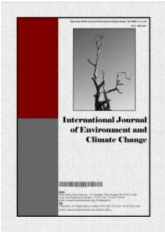

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Study on Stability Parameters for Yield and Compact Plant Type Characters in Hybrids Derived from Multiple Cross Derivatives of Upland Cotton (*Gossypium hirsutum* L.) and Amenable for HDPS

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

Stability of 42 F1 hybrids derived by crossing six lines and seven testers in line x tester mating design was studied by planting in three different locations for yield and compact plant traits. Analysis of variance showed significant differences among the genotypes for all the traits when tested against pooled deviation and pooled error. The mean squares due to environments (E) was found significant for all the characters except for days to 50% flowering, length of the sympodial branches, boll weight and ginning outturn. Significant interaction of G x E was exhibited by all traits except for days to 50% flowering, number of monopodial branches, leaf area and ginning outturn when tested against pooled deviation, indicating differential behaviour of genotypes in changing environments. The study also revealed the importance of both linear and non-linear components in determining the interaction of genotypes with environment. The cross combinations viz., MC 17-6 x MC 3-2 , MC 4-3 x MC 3-2, MC 16-3 x MC 17-2, MC 23-2 x NH 630, MC 23-2 x MC 3-2 and MC 17-6 x MC 22-2 had shown stable performance over locations for yield along with few compact plant type characters based on stability parameters and could be subjected for further evaluation to develop hybrids amenable for HDPS.

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Keywords: Gossypium hirsutum; stability; compact plant type; multiple cross derivatives; HDPS.

1. INTRODUCTION

Cotton (*Gossypium hirsutum* L.,) is one of the most important fibre crop and major source of natural fibre worldwide and is considered as most important industrial crop (Imran et al. 2012). In India, it is grown under varied environmental conditions and affected with various biotic and abiotic factors limiting the yield of cotton. India has pride place in global cotton scenario with largest area of 132.85 lakh ha under cultivation nearly accounting for one-third of global cotton area [1] during the year 2020-21. The productivity of cotton in the last decade has stagnated at around 500 Kg/ha which is lower when compared to Australia (1833 kg/ha), China (1633 kg/ha) and Brazil (1522 kg/ha) (www.apps.fas.usda.gov) which could be attributed to the fact that a large area (more than 90 per cent) is being cultivated with *Bt* cotton hybrids at a plant population of 9000 to 12000 plants/ha even under rainfed ecology. In recent years, cotton breeding was focused much on development of hybrids / varieties having compact plant type features that are amenable for High Density Planting System (HDPS) and is being adopted in USA, Australia, China, Brazil and Uzbekistan with the straight varieties at a plant population ranging from 1 lakh to 2.5 lakh plants/ha using narrow and ultra narrow spacing [2], while in India, the recommended plant density for cotton seldom exceeded 55000 plants/ha [3] and hence, there is a need to develop stable hybrids / varieties having compact plant type features with synchronous maturity to improve the yield of cotton particularly in rainfed conditions. The crop performance can be influenced by three factors *viz*., genotype, environment in which it is grown and interaction of genotype with environment [4]. Analysis of genotype –by-environment interactions and their influence on yield and plant type may help the cotton breeders to identify stable parents and crosses that are amenable for HDPS. Stability analysis helps the breeder in developing varieties / hybrids suitable for wider adaptability and for specific environmental conditions. In the present context of developing genotypes suitable for HDPS, estimation of phenotypic stability of parents / hybrids for yield and plant type characters will be useful as an important tool for plant breeders for identification of genotypes having wider adaptability across environments when tested under fluctuating environments. It is established that, more stable genotypes can adjust their phenotypic response to provide some measures of uniformity despite fluctuating environmental conditions [5]. Cotton is more sensitive to environmental fluctuations because of its' indeterminate growth habit [6]. Hence, the present investigation was carried out to identify genotypes having stable features of compact plant types with yield stability.

2. MATERIALS AND METHODS

The material for present study comprised of six lines viz., MC 4-3, MC 5-1, MC 9-1, MC 16-3, MC 17-6 and MC 23-2, seven testers viz., NH 630, MC 3-2, MC 17-1, MC 19-2, MC 22-2, MC 11-1 and MC 17-2 and their 42 F_1s obtained through Line x Tester mating design. The material was sown in completely randomized block design replicated thrice by adopting a spacing of 60 cm x 30 cm at three different locations *viz*., Aswaraopet, Warnagal and Adilabad which represents different agro-ecological conditions during *Kharif* 2014-15. The data were recorded on fourteen characters *viz.,* days to 50% flowering, days to first boll bursting, plant height (cm), number of monopodial branches, earliness index, number of sympodial branches, length of the sympodial branches (cm), leaf area (cm^2), number of bolls per plant, boll weight (g), harvest index, 100-seed weight (g), seed cotton yield per plant (g pl^{-1}) and ginning outturn (%). Analysis was carried out as per the method suggested by Eberhart and Russell [7].

