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Research Article

Genotype x Environment interaction for yield and yield contributing traits in *Rabi* Sorghum

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Abstract
The analysis of variance for phenotypic stability revealed that the variation due to genotype x environment was considerable for all the characters studied. The significance of G x E (linear) and pooled deviation for majority of the traits suggested the importance of both linear and non-linear components in determining total genotype x environment interactions. Perusal of stability parameters revealed that eight parents were found to be average stable for grain yield. Nevertheless, it was noticed that the male parent RSV 1460 and RPOSV 3 exhibited bi value significantly greater than one, showed below average stability, which was suitable for favourable environments. Among hybrids twenty five hybrids exhibited high mean, unit regression (b_i) and least deviation from regression (S^2d_i) and therefore they were classified as stable with average response to environments. In general, the hybrids found stable for grain yield also showed stability for two or more component characters, which indicated that the stability of various component traits might be responsible for stability of these hybrids for grain yield per plant. The best three hybrids *viz.*, 1543A x RSV 1297, 1343A x RSV 1200 and 1343A x SPV 1359 were found to have average stability over environments for grain yield per plant with one or more stable yield contributing traits, signifying their potential for commercial exploitation for genetic improvement in *rabi* sorghum.

Key words:
Genotype x Environment interaction, stability, linear, non-linear

Introduction

Evaluation of genotypes for consistency of performance in different environments is important in plant breeding programmes. The relative performance of genotypes often changes from one environment to another. The occurrence of large genotype x environment interaction poses a major problem of relating phenotypic performance to genetic constitution and makes it difficult to decide which genotypes should be selected. It is important to understand the nature of genotype x environment interaction to make testing and ultimately selection of more efficient genotypes.

Breeding genotype with wider adaptability has been ultimate aim of plant breeders. A variety is desirable for commercial exploitation over a wide range of environment, if adaptability in real sense is due to genetic make up. Although plant breeders have been unable to exploit them fully in breeding programme. This has been due to problems of measuring adaptability or other complexities of natural environments. Eberhart and Russell (1966) defined a stable genotype as one, which produced high mean yield and depicted regression coefficient (b_i) around unity and deviations from regression (S^2d_i) near zero. Present investigation aimed to study the interaction of 91 genotypes (five male sterile lines, fourteen testers, resultant seventy hybrids and two checks) of *rabi* sorghum with environments.

Materials and methods

The experimental material comprised of five male sterile lines, fourteen testers, resultant seventy hybrids and two checks of *rabi* sorghum. The experiment consisted of 91 genotypes was conducted in randomized block design with three replications during *rabi* 2012-13 at three different locations *viz.*, E_1 : College farm, Navsari Agricultural University, Navsari (Agroclimatic Zone 1- South Gujarat Heavy rainfall zone, annual rainfall 1793mm and semi arid to dry sub humid climatic condition), E_2: Main Sorghum Research Station, Athwa farm, NAU, Surat and E_3: Agricultural Research Station, Achhalia (Agroclimatic Zone 2- South Gujarat, annual rainfall 974mm and semi arid to dry sub humid climatic condition), during *rabi* 2012-13. In individual experiment, each net plot had single row of 3 m each, the inter row spacing 45 cm apart. The border row was planted around each replication. Recommended package of practices was followed to raise good crop. For observations five plants were selected at random from each plot and were tagged. Observations were recorded on the randomly selected plants from each treatment in each replication for grain yield per plant, panicle length, primaries per panicle, panicle weight, harvest index, 1000- grain weight and protein content. Data were analysed following model proposed by Eberhart and Russel (1966)

Results and discussion

The analysis of variance for phenotypic stability (Table 1) revealed that mean squares due to genotypes as well as environments were highly significant for all the characters when tested against pooled deviation. The genotypes interacted significantly with environments for all the characters when tested against pooled error specifying that the genotypes interacted significantly to diverse environments.

The mean squares due to environments (linear) were highly significant for all the characters when tested against pooled deviation. However, the same was significant for all the characters when tested against pooled error. This indicated that variation among environments was linear and it signifies unit change in environmental index for each unit change in the environmental conditions.

