1607 Stability of G*. hirsutum* genotypes for performance across Indian rainfed ecosystems

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Twenty genotypes of cotton, *G. hirsutum,* were evaluated in four diverse locations in central and south India over two seasons and analyzed for stability of yield and yield components. The joint regression analysis revealed the presence of significant genotype x environment interaction for seedcotton yield, number of bolls plant^{-1} and boll weight. Heterogeneity between regressions (linear component of genotype x environment interaction) was significant for seedcotton yield and number of bolls plant^{-1}. The result indicated that genotypes GSHV-97/612 and L-762 were the most productive with high mean yield and suitable for favorable environments. The genotype Vikas was found to be the most stable across environments.

Key words: cotton, yield, stability, yield components and genotypes.

Introduction

Cotton is grown in more than 60 tropical and subtropical countries worldwide. Upland, or American, cotton (*Gossypium hirsutum*) is at present the predominant species, accounting for almost 91% of the global production. *G. hirsutum* genotypes have relatively high productivity and wide adaptability (Niles and Feaster, 1984). Productivity of cotton in India is low when compared to many other cotton producing countries. There are several causes for this low productivity. One of the important constraints in achieving higher yield has been the non-availability of stable cotton cultivars adapted to fluctuating environments. Cotton is highly sensitive to weather fluctuations and it exhibits a high level of genotype x environment interactions (Miller *et al.,* 1962). El. Shaarawy (1998) suggested the methods to improve the AMMI model for measuring the stability of genotypes A genotype may behave differently when tested over diverse environments and even the same genotype may behave differently over years at a given location. Research efforts therefore have to be made to develop suitable cotton cultivar that will give constant yield performance over locations and seasons. Breeding for yield under rainfed conditions is complicated by fluctuations in climatic factors, making the identification of yield potential of genotypes in breeding programmes complex and difficult. There is a need to identify stable genotypes performing better across environments than today's cultivars in India. Stability features should be kept paramount in choosing parental genotypes for hybridization in breeding programs. Hence, the present investigation was under taken to estimate genotype x environment interactions in cotton grown over four locations under eight environments to identify genotypes which could perform uniformly over diverse environments.

Material and Methods

Based on their previous superior performance in India (data not shown), twenty *G. hirsutum* genotypes adapted to different production regions were selected from the breeding trails of the All India Coordinated Cotton Improvement Programme. These genotypes were grown under rainfed conditions during 2002-03 and 2003-04 in randomized block designs with 3 replication in four centers, viz., Dharwad (Karnataka), Surat (Gujrat), Guntur (Andhra Pardesh), and Khandwa (Madhya Pardesh) which covers the central and southern zones. Recommended agronomic practices for the respective zones were followed. The observations on yield and yield components such as bolls plant^{-1}, boll weight, and sympodia plant^{-1} were recorded. Twenty randomly selected bolls of each entry were collected, weighed ,and the average calculated and recorded as boll weight (g boll^{-1}).

The data from all the centers were pooled and the stability analysis applied following the method of Eberhart and Russell (1966).

Results and discussion

According to Eberhart and Russell (1966), an ideal genotype as a source of breeding material should have high mean yield, linear regression nearer to unity, and the least non-significant deviation from regression apart from combining ability. Bilbro and Ray (1976) pointed out that the value of the regression coefficient (bi) indicates the adaptation of the genotype to environment when the performance of an individual genotype is regressed on the environmental means. Thus to judge the stability of a genotype, both S^2d and bi were taken into consideration. The combined analysis of variance of the yield data showed that mean differences between genotypes were highly significant indicating the presence of genetic variation among the 20 genotypes (Tables 1 and 2). The significant value of genotypes x environment interaction revealed that the genotypes interacted with different environments.