3. RESULTS AND DISCUSSION

The analysis of variance revealed that the genotypes and environments were significant for most of the characters except for days to 50% flowering, length of the sympodia, boll weight and ginning outturn indicating the diversity among the genotypes and environments. Significant interaction of G x E was exhibited by thirteen characters except for days to 50% flowering, number of monopodial branches, leaf area and ginning outturn when tested against pooled deviation, indicating differential behaviour of genotypes in changing environments. Similar results were also reported earlier by Patel et al. [8], Laghari et al. [9], Reddy et al. [10], Campbell and Jones [11], Hassan [12], Tuteja [13], Verma et al. (2008), Satish et al. [14], Shinde et al. [15], Hassan et al. [16], Singh et al. [17] and Sohair et al. [18]. Partitioning of sum of squares into that of genotypes, environments + (genotypes x environment) and pooled error revealed that mean squares due to genotypes were highly significant for all the characters studied, indicating the presence of genetic variability in the experimental material [19,20]. Mean squares due to environments + (genotypes x environments) were significant for most of the characters except for days to 50% flowering, number of monopodia, length of the sympodia and ginning outturn depicted the existence of G x E interaction Table 1a and 1b. These findings are in conformity with Nirania et al. [21], Campbell and Jones [11], Tuteja et al. [22] and Singh et al. [17]. Significant variation due to environment (linear) was observed for all the characters studied except for days to 50% flowering, length of the sympodia, boll weight and ginning outturn revealing the linear contribution of environmental effects and additive environmental variance on these characters. The linear component of genotype x environment was significant for all characters except for days to 50% flowering, number of monopodia, length of the sympodia, leaf area and ginning outturn suggesting that the genotypes significantly differing for their linear response to environments Table 1a and 1b. The mean sum of squares for pooled deviation was significant for eleven characters except for earliness index, number of bolls per plant and harvest index indicating the non-linear response and unpredictable nature of genotypes by significantly differing for stability. This reveals the importance of both linear and non-linear components in determining interaction of the genotypes with environments in the present study Table 1a and 1b. Similar reports were given by Satish [23], Killi and Harem [24], Kavithamani et al. [25], Nidagundi et al. [26], Singh et al. [17], Patel et al. [27], Riaz et al. [28] and Verma et al. [29] whereas linear effects for plant height, number of monopodia, number of sympodia, number of bolls per plant, boll weight, seed cotton yield, ginning% was also reported by Tuteja et al. [22], Balakrishna et al. [30], Janwal et al. [31], Vanisri et al. [32], Chinchane et al. [6], Pinki et al. [5] and Vavdiya et al. [33].

The results of the present study are presented in Table 2a and 2b. For days to first boll bursting deviation from regression was found non-significant for 39 crosses and hence, we can predict their performance. Among the crosses, MC 4-3 X MC 17-2, MC 16-3 X MC 11-1 and MC 17-6 X NH 630 had shown desirable mean for this trait with bi value around one and were found stable over locations. The cross combinations MC 23-2 X MC 3-2 followed by MC 9-1 X MC 19-2, MC 16-3 X MC 17-1 were found suitable for better environment with desirable mean and bi>1. The hybrid combinations MC 5-1 X MC 17-1 and MC 4-3 X MC 17-1 showed desirable mean with significant regression coefficient (less than one) and are suitable to poor environment (bi<1).

Out of the 42 cross combinations tested for plant height, 14 crosses showed significant deviation from regression, hence, we cannot predict their performance. The cross combinations MC 17-6 X MC 22-2, MC, MC 9-1 x MC 19-2, MC 16-3 X NH 630, MC 23-2 X MC 17-2, MC 5-1 X MC 22-2 and MC 9-1 X NH 630 exhibited lowest plant height with regression coefficient close to one and average stability. The crosses MC 17-6 X MC 19-2 and MC 9-1 X MC 22-2 were found to exhibit desirable plant height with greater than one regression coefficient (bi) and hence, suitable for better environment. The cross combinations MC 17-6 X NH 630, MC 4-3 X MC 17-2 and MC 23-2 X MC 3-2 had shown regression coefficient less than one with desirable mean. Similar type of results for stability in cotton for plant height were also reported by Satish [23].

For earliness index, the performance of all 42 cross combinations can be predicted as the deviation from regression was non - significant. Among the hybrid combinations, MC 17-6 X NH 630 followed by MC 5-1 X NH 630, MC 16-3 X MC 3-2, MC 17-6 X MC 17-1, MC 23-2 X MC 22-2 and MC 23-2 X MC 11-1 had shown highest earliness index with bi value closer to unity and were found stable over environments. The cross combinations MC 4-3X NH 630 and MC 4-3 X MC 3-2 exhibited desirable mean for earliness index with significant regression coefficient (greater than one) and suitable for better environment. The cross MC 4-3 X MC 19-2 had shown desirable mean with significant regression value less than one and it is suitable to poor environment.

