countries. Cotton enjoys a pre-eminent status among all the cash crops in the country being the principal material for flourishing textile industries. The efforts are made to improve the productivity of cotton using different methods. The development of hybrids by using diverse parents, evaluation of the cross combinations and identification of stable genotype forms the important objectives in cotton breeding programmes. Crop yield is a quantitative trait that generally exhibits large genotype by environment interactions. Consequently, differences in yield performance between genotypes vary widely among environments. The occurrence of G × E interactions complicates the selection of genotypes with superior performance as performance ranking of the test genotypes may change at different environments (Cooper and DeLacy, 1994). Generally, G × E interactions are considered a hindrance to crop improvement in target region (Kang, 1998), but they can be viewed as a reflection of the differences in genotype adaptation, which may be exploited by selection and/or by adjustments of the testing strategy. The study of G × E interaction serves as a guide for various environmental niches. It is possible to identify genotypes with stability for high yield, through the stability for yield and yield component characters. There are various reports indicating that dates of sowing had significantly influenced the seed cotton yield and yield

Table 1: Analysis of variance (mean squares) of stability for different characters in cotton

Source	df	Plant height (cm)	No. of monopodia per plant	No. of sympodia per plant	No. of bolls per plant	Boll Weight (g)	Seed cotton yield per plant (g)
Genotypes (G)	59	186.51**++	0.35**++	2.25**++	123.13**++	0.25**++	1124.13**++
Environments (E)	2	22274.90**++	2.21**++	514.50**++	1558.22**++	4.16**++	42608.86**++
G × E	118	43.67	0.07**++	0.84**	13.83**	0.016	143.74**
E + (G × E)	120	414.19**++	0.11**++	9.40**++	39.57**++	0.09**++	851.50**++
Environments (linear)	1	44549.79**++	4.42**++	1029.00**++	3116.45**++	8.32**++	85217.72**++
G × E (linear)	59	47.67	0.11**++	0.671	7.085	0.009	59.538
Pooled deviation	60	39.01	0.04**	0.98**	20.23**	0.02*	224.15**
Pooled error	354	39.42	0.01	0.49	6.80	0.02	61.10

attributing characters in cotton (Sunayana *et al.*, 2018).

Materials and Methods

The experimental material comprised of 45 crosses developed through line x tester mating design, their 14 parental lines (nine lines and five testers) along with standard check hybrid (G.Cot.Hy.-22). These 60 genotypes including standard check hybrid (G.Cot.Hy.-22) were evaluated using Randomized Block Design with three replications under three dates of sowing (environments) *i.e.* E_1 = onset of monsoon (25th June, 2022), E_2 = 20 days after 1st sowing (15th July, 2022) and E_3 = 20 days after 2nd sowing (4th August, 2022) during *kharif* 2022-23. Each entry was accommodated in single row of 6.3m length spaced at 120 cm apart with plant-to-plant spacing of 45 cm. Recommended practices and plant protection measures were adopted timely to raise the healthy crop. The observations on five randomly selected plants were recorded for plant height (cm), number of monopodia per plant, number of sympodia per plant, number of bolls per plant, boll weight (g), seed cotton yield per plant (g). The statistical analysis for genotype x environment interaction and stability was carried-out according to the procedure outlined by Eberhart and Russell (1966) for seed yield and its components.

Results and Discussion

The stability analysis conducted on various genotypes revealed significant differences across all traits when tested against both pooled error and pooled deviation (Table 1). Additionally, the variance attributed to environments (E) was found to be significant for all traits, suggesting a notable influence of environmental factors on the observed variations. Notably, the genotype by environment (G × E) interaction was significant for most traits, except for boll weight when tested against pooled error. When considering the combined effect of E + (G × E), significant impacts were observed across all traits against pooled error and pooled deviation. Moreover, the linear component of G × E interaction was significant number of monopodia per plant emphasizing the importance of environmental factors on these characteristics. Interestingly, the non-linear component of G × E interaction was significant for most traits, highlighting complex relationships between genotypes and environments. A very high proportion of total variance was accounted for the environment (linear) component. Higher magnitude of mean squares due to environment (linear) indicated that differences among environments were considerable for all the characters and revealed that these characters were highly influenced by environments, thereby suggesting that large differences among environments along with the greater part of genotypic response was a linear function of environments. This indicated that environments created by various sowing dates were justified and had mostly linear effect. These results are in agreement with the earlier findings of Dhaliwal *et al.*, (2003), Sunayana *et al.*, (2018) and Vavadiya *et al.*, (2021). Overall, these findings underscore the intricate interplay between genotypic variations and environmental influences on the traits studied, necessitating careful consideration for effective breeding and cultivation.