The environmental index was highest in Environment 5 (E5) i.e., Guntur, at 1072 kg ha^{-1} during 2002-03, followed by E3 at 673 kg ha^{-1} during 2002-03 while the lowest environmental index of -748 kg ha^{-1} was recorded in Dharwad during 2003-04 (Table 1). The analysis of variance for stability parameters indicated significant G X E as well as pooled deviations indicating that genotypes differ with respect to their stability values and also the deviation between observed and expected values and different locations (Table 2).

Stability parameters

The analysis of stability was conducted as per the concept given by Eberhart and Russel (1996). This procedure involves three parameters, namely productivity (mean yield), stability as indicated by regression value (bi) on an environmental index, and deviation of observed values at each location from the expected values (S^2d). Among the genotypes tested, GSHV-97/612 registered highest seedcotton yield of 1412 kg ha^{-1}, but it also produced a regression value of 1.28, which significantly deviated from one (Table 3). The S^2d value was also significant. These values indicated that, GSHV-97/612 is better suited to high fertility situation and favourable environment. A similar trend of difference was observed earlier by Patankar (2002)..

The genotype L-762 (with a mean yield of 1301 kg ha^{-1}) and H-1250 (with a mean yield of 1248 kg ha^{-1}) were also found suited to favorable environments and revealed the same degree of unpredictability in their performance (Table 3). LH-1968, which was next in order with respect to performance (1226 kg ha^{-1}) and the cultivar CPD-371, displayed average stability. Vikas was found to possess average yield but a high degree of stability coupled with non significant S^2_d values. This is a more desirable cultivar compared with the other cultivars evaluated relative to stable performance.

Path of Productivity

The most productive five genotypes of this study are presented in Table 4 and 5. The per se values of these genotypes for yield, number of bolls and boll weight are expressed as percent deviation from the population mean. The conversion helps in determining the contribution of the yield traits to the high productivity of these genotypes. The percent deviation values given in the Table 5 indicate that as a group, these cultivars are high yielding because of both boll number and boll weight.

However, there are clear differences among these genotypes regarding the path of productivity. For instance GSHV 97/612 recorded high yield attributable to the contribution from increase in boll weight as well as boll number. The productivity in remaining genotypes was only due to one component that is either boll weight (LH 1968) or boll number (L 762, H-1250, and Vikas). The differential paths clearly indicate that these genotypes with diverse paths can be hybridized to combine different yield traits for assured improvement in productivity by complementation effect.

Boll weight

Genotypes differed for boll weight (Table 6). The highest mean boll weight was recorded by LH-1968 (3.4 g) followed by PUSA 8-6 (3.4 g), while, CA-29 (2.8 g) and RS-810 (3.0 g) recorded the least mean boll weight (Table 7).

No. of bolls plant^{-1}

Genotypic differences were significant for this trait (Table 8). The highest mean number of bolls per plant across 8 environment was recorded by NH 545 (21.7) Vikas (21.5) and L-762 (21.3), while, least mean number of bolls per plant was recorded by CPD 446 (16.6), TCH-1599 (17.2) and PUSA 8-6 (17.8). The environmental index for bolls per plant was positive at Guntur and Surat while it was negative in Dharwad and Khandwa. During 2002-03 the mean boll weight was more than the boll weight of 2003-04 at all locations except at Khandwa.

The boll weight of 2 genotypes (LH-1968 and GSHV-97/612 in Table 4) and the boll number of 3 genotypes (Vikas, L-762 and GSHV-97/612) or above their group means. These genotypes are to be crossed to get segregates complimenting each other for number of bolls and boll weight. These genotypes are to be involved in hybridization programme either by involving two complementary parents or through multiple crosses followed by selection in segregating population. The ANOVA tables 7 and 9 for boll weight and boll number respectively indicate the presence of interaction between genotype and environment. The genotype GSHV-97/612 is superior by virtue of complementation of these traits particularly boll weight.