For number of sympodial branches 37 cross combinations exhibited non - significant deviation from regression hence, we can predict their performance. Among the crosses, MC 4-3 X MC 3-2, MC 4-3 X MC 17-1 and MC 17-6 X NH 630 exhibited highest mean for number of sympodial branches with regression coefficient near to unity and exhibited average stability. The hybrid combination MC 5-1 X MC 3-2 exhibited desirable mean for this trait with significant bi value greater than one hence, suitable for better environment (bi>1). The cross combination MC 17-6 X MC 17-1 had shown desirable mean with bi value less than one and was found suitable for poor environment. Stable hybrids for number of sympodia plant^{-1} were also reported by Satish [23], Nidagundi et al*.* [26] and Sirisha et al. [34].

Thirty one crosses had shown significant deviation from regression for length of the sympodial branches and hence, their performance cannot be predicted. Among the hybrid combinations, MC 17-6 X MC 3-2 and MC 9-1 X MC 17-1 had exhibited desirable mean for this character with bi value nearer to one and exhibited average stabilitywhereas MC 4-3 X MC 17-1 and MC 9-1 X MC 3-2 had shown desirable mean and were found suitable for better environment (bi>1) while MC 4-3 X MC 19-2 exhibited desirable mean with regression coefficient value of less than one (bi<1) and hence, suitable for poor environment.

Thirty nine hybrid combinations had shown non - significant deviation from regression and hence, we can predict their performance for number of bolls per plant. The hybrids MC 23-2 X MC 17-2, MC 17-6 X MC 3-2, MC 17-6 X MC 17-2, MC 23-2 X MC 19-2, MC 17-6 X MC 22-2 and MC 17-6 X MC 19-2 exhibited desirable mean value with bi value nearer to unity and average stability whereas MC 4-3 X MC 3-2 and MC 4-3 X MC 11-1 were exhibited high mean and found suitable for better environment (bi>1). The crosses MC 4-3 X MC 17-2 and MC 9-1 X NH 630 had shown desirable mean and were found suitable for poor environment (bi<1). Patil and Patel [35], Basanagouda et al*.* [36], Kavithamani et al*.* [25], Nidagundi et al*.* [26], Dewdar [37], Verma et al*.* [29], Sirisha et al. [34] and Vavdiya et al. [33] also identified stable hybrids for number of bolls plant^{-1}.

For boll weight 35 cross combinations had shown significant deviation from regression and the combinations *viz.,* MC 16-3 X NH 630 and MC 5-1 X MC 17-1 exhibited high boll weight with bi value nearer to unity and shown average stability where as the crosses MC 23-2 X MC 3-2 and MC 23-2 X NH 630 had exhibited highest boll weight and were suitable for better environment (bi>1). The cross MC 23-2 X MC 17-2 had shown desirable mean with less than one regression coefficient value and found suitable for poor environment. Stable crosses for this trait were also reported by Patil and Patel [35], Basanagouda et al. [36], Kavithamani et al. [25], Nidagundi et al. [26], Singh et al. [17], Verma et al. [29], Jamwal et al. [31], Sirisha et al. [34] and Vavdiya et al. [33].

The deviation from regression was non-significant for all the 42 cross combinations for harvest index while the cross combinations MC 4-3 X MC 17-1, MC 16-3 X NH 630, MC 16-3 X MC 11-1, MC 16-3 X MC 17-2, MC 17-6 X MC 11-1 and MC 23-2 X MC 3-2 were found to exhibit regression coefficient closer to one and high mean values and hence, found stable over locations, whereas MC 16-3 X MC 17-2, MC 16-3 X MC 17-1 and MC 9-1 X MC 22-2 had shown regression coefficient greater than unity with high mean and found suitable for better environment. The hybrids MC 17-6 X MC 19-2, MC 16-3 X MC 19-2, MC 9-1 X MC 3-2 and MC 9-1 X MC 11-1 exhibited regression coefficient of less than one with high mean value and perform better under poor environmental conditions.

For 100-seed weight four hybrids had shown significant deviation from regression, the cross combination MC 23-2 X MC 17-1 followed by MC 4-3 X MC 19-2, MC 9-1 X MC 19-2, MC 4-3 X MC 11-1 and MC 16-3 X MC 17-2 exhibited bi value near to one with average stability while the crosses MC 23-2 X MC 22-2 and MC 9-1 X MC 3-2 had shown desirable mean with regression coefficient greater than one and found suitable for better environment, the hybrids MC 5-1 X MC 11-1, MC 5-1 X MC 17-1 and MC 4-3 X MC 17-1 exhibited regression coefficient less than one with desirable mean values and were found suitable for poor environment.