Eberhart and Russell (1966) defined genotypes with higher mean values (*xi*), unit regression coefficients (bi=1) and non-significant deviation from linear regression (S2di=0) to be stable for that particular character and adaptable to different environmental conditions. Genotypes with a higher mean value and regression coefficient greater than unity (bi>1), as well as a non-significant deviation from linear regression, were regarded as responsive and suitable for favourable environmental conditions. Furthermore, genotypes with higher mean values and regression coefficients smaller than unity (bi<1) or negative and non-significant deviations from linear regression were considered to be best suitable for poor/unfavourable environmental conditions. Likewise, all the genotypes were classified as being suitable for different environmental conditions. The results of the

Table 2a: Estimates of stability parameters for plant height (cm) and number of monopodia per plant in cotton.

Sr. No.	Genotypes	Plant height (cm)			Number of monopodia per plant		
		x	bi	S^2di	x	bi	S^2di
1	GJHV-522	81.33	0.83**$^{++}$	-37.52	0.00	0.00	-0.01
2	GJHV-548	102.00	1.41**	120.00$^{\#}$	1.13	0.00	-0.01
3	GTHV-13/32	96.33	0.88**	30.89	1.07	0.19^{++}	0.00
4	GBHV-187	94.78	1.09**	-31.82	1.27	1.07	0.01
5	GISV-360	105.44	1.45**	25.26	1.07	0.19^{++}	0.00
6	GISV-365	91.44	0.94*	59.18	1.07	0.35**$^{++}$	-0.01
7	TCH-1828	103.00	1.12**	-16.61	1.22	0.84	0.03$^{\#}$
8	SIMA-5	94.11	1.16**	34.05	1.09	0.36^{++}	-0.01
9	RAH-1047	99.00	1.42**	45.67	1.22	1.37**	0.01
10	GJHV-503	92.22	0.82**	1.42	1.96	3.48**$^{++}$	-0.01
11	GJHV-517	105.78	0.77**	-16.94	1.80	3.20	0.20$^{\#\#}$
12	GJHV-534	98.33	1.24**$^{++}$	-39.32	1.40	0.53	0.00
13	GJHV-585	108.22	1.16*	115.8$^{\#}$	1.09	0.36^{++}	-0.01
14	G.Cot-38	90.33	1.26**$^{++}$	-39.12	1.56	3.11**$^{++}$	0.01
15	GJHV-522 × GJHV-503	102.89	0.97**	-33.13	1.44	2.58**$^{++}$	0.02
16	GJHV-522 × GJHV-517	105.22	0.65**	7.26	1.07	0.35**$^{++}$	-0.01
17	GJHV-522 × GJHV-534	102.67	0.59	40.04	1.11	0.53**$^{++}$	-0.01
18	GJHV-522 × GJHV-585	111.67	0.70**	-19.67	1.22	0.68	0.00
19	GJHV-522 × G.Cot-38	96.22	0.58**$^{++}$	-33.58	1.16	-0.90^{++}	0.02
20	GJHV-548 × GJHV-503	114.67	1.00**	-30.33	1.51	2.77**$^{++}$	0.00
21	GJHV-548 × GJHV-517	117.33	0.88**	-4.82	1.36	0.08	0.29$^{\#\#}$
22	GJHV-548 × GJHV-534	116.33	0.71**$^{++}$	-35.83	1.33	1.69	0.11$^{\#\#}$
23	GJHV-548 × GJHV-585	120.56	1.22**	33.24	1.16	-0.36^{++}	0.00