The variances due to G x E were further partitioned in to components (i) G x E (linear) and (ii) G x E (non-linear) *i.e.* pooled deviation. The coincidence of genotypic performance with environmental values was observed for grain yield, panicle length, primaries per panicle and harvest index an evident from significant genotypes x environments (linear) mean squares when tested against pooled deviations. Although, G x E (linear) was found to be significant for all the characters when tested against pooled error indicating differential performance of genotypes under diverse environments but with considerably varying norms, *i.e*., the linear sensitivity of different genotypes is variable. The mean squares due to pooled deviations were significant for all the characters except harvest index, which suggested that performance of different genotypes fluctuated significantly from their respective linear path of response to environments.

On comparing relative magnitude of genotype x environment (linear) and pooled deviation from linearity (non-linear), it was found that the linear component was high for grain yield per plant, panicle length, primaries per panicle, panicle weight, and harvest index indicating that linear component contributed more towards the genotype x environment interactions. In case of 1000-grain weight and protein content both linear and non-linear components was almost equal indicating importance of both linear and non linear components in determining genotype x environment interactions for these attributes.

These results were in general, concurring with those of Muppidathi *et al.* (1995[a & b]), Narkhede *et al.* (1998[a & b]), Muppidathi *et al.* (1999[a & b]), Patil *et al.* (1991), Shivanna *et al.* (1992), Das and Prabhakar (2003), Khandelwal *et al.* (2005) and Kale (2012).

The stability parameters *viz.*, mean performance (X), regression coefficient (bi) and individual squared deviation from linear regression (S^2di) for parents as well as hybrids were estimated for seven characters to assess the stability over the environments and are presented in Table 2.1-2.3. Total 91 genotypes were divided in to two groups; first comprising all hybrids with hybrid check CSH 15R and second comprising all parents with varietal check BP 53. Population means of these two groups were estimated separately and used for assessment of stability parameters.

For grain yield per plant significant deviation from regression were exhibited by 12 hybrids and 02 parents, revealing larger contribution of non-linear component is important than linear components towards G x E interaction. Among parents, three females *viz.*, 104A, 1343A and 1543A, eight males and varietal check BP 53 had higher mean than parental mean with bi magnitude not significantly deviating from unity and non-significant deviation from regression, hence they were considered stable for this trait. The male parent RSV 1460 and RPOSV 3 exhibited high mean, bi value significantly greater than unity and non-significant deviation from regression, thus showing below average stability which was suitable for rich environments. Out of 70 hybrids and check (CSH 15R) tested, 25 hybrids exhibited high mean, along with regression coefficient near unity and non-significant deviation from regression and therefore they were classified as stable hybrids. In addition to these stable hybrids, four hybrids 1409A x RSV 1006, 1409 A x RSV 1704, 1543A x SPV 1359 and 1543A x SPV 1546 had high mean, regression coefficient greater than unity and non significant deviation from regression showed specific adaptability for favourable environments. While one hybrid, 1409A x RSV 1093 showed specific adaptability to poor environments for grain yield per plant. The superlative five stable hybrids were 1543A x RSV 1297, 1343A x RSV 1200, 1343A x SPV 1359, 1543A x SPV 1704 and 1543A x RSV 1188.

As regards to panicle length, among the parents, three females *viz.*, 1343A, 1543A and 9168A and three males *viz.*, RSV 1093, RSV 1200 and SPV 1359 recorded higher mean than parental mean with bi magnitude not significantly deviating from unity and non-significant deviation from regression, hence were considered as stable. Out of 70 hybrids tested, 27 hybrids exhibited high mean, along with regression coefficient near unity and non-significant deviation from regression and therefore they were classified as stable hybrids.

Among the hybrids, 2 hybrids *viz.*, 1409A x SPV 1546 and 104A x RSV 1297 exhibited high mean, bi value significantly greater than unity and non-significant deviation from regression showing below average stability and were found suitable for rich environments. The superlative five stable hybrids were 1409A x RSV 1297, 1409A x SPV 1704, 1409A x RSV 1200, 1409A x RSV 1460 and 1543A x RSV 1297.