Fifteen cross combinations exhibited significant deviation from regression for seed cotton yield plant^{-1} and the crosses MC 17-6 X MC 17-1, MC 16-3 X MC 17-2, MC 4-3 X MC 3-2, MC 9-1 X MC 3-2, MC 9-1 X MC 17-1, MC 9-1 X MC 19-2, MC 17-6 X MC 3-2, MC 17-6 x MC 22-2 and MC 23-2 X MC 3-2 were found to exhibit average stability while MC 17-6 X MC 19-2, MC 23-2 X MC 17-2 and MC 9-1 X NH 630 exhibited bi value greater than one with desirable mean and hence, perform well under favourable environment. Stability of hybrids for seed cotton yield plant^{-1} was also reported earlier by Killi and Harem [24], Patil and Patel [35], Basanagouda et al*.* [36], Kavithamani et al*.* [25], Nidagundi et al*.* [26], Singh et al*.* [12], Dewdar [37], Patel et al*.* [27], Verma et al*.* [29], Sirisha et al. [34] and Vavdiya et al. [33].

Table 1a. Analysis of variance for seed cotton yield and compact plant traits for stability in cotton

Source of variation	d.f	Days to 50% flowering	Days to first boll bursting	Plant height (cm)	Number of monopodial branches	Earliness index	Number of sympodial branches	Length of the sympodial branches (cm)	Leaf area (cm^2)	Number of bolls per plant
Genotypes	56	22.75*	7.18**	89.12**	0.22**	50.50**	8.60**	5.78**	182794.30**	10.74**
Envi.+ (Geno.x Envi.)	114	6.59	4.88**	25.48**	0.10	1.62**	2.55	5.03	105598.64*	4.68**
Environments	2	1.43	40.01**	172.09**	1.42**	9.24**	6.45*	1.65	1253031.75**	77.83**
Geno.x Envi.	112	6.68	4.25**	21.95**	0.07	1.85**	3.49**	7.20**	85108.76	3.37**
Environments (Linear.)	1	2.85	80.02**	344.18**	2.84**	18.48**	12.90**	3.30	2506063.50**	155.67**
Geno.x Envi.(Linear.)	56	0.64	7.25**	29.00**	0.08	2.00**	2.70	5.60	102020.45	5.74**
Pooled Deviation	57	12.49**	1.23**	14.63**	0.07**	0.98	2.30**	4.58**	67000.64**	0.99
Pooled Error	336	0.22	0.79	4.00	0.00	3.04	0.68	0.09	21107.93	1.15
Total	170	11.91	5.63	44.37	0.14	17.49	3.88	3.89	131027.80	6.68

Table 1b. Analysis of variance for seed cotton yield and compact plant traits for stability in cotton

Source of variation	d.f	Boll weight (g)	Harvest index (%)	100- Seed weight (g)	Seed cotton yield (g pl^{-1})	Ginning out turn (%)
Genotypes	56	0.37**	0.00**	3.22**	111.59**	17.79**
Envi.+ (Geno.x Envi.)	114	0.10**	0.00**	0.38**	68.90**	5.95
Environments	2	0.08	0.03**	4.32**	1052.26**	6.02
Geno.x Envi.	112	0.14**	0.00**	0.41**	62.64**	5.95
Environments (Linear.)	1	0.17	0.07**	8.64**	2104.52**	12.04
Geno.x Envi.(Linear.)	56	0.13**	0.00**	0.37**	65.07**	2.59
Pooled Deviation	57	0.06**	0.00	0.23**	37.62**	9.14**
Pooled Error	336	0.00	0.00	0.07	8.78	0.08
Total	170	0.16	0.00	1.24	75.52	9.85

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

Table 2a. Mean performance and stability parameters for days to first boll bursting, plant height, earliness index and number of sympodial branches in cotton