24	GJHV-548 × G.Cot-38	114.33	0.98**	-39.03	1.33	0.88**	0.00
25	GTHV-13/32 × GJHV-503	108.33	0.89**	-35.22	1.44	3.07*	0.16$^{\#\#}$
26	GTHV-13/32 × GJHV-517	119.00	0.69**	-21.08	1.36	1.69	0.08$^{\#\#}$
27	GTHV-13/32 × GJHV-534	111.11	1.57**$^{++}$	-39.38	0.00	0.00	-0.01
28	GTHV-13/32 × GJHV-585	117.00	1.35**	117.98$^{\#}$	1.07	0.51	0.00
29	GTHV-13/32 × G.Cot-38	108.78	0.91**	-36.32	1.13	0.69**$^{++}$	-0.01
30	GBHV-187 × GJHV-503	114.11	1.07**	80.60	1.82	3.02	0.17$^{\#\#}$
31	GBHV-187 × GJHV-517	115.00	1.14**	-10.19	1.49	0.52**$^{++}$	-0.01
32	GBHV-187 × GJHV-534	111.00	0.90**	-16.95	1.07	0.19^{++}	0.00
33	GBHV-187 × GJHV-585	109.22	1.15**	-33.74	1.24	1.54**	0.01
34	GBHV-187 × G.Cot-38	105.44	1.32**$^{++}$	-37.98	1.16	0.17^{++}	-0.01
35	GISV-360 × GJHV-503	111.67	1.13**	75.88	1.24	1.54**	0.01
36	GISV-360 × GJHV-517	114.11	0.59	53.19	1.22	0.03	0.04$^{\#}$
37	GISV-360 × GJHV-534	110.56	0.69*	36.93	1.18	0.39	0.06$^{\#\#}$
38	GISV-360 × GJHV-585	117.11	0.85**$^{++}$	-39.41	1.13	0.00	-0.01
39	GISV-360 × G.Cot-38	107.89	1.07**$^{++}$	-39.04	1.07	0.51	0.00
40	GISV-365 × GJHV-503	108.89	0.89**	-36.82	1.33	1.23**	-0.01
41	GISV-365 × GJHV-517	102.44	0.76**$^{++}$	-35.65	1.18	1.19*	0.01
42	GISV-365 × GJHV-534	109.00	0.89**	-35.22	1.02	0.17^{++}	-0.01
43	GISV-365 × GJHV-585	106.11	0.96**	26.65	1.09	0.68	0.00
44	GISV-365 × G.Cot-38	98.56	1.06**	-37.06	1.09	0.36^{++}	-0.01
45	TCH-1828 × GJHV-503	110.56	0.95**	-31.43	1.76	2.44**$^{++}$	-0.01
46	TCH-1828 × GJHV-517	105.11	1.28**	40.14	1.84	4.18**$^{++}$	-0.01
47	TCH-1828 × GJHV-534	109.22	0.79**$^{+}$	-31.83	1.20	0.67	0.02
48	TCH-1828 5 GJHV-585	117.00	0.37+	20.40	1.42	-1.80	0.16$^{\#\#}$

Continue ...

49	TCH-1828 × G.Cot-38	99.44	1.32**$^{++}$	-39.41	1.47	0.93	0.15$^{\#\#}$
50	SIMA-5 × GJHV-503	106.67	1.14**	31.32	1.87	2.69	0.28$^{\#\#}$
51	SIMA-5 × GJHV-517	105.78	1.08**	4.15	1.09	0.36^{++}	-0.01
52	SIMA-5 × GJHV-534	108.33	1.03**	9.51	1.04	0.18^{++}	-0.01
53	SIMA-5 × GJHV-585	108.56	1.29**	32.01	1.09	0.36^{++}	-0.01
54	SIMA-5 × G.Cot-38	99.33	1.37**$^{++}$	-35.57	1.16	1.02*	0.00
55	RAH-1047 × GJHV-503	104.33	0.96**	-25.93	1.62	2.39*	0.08$^{\#\#}$
56	RAH-1047 × GJHV-517	102.78	1.17**$^{++}$	-39.35	1.58	3.12**$^{++}$	0.00
57	RAH-1047 × GJHV-534	110.00	0.96**	-27.44	1.18	0.18^{++}	-0.01
58	RAH-1047 × GJHV-585	112.78	1.07**$^{++}$	-39.41	1.16	0.33	0.00
59	RAH-1047 × G.Cot-38	103.22	0.87**	20.48	1.58	0.07	0.18$^{\#\#}$
60	G.Cot.Hy.-22 (C)	106.89	0.61*	15.63	1.78	2.07**$^{++}$	0.00
	Mean	106.33			1.26		