For primaries per panicle the female 1343A along with 4 male parents and check BP 53 were stable as evident from their high mean, unit regression coefficient and non-significant non-linear component. Among the 70 hybrids and check (CSH 15R) tested, 27 hybrids exhibited high mean, along with regression coefficient near unity and non-significant deviation from regression and therefore they were classified as stable hybrids. The superlative five stable hybrids were 1543A x RSV 1297, 1343A x RSV 1200, 1343A x SPV 1359, 1543A x SPV 1704 and 1343A x SPV 1704. The two hybrids 104A x RSV 1130 and 1343A x SPV 1546 showed below average stability which were suitable for rich environments.

Among parents, one female (1343A), 10 males and check BP 53 had higher mean than parental mean with bi magnitude not significantly deviating from unity and non-significant deviation from regression, were considered stable for panicle weight. Among the hybrids, 23 hybrids exhibited high mean, along with regression coefficient near unity and non-significant deviation from regression and therefore they were classified as stable hybrids. Hybrid, 1543A x RSV 1427 recorded high mean, bi significantly less than unity, exhibited above average response and suitability for poor environments. One hybrid 1343A x SPV 1359 exhibited high mean, bi value significantly greater than unity and non-significant S^2di, showing below average stability and suitability for favourable environments. The superior five stable hybrids were 1543A x RSV 1297, 1343A x RSV 1200, 1343A x SPV 1704, 1543A x RSV 1188 and 1543A x SPV 1704.

For harvest index, 4 females, 01 male (RSV 458) and varietal check BP 53 recorded high mean, non significant regression coefficient and non-significant S^2di values showing average stability over environments. The male parent RSV 1093 was found suitable for favourable environments. Among 70 hybrids, 30 hybrids had high mean, non significant regression coefficient and non-significant S^2di values which indicated their ideal stability over environments. The performance of 4 hybrids (1343 A x RSV 1188, 1409A x RSV 458, 1409A x RSV 1188 and 1409A x RSV 1460) could not be predicted under variable environments in view of significant S^2di values. Three hybrids 1409A x RSV 1200, 1543A xS PV 1359 and 9168A x RSV 1200 exhibited high mean, bi value significantly less than unity and non-significant deviation from regression showed above average stability which were suitable for poor environments, whereas hybrid 104A x RSV 1460 was suitable for rich environment. The best five hybrids among the stable hybrids for this trait were 1343A x RSV 1200, 1343A x SPV 1359, 1543A x SPV 1704, 1543A x RSV 1297 and 1543A x SPV 1704.

As regards to 1000 grain weight, among the parents, 3 male along with check BP 53 had higher mean than parental mean with bi magnitude not significantly deviating from unity and non-significant deviation from regression, hence were considered as stable for this trait. Among all parents RSV 1188 and hybrids cross 9168A x SPV 1546 exhibited high mean, bi value significantly greater than unity and non-significant S^2di values, exhibiting below average stability which was suitable for rich environments, while male SPV 1704 has exhibited above average stability for this trait. Performance of 16 hybrid, 6 testers and 1 female was unpredictable behaviour due to high mean bi around unity and S^2di significantly deviating from zero. Out of 70 hybrids and check (CSH 15R) tested, 14 hybrids exhibited high mean, along with regression coefficient near unity and non-significant deviation from regression and therefore they were classified as stable hybrids. The superlative three stable hybrids were 1543A x RSV 1188, 1543A x RSV 1297 and 1343A x RSV 1200.

For protein content, females 1543A and 9168A along with one male parent SPV 1704 had higher mean than parental mean, bi magnitude not significantly deviating from one and non-significant deviation from regression, hence were considered stable for this trait. Among the males, SPV 1546 and among crosses, 9168A x RSV 1130 and 9168A x RSV 1297 exhibited bi value significantly less than one, showing above average stability which were suitable for poor environments. Among the hybrid group, 9 hybrids exhibited high mean, along with regression coefficient near unity and non-significant deviation from regression and therefore they were classified as stable hybrids. Performance of 20 hybrids was unpredictable due to high mean bi around unity and S^2di value significantly deviating from zero. The superlative five stable hybrids were 1409 A x RSSGV 43, 1409A x SPV 1704, 104A x SPV 1359, 9168A x RSV 1460 and 1409A x RSV 458.