Crosses	Days to first boll bursting			Plant height			Earliness index			Number of sympodial branches		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
MC 4-3 X NH 630	96	0.108	-0.716	84.004	2.979	31.574**	64.46	3.61*	-2.99	16.22	4.22	0.11
MC 4-3 X MC 3-2	97	2.403	-0.662	85.000	2.571	9.190	63.83	3.61*	-2.99	19.70	0.73	-0.54
MC 4-3 X MC 17-1	97	-1.270*	-0.740	83.444	4.170	4.192	68.47	0.48	-2.95	19.30	1.25	-0.58
MC 4-3 X MC 19-2	96	3.687	-0.672	76.707	1.797	1.729	58.68	-0.48*	-2.99	18.31	2.10	0.11
MC 4-3 X MC 22-2	94	3.120	-0.439	80.809	2.873	4.662	58.78	1.23	-2.97	18.33	3.28	0.26
MC 4-3 X MC 11-1	96	1.471	-0.183	81.010	-3.131	50.345**	58.73	1.24	-2.96	18.84	1.80	-0.67
MC 4-3 X MC 17-2	96	1.012	-0.212	74.947	-2.294	3.337	59.40	1.31	-2.94	18.48	-0.66	16.77*
MC 5-1 X NH 630	95	2.188	-0.753	73.124	1.924	23.565**	64.31	0.75	-2.96	17.24	-0.67	1.09
MC 5-1 X MC 3-2	95	1.555	3.463*	78.736	4.066	15.831*	53.01	0.95	-2.99	18.09	3.52*	-0.67
MC 5-1 X MC 17-1	96	-0.918*	-0.772	87.520	1.043	-3.693	50.47	0.67	-2.92	17.51	3.88	-0.66
MC 5-1 X MC 19-2	97	-2.984*	-0.759	80.566	0.865	15.903*	53.85	1.39	-2.90	17.53	-2.37	1.91
MC 5-1 X MC 22-2	96	-3.200	-0.409	75.422	1.154	-2.589	52.51	1.52	-2.84	16.63	3.55	2.09
MC 5-1 X MC 11-1	98	-1.836*	-0.768	77.528	-1.942	-3.609	57.13	0.28	-2.95	17.36	-0.35	-0.57
MC 5-1 X MC 17-2	97	2.309	-0.632	76.810	2.427	5.641	56.18	0.75	-2.96	13.02	2.48	-0.25
MC 9-1 X NH 630	97	-1.419	1.066	76.044	0.992	-3.221	57.20	1.23	-2.97	17.76	3.19	0.23
MC 9-1 X MC 3-2	97	5.078	-0.236	83.451	3.960	7.294	63.89	-3.91	-2.71	15.09	2.05	3.00*
MC 9-1 X MC 17-1	101	-2.024	1.473	87.732	0.946	31.366**	57.37	1.23	-2.97	14.31	1.80	0.60
MC 9-1 X MC 19-2	97	2.066*	-0.767	84.727	0.851*	-3.951	58.61	1.22	-2.97	16.38	-5.59	1.37
MC 9-1 X MC 22-2	95	1.513	-0.358	76.517	3.457	-2.382	58.89	1.04	-2.99	14.49	4.21	-0.65
MC 9-1 X MC 11-1	96	3.144	5.419*	89.538	2.767	-2.663	55.88	1.22	-2.97	15.00	2.82	-0.30
MC 9-1 X MC 17-2	97	2.782	-0.088	84.022	1.329*	-3.950	57.06	0.45	-2.84	15.23	1.82	-0.01
MC 16-3 X NH 630	94	-0.108	-0.716	74.129	1.383	-2.352	60.57	0.05*	-2.99	16.17	-1.63	0.48
MC 16-3 X MC 3-2	96	-1.795	1.444	84.776	-0.255	-1.580	63.82	1.11	-2.99	16.94	1.72	-0.64
MC 16-3 X MC 17-1	98	2.876*	-0.760	73.002	-2.470	58.168**	56.69	1.96	-2.99	17.89	4.48	3.93*
MC 16-3 X MC 19-2	96	-2.970	-0.420	78.938	0.837	41.260**	55.95	1.22	-2.99	17.00	-1.72	1.39
MC 16-3 X MC 22-2	94	0.473	-0.570	75.272	4.084	5.308	52.63	1.45*	-2.99	16.56	-2.80	3.04*
MC 16-3 X MC 11-1	95	0.689*	-0.773	74.739	-1.727	-0.817	58.01	0.51*	-2.99	15.32	-2.51	0.96
MC 16-3 X MC 17-2	96	-0.960	1.118	77.056	-0.611	40.38**	58.18	-0.79	-2.96	17.11	1.87	-0.66
MC 17-6 X NH 630	96	0.647	1.305	72.691	0.596	3.296	66.87	1.22	-2.67	18.82	1.37	-0.10
MC 17-6 X MC 3-2	97	4.793	0.530	76.588	-1.271	39.25**	59.23	-0.89	-2.98	19.12	-1.90	0.65
MC 17-6 X MC 17-1	99	4.389	-0.194	84.084	-0.442	2.008	60.87	1.26	-2.99	24.01	-4.03	1.15
MC 17-6 X MC 19-2	97	1.607	-0.770	75.350	4.520	11.286	57.52	0.56	-2.99	17.65	2.39	-0.64