*, ** significant at 5% and 1% levels of probability, respectively when deviate from "0"
+, ++ significant at 5% and 1% levels of probability, respectively when deviate from "1"
#, ## significant at 5% and 1% levels of probability, respectively

stability analysis for six important yield contributing characters are presented in Table 2a, 2b and 2c.

In this study, 21 crosses exhibited superior plant height compared to the overall mean, with a regression coefficient around unity (b_i=1) and non-significant deviation from regression (S^2d_i=0), indicating stability and wide adaptability across environments. For monopodia per plant, only two crosses (GJHV-548 × G.Cot-38 and GISV-365 × GJHV-503) showed stability and broad adaptability. For sympodia per plant, two lines, two testers, and 16 crosses demonstrated higher mean values with unit regression and non-significant deviations, indicating

Table 2b: Estimates of stability parameters for number of sympodia per plant and number of bolls per plant in cotton.

Sr. No.	Genotypes	Number of sympodia per plant			Number of bolls per plant		
		x	bi	S^2di	x	bi	S^2di
1	GJHV-522	16.79	1.18**$^{+}$	-0.38	33.22	0.63**$^{++}$	-6.76
2	GJHV-548	20.09	1.00**	0.30	48.44	1.13**	2.43
3	GTHV-13/32	18.04	0.82**	0.23	25.67	0.50	12.21
4	GBHV-187	18.80	1.03**$^{++}$	-0.49	43.89	0.91**	-3.07
5	GISV-360	18.44	0.81**$^{+}$	-0.36	25.11	0.67**	-4.44
6	GISV-365	17.16	1.03**	0.62	27.33	0.44+	-3.02
7	TCH-1828	19.59	0.93**	-0.34	36.56	1.28	33.95
8	SIMA-5	16.70	1.02**	-0.13	28.56	0.60	2.99
9	RAH-1047	18.62	1.16**$^{++}$	-0.44	48.44	1.35*	15.09
10	GJHV-503	17.28	0.82**	0.24	36.22	0.79	10.35
11	GJHV-517	19.76	1.10**	0.12	35.33	1.34**	6.89
12	GJHV-534	18.49	1.16**$^{+}$	-0.38	36.78	1.15**	-3.00
13	GJHV-585	19.41	1.10**	1.26	44.11	1.13*	9.21
14	G.Cot-38	18.84	0.91**	0.52	36.89	1.34	20.40
15	GJHV-522 × GJHV-503	20.84	0.91**	-0.42	53.56	1.51**	-2.68
16	GJHV-522 × GJHV-517	19.76	0.91	4.29$^{\#\#}$	33.67	0.33	22.36
17	GJHV-522 × GJHV-534	19.04	0.41	3.28$^{\#\#}$	41.11	1.15**	-3.00
18	GJHV-522 × GJHV-585	19.04	0.96**	0.49	46.00	0.85	5.63
19	GJHV-522 × G.Cot-38	18.71	1.10**	-0.30	40.33	1.01**	-2.55
20	GJHV-548 × GJHV-503	19.67	0.80**$^{+}$	-0.37	49.33	1.02**	-0.62
21	GJHV-548 × GJHV-517	19.77	0.99*	2.37$^{\#}$	44.11	0.91**	-6.63
22	GJHV-548 × GJHV-534	19.81	0.97**	-0.40	42.00	1.22	29.64
23	GJHV-548 × GJHV-585	19.92	0.81	2.51$^{\#}$	53.33	1.27**	4.88
24	GJHV-548 × G.Cot-38	21.39	1.01**	-0.20	52.44	1.20**	1.96
25	GTHV-13/32 × GJHV-503	18.36	0.84**$^{++}$	-0.44	42.11	1.17**	-1.08

Continue ...

