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Comparative studies on stability parameters and sustainability index for selecting stable genotypes in upland cotton (*Gossypium hirsutum* L.)

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Abstract

Comparative studies on stability parameters and sustainability index for selecting stable genotypes in upland cotton (*Gossypium hirsutum* L.) was carried out accordinag to Eberhart and Russell model with sustainability index model. Stability analysis was carried out on 12 intra-hirsutum hybrids for seed cotton yield, number of bolls/plant, boll weight, 2.5 % span length, and bundle strength on three years data *viz.*, 2001, 2002 and 2003. Based on the linear component (bi), non linear response (S^2di) and high mean performance (x), CSHH 198, CSHH 238, CSHH 825 and Om Shankar were found stable for seed cotton yield. While based on sustainability index and best performance, the hybrids CSHH 238, CSHH 243, CSHH 4311 and CSHH 825 were found to be stable. Similarly, for number of bolls/plant deviation from regression was non significant for CSHH 198, CSHH 243, CSHH 825 and Ankur 651 whereas, on the basis of sustainability index and mean performance Om Shankar, CSHH 198, Ankur 651 and LHH 144 were found stable. For boll weight, all the hybrids recorded very high sustainability index, which indicated that this character is least influenced by the environmental factors, whereas, analysis of variance in the Eberhart and Russell model indicated absence of G × E interaction and hence no stability parameters can be estimated for boll weight. For quality traits like 2.5 % span length and tenacity had very high sustainability index in all the hybrids tested, indicating that these characters are least affected by environmental fluctuations. These results were found to be contrary with the findings based on Eberhart and Russell model and hence sustainability index model may not be used for selecting the stable genotypes.

Key words: Upland cotton, sustainability index, yield, stability parameters

Introduction

Seed cotton yield and its component traits are highly affected by environment. With the statistical and biometrical techniques developed to estimate stability parameters, it would be possible to determine genotypic response for wider adaptability. Techniques for GE analysis based on linear regression [1-3] can be informative when GE interaction has high linear association with the environmental index but when the non linear component is also significant [4, 5]. The analysis based on Eberhart and Russell model being relatively simple has been widely used for stability analysis. With the advancement of statistical techniques, methods are available for analysis of GE interactions which consists of complementary procedures of classification and grouping the genotypes according to their response in different environments [6, 7].

The present investigation was therefore conducted to find out the stability for seed cotton yield and its component traits of intra-hirsutum hybrids and to compare model of Eberhart and Russell and the new model based on sustainability index used by other workers in cotton [5, 6, 7].

Materials and methods

The experimental material consisted of 9 intra-specific hybrids namely CSHH 198, CSHH 238, CSHH 238Y, CSHH 243, CSHH 258, CNHH 348, CSHH 825, CSHH 918, and CSHH 4311 developed at Central Institute for Cotton Research, Regional Station, Sirsa and 3 check hybrids i.e. Ankur 651, Om Shankar and LHH 144. These 12 hybrids were grown in a complete randomized block design with three replications during *kharif* season of 2001, 2002 and 2003. The plot size was 9.0 × 5.0 meter with five rows spaced 100 cm apart in each environment. The data were recorded on seed cotton yield (g), number of bolls/plant, boll weight (g). The seed cotton yield was recorded on plot basis and converted into kg/ha. After ginning, the lint was tested for 2.5% span length and tenacity (g/tex) on high volume instrument (HVI) as per usual method [8].

The data were analyzed for stability parameters as per method of Eberhart and Russell (1966). The significance of stability parameters (bi) and its deviation from unity were determined by t-test. The sustainability indices were estimated by the following formula used by earlier workers [6, 7, 9].

$$S.I. = \frac{Y - \sigma n}{Y_M} \times 100$$

Where Y = Average performance of a genotype, σn = Standard deviation and Y_M = Best performance of a genotype in any year.

The values of sustainability index were divided arbitrarily into five groups *viz.* very low (upto 20%), low (21-40 %), moderate (41-60 %) high (61-80) and very high (above 80%).