When stability parameters as suggested by Eberhart and Russell (1966) were studied for different genotypes (5 females, 14 males, 70 hybrids and 2 checks), it was revealed that none of the genotype was found stable for all the traits. Any generalization regarding stability of genotypes for all the characters was therefore not possible. Among these genotypes, 25 hybrids exhibited unit regression (b_i) and least deviation from regression (S^2d_i) and therefore they were classified as stable with average response to environments. Perusal of stability parameters further revealed that 8 parents were found to be stable for grain yield for all the environments. In general, the female and male parents behaved differently in different environments as observed by Patel *et al.* (1984). However, it was noticed that the male parent RSV 1460 and RPOSV 3 exhibited bi value significantly greater than one, showed below average stability and suitability for rich environments for grain yield per plant. Instances where a few true breeding varieties were comparable in yield to hybrids under favorable environmental conditions have been reported by Rao and Harinarayana (1969) and Singhania & Rao (1976).

The heterozygous entries (hybrids) were in general, slightly more stable than the homozygous ones (parents), but the wide ranges found within both the parents and hybrids for stability parameters indicated that it should be possible to select stable entries at both levels of genetic structure. These results corroborated with the findings of Reich and Atkins (1970), Majisu and Dogget (1972), Patanothai and Atkins (1974), Rao *et al.* (1981), Patel *et al.* (1984), Haussmann *et al.* (2000) and Kale (2012).

From the stability analysis, it could be seen that the best three stable hybrids for grain yield per plant were 1543A x RSV 1297, 1343A x RSV 1200, 1343A x SPV 1359. In general, the hybrids found stable for grain yield also showed stability for two or more component characters, which indicated that the stability of various component traits might be responsible for the observed stability of various hybrids for grain yield per plant. In the present investigation, the best three hybrids *viz.*, 1543A x RSV 1297, 1343A x RSV 1200, 1343A x SPV 1359 were found to have average stability over environments for grain yield per plant with one or more stable yield contributing traits, signifying their potential for commercial exploitation for genetic improvement in *rabi* sorghum.

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Table 1. Analysis of variance (mean square) for phenotypic stability for different characters in *rabi* sorghum

Source of variation	d.f.	GY	PL	PPP	PW	HI	TW	PC
Genotypes	90	378.73++**	28.51++**	371.85++**	480.70++**	87.16++**	50.62++**	3.68++**
Environments	2	147.39+*	11.68++**	565.65++**	195.01++**	127.38++**	254.97++**	4.44++**
G x E	180	34.93++**	2.25+**	60.65+**	36.89**	5.11++**	6.91**	0.73**
Environments (Lin)	1	294.78++**	23.36++**	1130.30++**	390.02++**	254.76++**	509.94++**	8.88++**
G x E (Lin)	90	47.45++**	2.97++**	76.30++**	43.80+**	7.81++**	7.66**	0.69**
Pooled Deviation	91	22.16**	1.51**	44.51**	29.66**	2.38	6.100**	0.75**
Pooled Error	540	9.44	0.42	10.25	8.27	2.15	0.55	0.06

+, ++: Significant against pooled deviation M.S. at 5% and 1% levels, respectively.
*, **: Significant against pooled error M.S. at 5% and 1% levels, respectively.
GY : Grain yield per plant (g) PL : Panicle length (cm) PPP : Primaries per panicle
PW : Panicle weight (g) HI : Harvest Index (%) TW : 1000-grain weight (g)
PC : Protein content(%)

Table 2.1 Stability parameters for grain yield per plant, panicle length and primaries per panicle in *rabi* sorghum