26	GTHV-13/32 × GJHV-517	18.94	0.92**	0.20	39.22	1.04**	-6.28
27	GTHV-13/32 × GJHV-534	18.91	1.33**$^{++}$	-0.43	41.00	0.76	1.03
28	GTHV-13/32 × GJHV-585	19.50	1.05*	3.93$^{\#\#}$	47.44	1.43**	0.52
29	GTHV-13/32 × G.Cot-38	19.53	1.39**	0.57	37.78	1.36	44.64
30	GBHV-187 × GJHV-503	19.68	0.84*	1.38	42.56	1.18**	-2.29
31	GBHV-187 × GJHV-517	19.98	1.10**	-0.05	40.56	0.57	46.66
32	GBHV-187 × GJHV-534	19.57	1.11**	-0.03	36.44	0.96*	1.22
33	GBHV-187 × GJHV-585	18.47	1.20**$^{++}$	-0.48	44.89	1.20*	7.73
34	GBHV-187 × G.Cot-38	20.43	1.35**$^{++}$	-0.44	41.33	1.28	30.60
35	GISV-360 × GJHV-503	18.94	1.06**	0.40	35.33	1.55	72.82
36	GISV-360 × GJHV-517	18.73	0.73**	0.32	32.00	0.68*	-2.51
37	GISV-360 × GJHV-534	18.31	0.68*	0.84	31.44	0.52**$^{++}$	-6.01
38	GISV-360 × GJHV-585	19.31	1.18**	0.58	34.44	0.50	27.72
39	GISV-360 × G.Cot-38	19.62	1.08**	-0.46	29.78	0.79	3.23
40	GISV-365 × GJHV-503	19.62	1.17**	-0.21	41.78	1.08**	-3.30
41	GISV-365 × GJHV-517	18.29	0.72**	0.06	35.11	1.19**	1.23
42	GISV-365 × GJHV-534	19.58	0.93**	0.39	37.44	0.91**	-2.49
43	GISV-365 × GJHV-585	18.87	0.87**	1.23	35.56	0.63**$^{++}$	-6.76
44	GISV-365 × G.Cot-38	18.92	0.97**	-0.17	37.56	1.20**	-5.06
45	TCH-1828 × GJHV-503	19.11	0.66*	0.94	43.22	1.60*	23.77
46	TCH-1828 × GJHV-517	19.10	1.37**	0.37	36.33	0.74	3.70
47	TCH-1828 × GJHV-534	19.91	0.76	3.94$^{\#\#}$	36.0	0.71**$^{++}$	-6.65
48	TCH-1828 5 GJHV-585	19.44	1.06**	2.11$^{\#}$	36.44	1.45**	3.10
49	TCH-1828 × G.Cot-38	18.74	1.30**	0.51	39.22	0.28	132.63
50	SIMA-5 × GJHV-503	19.59	0.89*	1.82$^{\#}$	45.11	0.76	24.13
51	SIMA-5 × GJHV-517	19.81	0.97**	-0.18	30.56	0.74**$^{++}$	-6.57
52	SIMA-5 × GJHV-534	19.52	0.86**	0.43	33.22	0.39	62.96
53	SIMA-5 × GJHV-585	18.66	1.13**	-0.29	37.56	0.61	72.80
54	SIMA-5 × G.Cot-38	19.10	1.07**	0.14	42.44	0.94*	3.92
55	RAH-1047 × GJHV-503	19.79	0.87**	1.16	44.22	1.45	48.32
56	RAH-1047 × GJHV-517	20.23	0.79**	0.83	42.11	2.12	96.55
57	RAH-1047 × GJHV-534	19.58	1.21**$^{++}$	-0.44	43.00	1.29**	-4.34
58	RAH-1047 × GJHV-585	19.10	1.45**$^{+}$	0.10	42.33	0.88	19.58
59	RAH-1047 × G.Cot-38	19.30	1.05**	-0.48	36.11	0.80**	-5.56
60	G.Cot.Hy.-22 (C)	18.48	1.07**$^{++}$	-0.48	41.44	1.50**$^{++}$	-6.53
	Mean	19.15			39.26		

*, ** significant at 5% and 1% levels of probability, respectively when deviate from "0"
+, ++ significant at 5% and 1% levels of probability, respectively when deviate from "1"
#, ## significant at 5% and 1% levels of probability, respectively

their wide adaptability. Regarding the number of bolls per plant, three lines, one tester, and 14 crosses displayed stability across environments. For boll weight, one line and 21 crosses showed superior performance with stability, reflected by a regression coefficient near unity and non-significant deviation from regression. All these traits demonstrated that the identified genotypes were stable and well-adapted across diverse environments.