Results and discussion

Stability analysis indicated that varieties and environments differed significantly for all the characters *viz.*, seed cotton yield, number of boll/plant, boll weight and 2.5 % span length except varieties for tenacity (Table 1). Variety × environment interaction was significant for all the characters except boll weight indicating differentiate expression of genotypes for the characters studied. Similarly, the environment (linear) component was significant for all the characters whereas, variety × environment (linear) was significant only for seed cotton yield and tenacity. However, magnitude of linear component was relatively more than the non linear component. The variance due to pooled deviation (non linear) was significant for all the characters reflecting considerable genetic diversity in the material which supports the observation of Perkins and Jinks [10]. Such deviation may be of practical use to construct and test the utility of multiple regression models to know critically the complex mechanism of adaptation.

According to Eberhart and Russell model a variety is considered to be stable if it shows high mean performance with unit regression coefficient (bi = 1) and minimum deviation (non significant) from the regression line (S^2di). For seed cotton yield 6 hybrids showed non-significant stability parameters which indicated that these hybrids were found to be stable. However, among the 6 stable hybrids, the hybrids CSHH 198, CSHH 238, CSHH 825 and Om Shankar had high yield of seed cotton and bi > 1.0 but non significant indicating the most stable genotypes for seed cotton yield. The remaining stable hybrids CSHH 918 and Ankur 651 exhibited poor performance and bi < 1.0 indicating their below average responsiveness, suitable for poor environments (Table 2). Similar results have been reported for stability of cotton yield by many workers [5, 6, 11].

Table 1. Analysis of variance for stability of seed cotton yield and related traits in intra-hirsutum hybrids

Source of variation	df	Mean square				
		Seed cotton yield (kg/ha)	Number of bolls/plant	Boll weight (g)	2.5% span length (mm)	Tenacity (g/tex)
Varieties	11	168492.07*	98.32*	0.533**	2.603*	1.216
Environments	2	1021639.23**	714.11**	0.080*	8.568**	10.037**
Var. × Env.	22	84730.61*	85.04*	0.024	0.883**	1.566**
Env. (linear)	1	2043278.46**	1428.22**	0.161*	17.136**	20.073**
Var. × Env. (linear)	11	122280.71*	104.51	0.021	0.652	2.532**
Pooled deviations	12	432448.79**	60.12**	0.025**	1.021**	0.550**
Pooled error	66	19470.12	15.33	0.020	0.222	0.681

*,**Significant at P = 0.05 and P = 0.01 levels respectively.

Table 2. Estimates of stability parameters for seed cotton yield and its components in intra-hirsutum hybrids.

S.No.	Variety	Seed cotton yield (kg/ha)			Number of bolls/plant			2.5% span length (mm)			Tenacity (g/tex)		
		$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S^2di	$\bar{X}$	bi	S2di
1	CSHH 198	2545	1.38	0.02	63	0.65	0.01	25.8	1.18	1.41**	22.3	1.37	0.130
2	CSHH 238	2447	1.32	0.01	58	1.22	1.02**	27.5	1.77	0.004	22.2	1.63	0.132
3	CSHH 238y	2462	2.89*	0.26*	52	0.31	1.08**	28.1	0.56	0.008	21.2	1.04	0.011
4	CSHH 243	2440	0.95	0.20*	69	2.25	0.03	26.4	0.99	0.06	22.2	1.07	0.076
5	CSHH 258	1975	0.22	0.55**	61	0.89	0.46**	27.8	1.95	0.87**	22.0	2.26	0.098
6	CNHH 348	2089	0.03	0.47**	69	2.13	0.81**	25.6	0.37	0.008	22.4	1.24	0.044
7	CSHH 825	2282	1.13	0.15	67	2.79*	0.01	27.7	1.25	2.05**	22.2	3.52*	0.018
8	CSHH 918	2173	0.52	0.05	56	0.49	0.77**	28.4	1.14	0.23*	21.4	−0.37	1.627**
9	CSHH 4311	2370	1.49	0.53**	59	0.38	1.16**	28.0	0.47	2.93**	22.6	−0.05	0.105
10	Ankur 651	1827	0.34	0.08	63	0.18	0.00	28.1	0.82	0.05	22.9	1.13	1.048**
11	Om Shankar	2570	2.08	0.08	70	1.23	0.39*	27.2	1.36	0.86**	22.1	0.32	0.026
12	LHH 144	2130	0.72	0.67**	59	0.29	0.55**	27.0	1.29	0.11	23.3	−1.15	0.273
Pooled mean		2276	-	-	66	-	-	27.3	-	-	22.2		
S.E. (bi)		-	0.50	-	-	0.71	-	-	0.84	-	-	0.57	-