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Table 1: Mean seedcotton yield (kg ha^{-1}) of cotton genotypes at 8 environments

Sl. No.	Genotypes	Dharwad		Surat		Guntur		Khandwa		Mean
		02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	
		E1	E2	E3	E4	E5	E6	E7	E8	
1	GSHV-97/612	920	417	1889	1062	2905	1999	1260	843	*1412*
2	L-762	951	555	1784	784	3021	1490	1015	808	*1301*
3	H-1250	639	388	2309	1049	2484	1356	898	864	*1248*
4	LH-1968	697	634	1809	1191	2484	1143	1027	824	*1226*
5	VIKAS	634	422	2154	728	2006	1690	1017	1015	*1208*
6	SCS-37	925	761	1661	710	2392	1329	1130	748	*1207*
7	CPD-731	915	417	1889	895	2298	1370	1037	826	*1206*
8	RAH-30	902	451	1833	759	2515	1075	1013	935	*1185*
9	CPD-446	924	630	1865	876	2067	1277	1008	806	*1172*
10	GBHV-139	834	461	1821	716	2322	1411	913	857	*1167*
11	CCH-526612	960	457	1562	698	2234	1440	1027	944	*1165*
12	L-760	737	592	1438	673	2458	1383	1016	866	*1145*
13	F-1945	856	209	2105	753	2171	1082	1110	823	*1139*
14	NH-545	881	252	2080	735	1639	1347	1063	904	*1113*
15	PUSA-8-6	658	152	1747	901	1995	1342	1067	915	*1097*
16	KH-134	667	310	2056	790	2110	1195	755	811	*1087*
17	AKH-8363	655	480	1586	500	2511	1063	1013	865	*1084*
18	TCH-1599	741	258	1611	736	2068	1293	1060	868	*1079*
19	CA-29	921	238	1877	759	1458	1184	1023	927	*1049*
20	RS-810	709	303	1716	712	1635	1197	1113	865	*1031*
	Mean	*806*	*419*	*1840*	*801*	*2239*	*1333*	*1028*	*866*	1167
	Environmental index	-361	-748	673	-366	1072	166	139	-301	-
	S.Em±	75.5	54.3	93.5	46.3	102.1	71.2	71.0	58.2	-
	CD (5%)	207.7	156.1	283.3	131.5	309.1	215.7	215.1	176.4	-

Table 2: Analysis of variance for yield stability parameter in cotton genotypes

Source	df	Mean sum of squares
Genotypes	19	70793*
Environment (non linear)	07	7255062
Genetic x Environment (GxE) nonlinear	133	37754
Envi + (GxE)	140	398620
Envi (linear	01	50785565*
GxE (linear)	19	66592**
Pooled deviation	120	32199
Pooled error	304	32514
Total	*159*	*57151799*

Table 3: Mean yield and stability parameters of *hirsutum* genotypes

Sl. No.	Genotype	Mean	bi	S^2d
1	GSHV-97/612	1411.8	1.28*	30644**
2	L-762	1301.0	1.28**	330258**
3	H-1250	1248.4	1.24*	337768*
4	LH-1968	1226.2	0.99	9911*
5	CPD-731	1206.2	1.01	244506*
6	VIKAS	1208.3	1.03	183715
7	SCS-37	1206.8	0.93	50092
8	RAH-30	1185.3	1.08	30904
9	CDP-446	1172.8	0.87**	140454
10	GBHV-139	1166.9	1.04	139454
11	CCH-526612	1165.2	0.91	201343**
12	L-760	1145.3	0.97	391524**
13	F-1945	1138.6	1.09	210674**
14	NH-545	1112.8	0.86	282042**
15	PUSA-8-8	1097.2	0.95	178100*
16	KH-134	1086.6	1.07	249655**
17	AKH-8363	1084.2	1.08	41994
18	TCH-1599	1079.4	0.93	149095*
19	CA=29	1049.2	0.62**	132541
20	RS-810	1031.2	0.76**	331733**

Table 4: Path of production of superior genotypes of per se performance.