In cotton, seed cotton yield per plant is the most important character. Simultaneous consideration of the mean, regression coefficient (b_i) and deviation from regression (S^2d_i) of the individual genotypes for seed cotton yield per plant showed that among the parents, GBHV-187, GJHV-548 and GJHV-585 were recorded high seed cotton yield along with stable and well adapted to all the environments. The high yielding parent GBHV-187 was also stable and well adapted to all the environments for number of bolls per plant. The parent GJHV-548 and GJHV-585 were also exhibited stable and well adapted performance to all the environments for number of sympodia per plant and number of bolls per plant. of these parents brings distinct strengths to cotton breeding programs, offering valuable traits for improvement and optimization.

Among the crosses, twelve crosses *viz.*, GJHV-522 × GJHV-503, GJHV-522 × GJHV-534, GJHV-548 ×

Table 2c: Estimates of stability parameters for boll weight (g) and seed cotton yield per plant (g) in cotton.

Sr. No.	Genotypes	Boll weight (g)			Seed cotton yield per plant (g)		
		x	bi	S^2di	x	bi	S^2di
1	GJHV-522	2.66	0.91**	-0.01	86.56	0.68**$^{++}$	-52.91
2	GJHV-548	2.83	0.94**	-0.01	136.89	0.97**	-7.33
3	GTHV-13/32	3.59	1.02**	0.00	92.67	0.57	190.13$^{\#}$
4	GBHV-187	3.10	1.03**	-0.01	137.56	1.02**	-50.89
5	GISV-360	4.06	1.32**$^{++}$	-0.01	103.33	0.72**	2.58
6	GISV-365	3.26	1.13**	-0.01	90.22	0.63**$^{+}$	-26.14
7	TCH-1828	3.09	1.01**	-0.01	114.67	1.06	402.10$^{\#\#}$
8	SIMA-5	2.66	0.94*	0.01	76.78	0.53**$^{++}$	-25.23
9	RAH-1047	2.64	0.89**	0.00	129.67	1.14*	293.21$^{\#}$
10	GJHV-503	3.17	1.08**	0.00	115.00	0.82**	-15.67
11	GJHV-517	3.38	0.99	0.07$^{\#}$	117.22	0.96**	-2.88
12	GJHV-534	3.30	0.94	0.08$^{\#}$	122.56	0.87**	-19.78
13	GJHV-585	2.94	0.99**	-0.01	132.00	1.11**	122.20
14	G.Cot-38	3.14	1.05**	-0.01	117.00	1.04*	264.05$^{\#}$
15	GJHV-522 × GJHV-503	3.22	0.57	0.00	174.33	1.22**	90.29
16	GJHV-522 × GJHV-517	3.51	1.20**	-0.01	121.67	0.76	279.57$^{\#}$
17	GJHV-522 × GJHV-534	3.44	1.02	0.05$^{\#}$	143.00	1.02**	2.92
18	GJHV-522 × GJHV-585	3.07	1.11*	0.02	145.78	1.10**$^{+}$	-59.03
19	GJHV-522 × G.Cot-38	3.21	1.13**	0.01	131.78	1.13**	193.76$^{\#}$
20	GJHV-548 × GJHV-503	3.10	0.87	0.04	149.67	1.00*	213.74$^{\#}$
21	GJHV-548 × GJHV-517	3.32	1.13**	-0.01	145.67	1.12**$^{+}$	-57.24
22	GJHV-548 × GJHV-534	3.32	0.86	0.13$^{\#\#}$	137.22	1.07**	-48.62
23	GJHV-548 × GJHV-585	3.10	1.08**	0.00	166.44	1.22**	-39.57