Crosses	Days to first boll bursting			Plant height			Earliness index			Number of sympodial branches		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
MC 17-6 X MC 22-2	98	-2.365	4.336*	72.487	1.109	10.249	55.88	0.14	-2.73	18.47	0.25	-0.67
MC 17-6 X MC 11-1	98	2.713	1.559	84.439	-0.247	0.208	57.23	0.95	-2.43	15.58	1.44	-0.57
MC 17-6 X MC 17-2	98	3.064	0.932	79.104	3.516	43.88**	52.07	-0.47	-0.90	18.45	1.89	0.39
MC 23-2 X NH 630	97	4.389	-0.194	69.599	-1.266	-3.647	56.55	-0.61	-2.89	16.34	-0.14	-0.61
MC 23-2 X MC 3-2	96	2.53*	-0.763	77.281	-4.436	7.427	53.88	0.14*	-2.99	16.15	5.03	2.62*
MC 23-2 X MC 17-1	99	5.74*	-0.718	85.458	2.067	8.240	58.43	0.96	-2.94	17.99	0.07	-0.34
MC 23-2 X MC 19-2	97	4.71**	-0.772	80.869	4.128	45.025**	56.71	1.73	-2.83	16.47	1.55	0.07
MC 23-2 X MC 22-2	96	-0.890	0.187	69.508	-1.255	12.884*	60.79	1.26	-2.96	16.44	2.49	-0.46
MC 23-2 X MC 11-1	98	3.120	-0.439	86.289	0.672	19.778*	60.33	1.23	-2.97	15.32	2.70	-0.38
MC 23-2 X MC 17-2	97	0.755	2.056	74.673	0.697	3.904	59.78	1.27	-2.96	18.54	-1.12	3.99**
Mean	96.68			79.33			58.67			17.24		
SE+-	0.93			1.96			1.74			2.61		

Table 2b. Mean performance and stability parameters for length of the sympodial branches, number of bolls per plant, boll weight and harvest index in cotton

Crosses	Length of the sympodial branches			Number of bolls per plant			Boll weight			Harvest index		
	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di	Mean	bi	S^2di
MC 4-3 X NH 630	15.34	3.88	1.22**	18.30	2.08	-0.73	2.67	-4.02	0.01*	0.25	0.62	0.00
MC 4-3 X MC 3-2	16.19	0.35	7.63**	20.35	1.71	0.68	3.14	2.87	0.04**	0.33	0.80	0.00
MC 4-3 X MC 17-1	15.39	6.11	0.18	17.66	1.67	-0.98	2.81	2.19	0.03**	0.36	1.09	0.00
MC 4-3 X MC 19-2	17.45	-1.65	-0.01	15.89	0.15*	-1.14	3.02	-7.42	0.07**	0.29	0.15	0.00
MC 4-3 X MC 22-2	18.32	16.02	14.36**	21.54	-1.27	0.54	2.42	-2.61	0.02**	0.34	1.22	0.00
MC 4-3 X MC 11-1	15.37	3.59	1.38**	18.86	1.59	-1.05	2.65	0.44	0.01**	0.32	0.58	0.00
MC 4-3 X MC 17-2	14.39	12.50	3.90**	18.44	-0.01	-0.38	2.71	1.54	0.00	0.34	0.28	0.00
MC 5-1 X NH 630	14.74	6.34	0.95**	17.93	2.22	3.64*	2.37	-0.32	0.02**	0.36	0.68	0.00
MC 5-1 X MC 3-2	15.93	7.26	3.20**	15.26	-0.11**	-1.15	3.21	5.11	0.00	0.32	0.20	0.00
MC 5-1 X MC 17-1	15.46	8.86	13.30**	16.75	-1.52*	-1.11	2.83	0.79	0.00	0.36	0.44	0.00
MC 5-1 X MC 19-2	14.91	0.06	0.15	16.85	-0.43	1.72	3.19	1.91	0.04**	0.30	0.41	0.00
MC 5-1 X MC 22-2	13.24	7.74	0.99**	15.14	-2.00*	-1.14	2.94	4.71	0.18**	0.34	0.41	0.00
MC 5-1 X MC 11-1	14.23	-8.13	1.67**	16.32	0.90	-0.11	3.27	-3.49	0.15**	0.32	0.70	0.00
MC 5-1 X MC 17-2	16.95	5.19	2.77**	16.24	-0.80*	-1.14	3.29	4.30	0.07**	0.27	0.23	0.00
MC 9-1 X NH 630	15.84	9.43	1.35**	19.94	0.39	-0.79	2.77	1.08	0.08**	0.29	0.62	0.00
MC 9-1 X MC 3-2	15.51	6.71	-0.05	16.19	0.58*	-1.15	3.22	2.95	0.01*	0.37	0.26	0.00
MC 9-1 X MC 17-1	13.44	1.06	0.23	13.31	0.92	-1.03	3.89	17.10	0.16**	0.29	3.25	0.002