Sl. No.	Genotypes	Yield (kg ha^{-1})	Bolls $plant^{-1}$	Boll weight (g $boll^{-1}$)
1	GSHV-971612	1412	20.5	3.23
2	L-762	1301	21.3	3.11
3	H-1250	1248	20.0	3.10
4	LH-1968	1226	19.1	3.45
5	Vikas	1208	21.5	3.08
	Group Mean	1279	20.5	3.19
	Entire Group Mean	*1187*	*19.4*	*3.15*

Table 5: Percent deviation of the per se values for yield traits in cotton genotypes

Sl. No.	Genotypes	Yield (kg ha^{-1})	Bolls $plant^{-1}$	Boll weight (g $boll^{-1}$)
1	GSHV-971612	18.96	5.67	2.54
2	L-762	9.61	9.79	-1.27
3	H-1250	5.14	3.09	-1.59
4	LH-1968	3.29	-1.55	9.52
5	Vikas	1.78	10.83	-2.22
	Mean	*7.67*	*5.57*	*1.40*

Table 6: Mean boll weight (g boll^{-1}) of cotton genotypes from 8 environments

Sl. No.	Genotypes	Dharwad		Surat		Guntur		Khandwa		*Mean*
		02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	
		E1	E2	E3	E4	E5	E6	E7	E8	
1	CPD-731	3.68	2.97	2.11	3.07	4.25	4.89	2.01	2.49	*3.18*
2	L-762	3.88	3.30	2.39	2.80	4.12	4.36	1.88	2.18	*3.11*
3	GSHV-97/612	4.60	3.18	2.10	3.10	4.38	4.36	1.94	2.14	*3.23*
4	CCH-526612	3.97	2.88	2.19	3.03	4.33	4.64	1.93	2.50	*3.18*
5	L-760	3.83	3.82	2.21	3.17	4.76	4.73	1.94	2.31	*3.34*
6	SCS-37	3.63	3.17	2.33	3.14	4.04	4.42	2.03	2.84	*3.20*
7	CPD-446	3.95	3.58	1.87	2.96	4.25	4.79	2.03	2.57	*3.25*
8	GBHV-139	3.53	3.15	1.92	3.15	4.28	4.47	2.01	2.42	*3.12*
9	RAH-30	3.88	2.92	1.94	3.04	4.23	5.16	2.00	2.25	*3.18*
10	KH-134	3.85	2.77	1.95	2.90	3.90	4.35	2.01	2.34	*3.01*
11	CA-29	3.53	2.78	2.03	2.81	3.85	3.87	1.40	2.14	*2.80*
12	NH-545	3.88	2.52	1.92	2.83	3.75	4.67	2.08	2.60	*3.03*
13	H-1250	3.78	2.80	2.10	2.99	4.51	4.54	1.52	2.53	*3.10*
14	LH-1968	4.17	3.17	2.49	3.40	4.68	4.83	2.40	2.44	*3.45*
15	F-1945	3.78	2.55	1.97	3.08	4.79	4.31	1.72	1.92	*3.02*
16	AKH-8363	3.75	2.87	1.75	3.18	4.65	4.53	1.88	2.50	*3.14*
17	TCH-1599	4.20	3.00	2.16	3.05	3.19	5.18	1.68	2.58	*3.13*
18	RS-810	3.25	2.65	1.90	2.93	4.11	4.25	2.34	2.44	*2.98*
19	VIKAS	3.73	3.22	2.12	3.03	4.46	4.30	1.58	2.20	*3.08*
20	PUSA-8-6	4.15	2.60	2.17	3.55	4.47	5.37	2.27	2.51	*3.39*
	Mean	*3.85*	*2.99*	*2.08*	*3.06*	*4.25*	*4.60*	*1.93*	*2.39*	3.15
	Environmental index	0.70	-0.16	-1.07	-0.09	1.1	1.45	-1.22	-0.76	-