24	GJHV-548 × G.Cot-38	3.18	0.97**	0.00	168.11	1.12*	246.94$^{\#}$
25	GTHV-13/32 × GJHV-503	3.43	1.14	0.03	140.33	1.20**	167.76
26	GTHV-13/32 × GJHV-517	3.63	0.84**	0.00	141.11	1.11**	-44.33
27	GTHV-13/32 × GJHV-534	3.58	1.40*	0.04	150.78	1.16**$^{++}$	-60.54
28	GTHV-13/32 × GJHV-585	3.54	1.28*	0.03	170.89	1.48**	397.28$^{\#\#}$
29	GTHV-13/32 × G.Cot-38	3.36	0.61	0.01	126.33	1.19	700.53$^{\#\#}$
30	GBHV-187 × GJHV-503	3.42	1.06*	0.01	146.44	1.25**	135.20
31	GBHV-187 × GJHV-517	3.67	1.10**	-0.01	150.44	0.91	676.70$^{\#\#}$
32	GBHV-187 × GJHV-534	3.48	0.69**$^{++}$	-0.01	127.56	0.92**	-33.70
33	GBHV-187 × GJHV-585	3.37	1.18**	-0.01	154.22	1.33**	282.17$^{\#}$
34	GBHV-187 × G.Cot-38	3.38	0.97**	0.00	139.00	1.18**	161.82
35	GISV-360 × GJHV-503	3.69	0.84**	-0.01	131.89	1.25	815.36$^{\#\#}$
36	GISV-360 × GJHV-517	4.00	1.42**	0.00	129.33	0.95**	-41.69
37	GISV-360 × GJHV-534	3.69	1.26**	-0.01	119.56	0.83**	25.72
38	GISV-360 × GJHV-585	3.73	1.25**$^{++}$	-0.01	125.89	0.76	419.92$^{\#\#}$
39	GISV-360 × G.Cot-38	3.67	1.22**$^{++}$	-0.01	110.78	0.94**	52.13
40	GISV-365 × GJHV-503	3.54	1.09**	0.00	146.33	1.07**	-49.43
41	GISV-365 × GJHV-517	3.67	0.36**$^{++}$	-0.01	127.78	1.07**	66.14
42	GISV-365 × GJHV-534	3.39	0.77	0.11$^{\#\#}$	123.11	0.90**	-46.51
43	GISV-365 × GJHV-585	3.52	1.06	0.04	128.44	0.90**	42.00
44	GISV-365 × G.Cot-38	3.64	1.12**	-0.01	136.22	1.07**	-38.26
45	TCH-1828 × GJHV-503	3.40	0.64**$^{++}$	-0.01	147.22	1.21**	77.02
46	TCH-1828 × GJHV-517	3.41	1.11**	0.00	123.33	0.90**	-41.29
47	TCH-1828 × GJHV-534	3.48	1.23**	0.00	125.78	0.94**	-58.92
48	TCH-1828 5 GJHV-585	3.16	0.27	0.01	117.11	1.02*	166.13

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49	TCH-1828 × G.Cot-38	3.06	1.13**	-0.01	121.11	0.62	1100.02##
50	SIMA-5 × GJHV-503	3.13	1.02*	0.02	141.67	0.86	594.08##
51	SIMA-5 × GJHV-517	3.76	1.28**	0.00	118.22	0.87**	-51.27
52	SIMA-5 × GJHV-534	3.44	1.20**	-0.01	117.00	0.66	658.70##
53	SIMA-5 × GJHV-585	3.47	1.07**	-0.01	131.67	0.78	630.00##
54	SIMA-5 × G.Cot-38	3.00	1.06**	-0.01	128.89	0.94**	-39.13
55	RAH-1047 × GJHV-503	3.48	1.19**	0.01	154.22	1.37*	489.37##
56	RAH-1047 × GJHV-517	3.48	0.10	0.06#	145.56	1.31*	547.18##
57	RAH-1047 × GJHV-534	3.34	1.20**	-0.01	145.89	1.20**	64.45
58	RAH-1047 × GJHV-585	3.37	1.060**	-0.01	143.89	0.95*	188.87#
59	RAH-1047 × G.Cot-38	3.52	1.09*	0.02	125.11	0.92**	-50.39
60	G.Cot.Hy.-22 (C)	3.33	0.51	0.00	140.11	1.12**	-16.37
	Mean	3.36			131.82		