Crosses	Length of the sympodial branches			Number of bolls per plant			Boll weight			Harvest index		
	Mean	**bi**	**S^2di**	**Mean**	**bi**	**S^2di**	**Mean**	**bi**	**S^2di**	**Mean**	**bi**	**S^2di**
MC 9-1 X MC 19-2	13.47	5.80	0.33*	16.57	1.15	0.31	3.05	0.98	0.01*	0.31	2.51	0.000
MC 9-1 X MC 22-2	14.10	5.61	3.03**	14.40	-0.51	-0.88	3.10	6.16	0.03**	0.33	1.77*	0.000
MC 9-1 X MC 11-1	14.78	-1.12	0.89**	15.07	-0.83*	-1.14	3.11	-0.53	0.05**	0.36	0.68	0.000
MC 9-1 X MC 17-2	13.50	-0.29	-0.06	12.53	1.18	-0.98	2.79	3.90	0.01*	0.28	1.29	0.000
MC 16-3 X NH 630	12.41	-5.29	1.85**	16.26	3.62	1.81	2.97	0.97	0.00	0.35	1.18	0.000
MC 16-3 X MC 3-2	13.24	4.97	2.84**	14.79	-0.98	-0.99	2.95	-3.92	0.03**	0.28	0.20	0.000
MC 16-3 X MC 17-1	13.89	-10.75	17.34**	17.44	3.61	-0.98	3.13	7.87	0.01*	0.34	1.69*	0.000
MC 16-3 X MC 19-2	15.30	-9.65	2.22**	17.84	5.38	-0.67	2.89	5.46	0.06**	0.36	0.52	0.000
MC 16-3 X MC 22-2	13.35	-10.84	5.05**	16.88	0.55	-0.48	3.35	-2.93	0.03**	0.35	0.62	0.000
MC 16-3 X MC 11-1	13.46	-10.50	2.68**	15.57	1.89	-1.12	3.10	-2.59	0.10**	0.35	0.80	0.000
MC 16-3 X MC 17-2	13.86	-3.96	2.15**	16.42	1.22	-1.05	3.53	2.50	0.09**	0.36	1.17*	0.000
MC 17-6 X NH 630	16.15	0.60	9.75**	17.59	0.61	3.50*	2.77	6.50	0.10**	0.32	0.15	0.000
MC 17-6 X MC 3-2	14.85	1.07	-0.05	18.10	1.16	-1.11	3.02	-1.84	0.01**	0.37	0.52	0.000
MC 17-6 X MC 17-1	15.24	-5.68	0.55**	22.99	1.76	4.66*	3.07	5.30	0.03**	0.34	-1.44	0.000
MC 17-6 X MC 19-2	14.13	10.04	7.35**	16.89	1.33	-0.66	3.63	-8.71	0.51**	0.38	0.28	0.000
MC 17-6 X MC 22-2	13.25	2.88	9.40**	17.59	1.39	-1.03	2.58	5.80	0.05**	0.30	1.57	0.000
MC 17-6 X MC 11-1	13.33	2.29	0.47*	16.51	0.36	-0.10	3.01	-4.96	0.12**	0.35	1.28	0.000
MC 17-6 X MC 17-2	14.00	-7.09	-0.08	17.73	0.75	2.49	3.44	-4.79	0.03**	0.32	1.80	0.000
MC 23-2 X NH 630	16.37	-3.47	0.33*	16.28	2.43	-1.00	3.05	1.67	0.00*	0.30	0.71	0.000
MC 23-2 X MC 3-2	13.84	-1.83	1.97***	13.55	1.09	-0.98	3.92	1.57	0.00	0.36	1.22	0.000
MC 23-2 X MC 17-1	15.08	-5.33	-0.09	15.95	1.45	-1.06	3.51	3.30	0.41**	0.34	1.85	0.000
MC 23-2 X MC 19-2	15.86	6.26	1.16**	17.66	1.28	-1.11	2.86	-0.05	0.00	0.35	1.30	0.000
MC 23-2 X MC 22-2	18.90	11.67	1.97**	17.43	-0.30	0.22	3.16	2.48	0.02**	0.36	0.93	0.000
MC 23-2 X MC 11-1	12.70	-0.16	-0.09	13.71	0.23	-1.02	3.08	1.39	0.13**	0.31	1.45	0.001
MC 23-2 X MC 17-2	14.88	12.80	0.22	19.08	1.14	-0.45	3.04	-1.64	0.00	0.34	0.10	0.000
Mean	14.98			16.84			3.01			0.33		
SE+-	7.15			0.60			4.63			0.39		

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

Table 2c. Mean performance and stability parameters for 100 – seed weight and seed cotton yield in cotton