Table 7: Analysis of variance of stability parameters for boll weight

Source	df	Mean sum of squares
Genotypes	19	0.175**
Env	7	20.09
G x E	133	0.068
Envit x Var x Env	140	1.07
Gen x Envi (GxE)	133	6.89**
Envi (lilenar)	01	140.6
GxE (linear)	19	0.0731*
Pooled deviation	120	0.0647
Pooled error	304	0.105
Total	*159*	*153.1*

Table 8: Mean number of bolls plant^{-1} of cotton genotypes from 8 environment

Sl. No.	Genotypes	Dharwad		Surat		Guntur		Khandwa		*Mean*
		02-03	03-04	02-03	03-04	02-03	03-04	02-03	03-04	
		E1	E2	E3	E4	E5	E6	E7	E8	
1	CPD-731	8.9	6.1	33.3	19.5	43.5	31.3	12.2	12.4	*20.9*
2	L-762	10.7	6.1	34.5	17.4	42.3	38.6	9.8	11.2	*21.3*
3	GSHV-97/612	10.8	6.9	32.9	27.5	38.9	25.4	9.9	11.7	*20.5*
4	CCH-526612	15.2	6.3	27.9	17.3	32.7	29.2	12.0	12.0	*19.1*
5	L-760	9.5	6.7	27.9	16.3	38.1	22.8	10.5	11.1	*17.9*
6	SCS-37	11.4	9.5	28.5	16.4	34.4	29.1	11.3	12.6	*19.1*
7	CPD-446	11.3	6.1	24.4	17.3	35.5	18.1	10.6	9.7	*16.6*
8	GBHV-139	10.3	4.8	31.6	19.8	46.9	27.1	9.3	8.7	*19.8*
9	RAH-30	8.9	4.1	31.6	21.7	32.9	29.0	11.1	13.6	*19.1*
10	KH-134	12.6	5.1	38.7	21.8	38.0	26.1	8.3	8.2	*19.9*
11	CA-29	13.0	3.7	36.1	20.1	36.3	25.8	12.2	11.5	*19.8*
12	NH-545	11.8	3.3	39.6	20.4	36.8	37.5	12.2	12.4	*21.7*
13	H-1250	10.3	4.6	42.5	26.1	31.9	20.3	11.4	12.6	*20.0*
14	LH-1968	11.7	7.9	29.1	21.8	35.0	24.4	12.0	11.3	*19.1*
15	F-1945	12.3	2.7	37.1	20.7	33.1	22.1	10.4	11.8	*18.8*
16	AKH-8363	7.5	7.9	30.8	15.5	41.5	23.4	12.7	12.4	*19.0*
17	TCH-1599	10.4	4.7	31.8	17.9	30.5	18.9	10.3	13.2	*17.2*
18	RS-810	13.5	4.5	31.5	20.5	34.5	21.1	10.5	11.2	*18.4*
19	VIKAS	8.8	7.5	39.5	18.9	36.7	37.1	10.8	12.5	*21.5*
20	PUSA-8-6	7.3	2.7	27.3	21.5	37.7	22.4	9.9	13.5	*17.8*
	Mean	*10.8*	*5.6*	*32.8*	*19.9*	*36.9*	*26.5*	*10.9*	*11.7*	19.4
	Environmental index	-8.6	-13.8	13.4	0.5	17.5	7.1	-8.5	-7.7	-

Table 9: Analysis of variance of stability parameter for number of bolls plant^{-1}

Source	**df**	**Mean sum of squares**
Genotypes	**19**	**15.92****
Envit (GxE)	**140**	**143.8**
Envi (non Linear)	**07**	**2657.2**
Gen x Envi (GxE)	**133**	**11.59***
Envi (lilenar)	**01**	**18600.4**
GxE (linear)	**19**	**19.06****
Pooled deviation	**120**	**9.83**
Pooled error	**304**	**20.9**
Total	***159***	***20444.8***