*,**Significant at P = 0.05 and P = 0.01 levels, respectively

For estimating the sustainability index analysis of variance for seed cotton yield and other characters revealed significant differences over the years indicating that enough genetic variability was present in the material studied. The hybrid CSHH 198 recorded the mean seed cotton yield of 2545 kg/ha with very high sustainability index of 91% indicating best performance of this hybrid (Table 3). The high level of best performance coupled with very high value of sustainability index could be taken as the indication of close proximity between the best performance and the average performance over the years. The second best hybrid Om Shankar recorded mean performance of 2604 kg/ha and sustainability index of 62 percent indicating its inconsistent performance over the years or this hybrid may give better yield performance under favorable conditions prevailing in a particular year. The same was confirmed during 2003-04 when the hybrids CSHH 238y and Om Shankar recorded the highest seed cotton yield of 3400 kg/ha and 3278 kg/ha, respectively. Similarly the hybrids CSHH 238, CSHH 243, CSHH 4311, CSHH 825 recorded their highest yield of 2889 kg/ha, 2778 kg/ha, 2833 kg/ha, 2639 kg/ha, respectively and also high sustainability index (70, 77, 67, 73%) indicating stability of the hybrids over the years. However, as per the Eberhart and Russell model the hybrids CSHH 238y, CSHH 243 and CSHH 4311 showed significant deviation from regression (S^2di) indicating that although being higher yielder were found to be unstable for this trait.

For number of bolls/plant the hybrid Om Shankar recorded the highest mean value of 72.3 as well as sustainability index of 79.0. The other stable hybrids were CSHH 198, Ankur 651 and LHH 144. On the

Table 3. Estimates of sustainability index based for seed cotton yield and its components in intra-hirsutum hybrids (mean of 3 years).

S.No.	Hybrids	Seed cotton yield (kg/ha)				Number of bolls/plant				Boll weight (g)			
		Mean	σn	Y_M	Sustai-nability index (%)	Mean	σn	Y_M	Sustai-nability index (%)	Mean	σn	Y_M	Sustai-nability index (%)
1	CSHH 198	2545	118	2678	91	57.3	8.3	64.0	77.0	4.2	0.3	4.5	87
2	CSHH 238	2447	408	2889	70	56.1	14.9	69.4	59.0	3.5	0.3	3.7	88
3	CSHH 238y	2462	855	3400	47	51.6	8.5	61.0	71.0	3.6	0.0	3.6	97
4	CSHH 243	2440	306	2778	77	69.7	17.4	89.5	58.0	3.8	0.1	3.9	94
5	CSHH 258	1975	159	2115	83	60.5	8.7	69.4	75.0	3.7	0.1	3.9	91
6	CNHH 348	2089	201	2277	83	68.7	18.1	88.0	57.0	4.1	0.1	4.2	94
7	CSHH 825	2282	347	2639	73	66.3	21.4	91.0	49.0	3.7	0.3	3.9	88
8	CSHH 918	2173	164	2356	85	57.3	8.3	64.0	77.0	4.1	0.2	4.0	98
9	CSHH 4311	2370	485	2833	67	59.6	9.7	68.0	73.0	4.4	0.2	4.7	89
10	Ankur 651	1827	130	1929	88	59.8	5.9	63.5	85.0	3.2	0.1	3.3	94
11	Om Shankar	2570	587	3176	62	72.3	7.9	81.5	79.0	3.0	0.1	3.1	92
12	LHH 144	2130	463	2710	61	57.8	5.1	61.0	87.0	4.3	0.1	4.4	95
Pooled mean		2276	-	-	-	66.0	-	-	-	3.8	-	-	-

Continued ...