Crosses	100 – Seed weight			Seed cotton yield		
	Mean	bi	S^2di	Mean	bi	S^2di
MC 4-3 X NH 630	9.49	0.91	-0.07	50.86	1.21	65.68**
MC 4-3 X MC 3-2	9.35	-0.23	-0.06	63.27	0.81	-8.44
MC 4-3 X MC 17-1	10.69	0.27	-0.06	50.65	1.16	-7.95
MC 4-3 X MC 19-2	11.20	1.14	0.03	50.35	0.94	4.88
MC 4-3 X MC 22-2	9.72	-0.13*	-0.07	54.04	-0.45	-3.74
MC 4-3 X MC 11-1	10.92	0.80	0.09	51.39	1.17	4.75
MC 4-3 X MC 17-2	9.59	-2.84	2.75**	47.87	-0.55	102.71**
MC 5-1 X NH 630	8.46	1.22	0.02	44.07	2.06*	-8.52
MC 5-1 X MC 3-2	10.23	1.97	0.24*	50.09	0.08	31.24*
MC 5-1 X MC 17-1	10.88	0.46	0.03	50.07	-0.83	48.42*
MC 5-1 X MC 19-2	10.51	0.14	-0.07	53.24	-0.21	-8.15
MC 5-1 X MC 22-2	10.09	1.44	0.04	45.56	-1.82	124.11**
MC 5-1 X MC 11-1	11.34	0.39	-0.06	51.08	2.22	7.88
MC 5-1 X MC 17-2	10.01	1.37	-0.07	56.38	-1.08	74.76**
MC 9-1 X NH 630	10.22	1.33	-0.05	61.37	1.98	30.39*
MC 9-1 X MC 3-2	10.53	1.99*	-0.07	53.23	0.74	-3.93
MC 9-1 X MC 17-1	10.71	1.64	-0.06	53.62	0.70	156.33**
MC 9-1 X MC 19-2	11.04	1.22	-0.07	51.91	0.68	-6.55
MC 9-1 X MC 22-2	10.33	2.22	-0.03	47.27	-0.35	97.38**
MC 9-1 X MC 11-1	10.86	0.41	0.02	48.15	0.34	25.63*
MC 9-1 X MC 17-2	8.59	1.67	-0.06	37.58	0.66	-7.62
MC 16-3 X NH 630	10.23	1.42	-0.03	50.89	2.93	10.78
MC 16-3 X MC 3-2	10.26	1.85	-0.07	45.73	-0.06	-6.19
MC 16-3 X MC 17-1	10.64	2.27**	-0.07	56.51	3.09	-3.08
MC 16-3 X MC 19-2	10.62	0.68	0.16	52.87	2.27	30.76*
MC 16-3 X MC 22-2	10.31	0.23	-0.05	56.10	2.20	-6.50
MC 16-3 X MC 11-1	9.63	-0.09	-0.02	48.98	2.50	37.01*
MC 16-3 X MC 17-2	11.28	1.49	-0.04	57.08	0.89	8.62
MC 17-6 X NH 630	10.35	1.63	-0.07	55.63	2.31	-7.03
MC 17-6 X MC 3-2	10.81	2.17	-0.06	55.48	1.29	-5.76
MC 17-6 X MC 17-1	10.68	1.64	-0.07	69.12	0.73	-8.65
MC 17-6 X MC 19-2	10.66	2.35	-0.02	62.16	2.66	127.65**
MC 17-6 X MC 22-2	10.09	0.78	-0.07	43.93	0.96	-5.95
MC 17-6 X MC 11-1	10.53	0.50	-0.07	50.75	0.69	48.77*
MC 17-6 X MC 17-2	9.54	1.23	-0.06	58.74	1.57	92.44**
MC 23-2 X NH 630	10.94	1.33	-0.06	50.67	1.39	-3.05
MC 23-2 X MC 3-2	10.85	2.36	-0.07	53.40	1.12	-8.05
MC 23-2 X MC 17-1	11.60	0.77	0.16	55.17	0.42	-4.87
MC 23-2 X MC 19-2	8.50	0.54	-0.07	51.23	0.80	-7.55
MC 23-2 X MC 22-2	11.46	2.00	-0.07	55.72	-0.53	-1.20
MC 23-2 X MC 11-1	11.37	0.62	0.28*	43.35	1.16	-7.61
MC 23-2 X MC 17-2	8.56	-2.91	0.60**	61.26	2.25	103.06**
Mean	9.98			51.55		
SE+-	1.13			0.93		

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

Table 3. The list of suitable hybrids identified for HDPS based on stability for seed cotton yield and compact plant traits

Hybrid	Stable characters
MC 17-6 x MC 3-2	Seed cotton yield, leaf area, length of the sympodia, number of bolls
MC 4-3 x MC 3-2	Seed cotton yield, number of sympodia, number of bolls and harvest index
MC 17-6 x MC 22-2	Seed cotton yield, plant height, 100-seed weight and number of bolls
MC 23-2 x NH 630	Seed cotton yield, harvest index and 100-seed weight
MC 16-3 x MC 17-2	Seed cotton yield, harvest index and 100-seed weight
MC 23-2 x MC 3-2	Seed cotton yield, harvest index and boll weight

4. CONCLUSON

The results of the present study revealed that out of forty two cross combinations evaluated for stability, seven crosses were found to exhibit wider adoptability for seed cotton yield per plant. The cross combinations MC 17-6 x MC 3-2 , MC 4-3 x MC 3-2, MC 16-3 x MC 17-2, MC 23-2 x NH 630, MC 23-2 x MC 3-2 and MC 17-6 x MC 22-2 had shown stable performance over locations for seed cotton yield per plant along with few compact plant type characters as shown in Table 3 and could be exploited for incorporation of stability for developing hybrids amenable for HDPS.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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