*, ** significant at 5% and 1% levels of probability, respectively when deviate from "0"
+, ++ significant at 5% and 1% levels of probability, respectively when deviate from "1"
#, ## significant at 5% and 1% levels of probability, respectively

GJHV-534, GJHV-548 × GJHV-585, GTHV-13/32 × GJHV-503, GTHV-13/32 × GJHV-517, GBHV-187 × GJHV-503, GBHV-187 × G.Cot-38, GISV-365 × GJHV-503, GISV-365 × G.Cot-38, TCH-1828 × GJHV-503 and RAH-1047 × GJHV-534 exhibited high mean values than the overall mean coupled with unit regression coefficient (non-significant at b_i=1) and deviation from regression around zero (S^2d_i=0), which suggested that they were stable and widely adapted genotypes over all the environments for seed cotton yield per plant. Only three crosses *viz.*, GJHV-522 × GJHV-585, GJHV-548 × GJHV-517 and GTHV-13/32 × GJHV-534 had higher mean than the overall mean coupled with a greater value of the regression coefficient (b_i>1) and a non-significant deviation from regression (S^2d_i=0) observed for this genotype, indicating that it was stable and specifically adapted to favourable environment. Not a single genotype was found stable for all the traits in the present study. This may be because the environment had a different effect on each character. Same results of hybrid stability for seed cotton yield have been reported by Sirisha *et al.*, (2019), Kumbhalkar *et al.*, (2021), Vavadiya *et al.*, (2021), Murthy and Pradeep (2022) and Deho *et al.*, (2023).

The stability of the genotypes for seed cotton yield per plant has been reported to be the result of stability for its component traits (Grafius, 1959; Luthra *et al.*, 1977). Singh (1983) suggested the utilization of stable and potential genotypes in breeding programmes for incorporation of stability. Hence, stability of the identified genotypes (crosses) for seed cotton yield per plant has been characterized with respect to yield attributes and the information is presented in Table 3. In this direction, top five crosses on the basis of seed cotton yield per plant *viz.*, GJHV-522 × GJHV-503, GJHV-548 × GJHV-585, TCH-1828 × GJHV-503, GBHV-187 × GJHV-503 and GISV-365 × GJHV-503 which were identified to be stable for seed cotton yield and its component characters and could be utilized further for yield improvement in cotton.

Conclusion

The stability analysis of various cotton genotypes revealed significant genotypic and environmental effects across all traits. The results indicated that the genotype by environment (G × E) interaction was significant for most traits, with both linear and non-linear components contributing to the observed variations. A high proportion of the total variance was attributed to environmental factors, highlighting the importance of environmental

Table 3: The best five widely adapted crosses identified on the basis of seed cotton yield per plant along with their stability for component traits in cotton.

S. No.	Crosses	Stable yield attributes
1	GJHV-522 × GJHV-503	Number of sympodia per plant and number of bolls per plant
2	GJHV-548 × GJHV-585	Plant height (cm) and number of bolls per plant
3	TCH-1828 × GJHV-503	Plant height (cm)
4	GBHV-187 × GJHV-503	Plant height (cm), number of sympodia per plant, number of bolls per plant and boll weight (g)
5	GISV-365 × GJHV-503	Plant height (cm), number of monopodia per plant, number of sympodia per plant, number of bolls per plant and boll weight (g)

influence on trait expression. The parents, GBHV-187, GJHV-548 and GJHV-585 were identified as the stable genotypes for seed cotton yield and its components and hence, may be utilized in breeding programmes for incorporation of stability in cotton. Among the crosses, 12 were identified as stable and widely adapted for seed cotton yield, while three crosses showed specific adaptation to favourable environments. Among these, the top five crosses *viz*., GJHV-522 × GJHV-503, GJHV-548 × GJHV-585, TCH-1828 × GJHV-503, GBHV-187 × GJHV-503 and GISV-365 × GJHV-503 offer valuable traits for cotton breeding programs aimed at yield improvement.

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