S.No.	Hybrids	2.5% span length (mm)				Tenacity (g/tex)			
		Mean	σn	Y_M	Sustainability index (%)	Mean	σn	Y_M	Sustainability index (%)
1	CSHH 198	25.8	1.4	27.2	90	22.3	1.1	22.9	92
2	CSHH 238	27.5	1.5	28.6	91	22.2	1.3	23.1	90
3	CSHH 238y	28.1	0.5	28.7	96	21.2	0.9	21.8	93
4	CSHH 243	24.4	0.9	26.9	95	22.2	1.0	22.9	93
5	CSHH 258	27.8	1.8	29.8	87	22.0	2.1	23.8	83
6	CNHH 348	25.6	0.3	25.9	98	22.4	1.3	23.5	90
7	CSHH 825	27.7	1.6	29.4	89	22.2	3.4	24.1	78
8	CSHH 918	28.4	1.1	29.5	93	21.4	1.2	22.2	91
9	CSHH 4311	28.0	1.5	29.5	90	22.6	0.8	23.4	93
10	Ankur 651	28.1	0.7	28.8	95	22.9	1.4	24.5	88
11	Om Shankar	27.2	1.4	28.4	91	22.1	0.2	22.2	98
12	LHH 144	27.0	1.1	28.1	92	23.3	1.2	24.4	91
Pooled mean		27.3	-	-	-	22.2	-	-	-

σn = Standard deviation, Y_M = Best performance of a genotype

contrary, linear component was non significant for all the hybrids except CSHH 825, whereas deviation from regression was non significant for CSHH 198, CSHH 243, CSHH 825 and Ankur 651. For boll weight, all the hybrids recorded the higher sustainability index, which indicated that this character is least influenced by the environmental factors. On the basis of the best performance and high sustainability index the hybrids CSHH 198, CNHH 348, CSHH 4311, and LHH 144 were found to be consistent over the years. However, analysis of variance in case of Eberhart and Russell model indicated absence of G × E interaction and hence no stability parameters were estimated for boll weight.

For quality traits like 2.5% span length and tenacity were found to have high sustainability index in all the hybrids tested, indicating that these characters are least affected by environmental fluctuations. All the quality traits recorded the sustainability index more than 80% indicating the close proximity between the best performance and the average performance over the years. But these results are not in agreement with the findings through Eberhart and Russell Model. For 2.5 % span length the regression coefficient (bi) the deviation from regression (S^2di) were found to be non-significant only for CSHH 238, CSHH 238Y, CSHH 243, CNHH 348 Ankur 651 and LHH 144. Similarly for tenacity, linear component was non-significant for all the hybrids except CSHH 825, while deviation from regression was non significant for all the hybrids except CSHH 918 and Ankur 651 indicating the stability of all the hybrids tested except CSHH 918 and Ankur 651.

Based on Eberhart and Russell model the hybrids CSHH 198, CSHH 238, CSHH 825 and Om Shankar were the most stable genotypes for seed cotton yield. For number of bolls/plant the linear component was non significant for all the hybrids except CSHH 825, whereas deviation from regression was non significant for CSHH 198, CSHH 243, CSHH 825 and Ankur 651. For 2.5% span length the regression coefficient (bi) the deviation from regression (S^2di) were found to be non significant only for CSHH 238, CSHH 23 8Y, CSHH 243, CNHH 348 Ankur 651 and LHH 144 and for tenacity, all the hybrids except CSHH 825, CSHH 918 and Ankur 651 were found stable.

In the sustainability index model, the hybrids CSHH 238, CSHH 243, CSHH 4311, CSHH 825 indicated the stability for seed cotton yield. For number of bolls/plant, the hybrids Om Shankar, CSHH 198, Ankur 651 and LHH 144 and for boll weight, the hybrids CSHH 198, CNHH 348, CSHH 4311, and LHH 144 were found to be consistent over the years. Similarly, for quality traits like 2.5 % span length and tenacity were found to have high sustainability index in all the hybrids tested, indicating that these characters are least affected by environmental fluctuations. Keeping in view, the contrasting findings of selecting the stable genotypes based on stability parameters of Eberhart and Russell model [2] and sustainability index model for all the characters studied, the sustainability index model may not be used in the present form for selecting the stable genotypes.

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