Sl. No.	Genotypes	Grain yield per plant (g)			Panicle length(cm)			Primaries per panicle		
		Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
1	104A x RSV 458	52.54	0.10	14.31	21.80	1.43	10.63 **	55.00	-4.82	39.60 *
2	104A x RSV 1006	61.63	3.35	93.57**	22.32	0.73	1.02	61.55	1.47	2.80
3	104A x RSV 1093	70.58	-0.575	25.36	23.93	5.28	-0.01	75.44	0.11	-3.67
4	104A x RSV 1130	58.15	-4.32	-2.43	22.38	3.74	-0.40	82.11	4.84*	-9.11
5	104A x RSV 1188	65.95	-4.17	-7.95	20.89	-5.36	5.38 **	76.44	4.50	325.38 **
6	104A x RSV 1200	60.75	1.27	-0.93	23.35	4.83	-0.08	69.55	0.24	66.90 **
7	104A x RSV 1297	61.96	-0.66	-2.75	24.40	4.35*	-0.42	71.44	-1.70	137.40 **
8	104A x SPV 1359	55.20	0.32	16.38	24.66	2.17	-0.36	63.44	2.59	14.42
9	104A x RSV 1427	59.93	2.05	-7.99	23.77	5.98	5.36 **	72.33	2.93	-9.77
10	104A x RSV 1460	58.44	0.35	-9.05	22.79	5.34	5.10 **	72.00	1.17	-7.09
11	104A x SPV 1546	60.83	3.31	-6.95	23.05	5.19	2.16 *	62.44	3.61	5.58
12	104A x SPV 1704	54.75	0.23	-9.06	22.80	1.93	2.90 **	72.89	1.85	59.33**
13	104A x RPOSV 3	25.09	4.52	26.99	17.08	-4.68	0.50	63.33	0.81	8.33
14	104A x RSSGV 43	45.87	-2.65	33.29 *	20.77	3.91	0.47	70.67	2.47*	-10.21
15	1343A x RSV 458	62.14	-0.92	-8.33	19.00	1.99	0.07	67.89	3.38	19.18
16	1343A x RSV 1006	62.45	1.48	-3.39	20.19	0.01	-0.29	76.78	5.17	-0.55
17	1343A x RSV 1093	71.79	-5.39	-5.99	21.11	1.61	2.22 *	75.33	4.70	-0.38
18	1343A x RSV 1130	63.22	-0.31	-3.56	21.47	-0.42	0.91	78.82	1.39	12.54
19	1343A x RSV 1188	70.05	1.33	-6.61	20.94	-5.13*	-0.37	76.56	0.61	198.68 **
20	1343A x RSV 1200	86.53	2.17	-8.46	22.52	2.00	-0.05	95.55	0.97	-7.41
21	1343A x RSV 1297	61.31	10.53	2.13	22.38	-0.63	-0.28	71.55	-2.61	37.27 *
22	1343A x SPV 1359	84.87	2.42	-8.84	23.21	1.60	1.07	92.11	1.79	-9.03
23	1343A x RSV 1427	75.06	-0.38	16.49	21.71	1.40	-0.42	87.11	2.90	-3.56
24	1343A x RSV 1460	68.48	2.62	26.96	21.38	1.91	1.08	75.67	0.00	3.31
25	1343A x SPV 1546	64.72	7.74	63.94 **	20.71	1.55	0.89	84.55	3.15*	-10.23
26	1343A x SPV 1704	79.17	-0.08	3.02	22.13	1.57	-0.42	87.78	1.58	-8.11
27	1343A x RPOSV 3	43.35	0.22	0.95	17.42	1.44	1.20	84.67	0.36	-8.93
28	1343A x RSSGV43	60.49	-10.37	2.17	18.25	0.26	1.66 *	84.33	6.94	-5.94
29	1409A x RSV 458	48.26	0.08	135.73 **	23.14	0.29	-0.05	53.56	-3.70	-2.58
30	1409A x RSV 1006	61.73	8.47*	-9.26	26.56	-1.38	-0.25	64.33	-2.24	147.76 **
31	1409A x RSV 1093	71.50	-6.08*	-8.69	26.62	9.12	0.41	67.89	3.15*	-10.23
32	1409A x RSV 1130	60.81	-0.59	-7.04	25.54	-8.41	1.15	74.17	-3.70	94.23 **
33	1409A x RSV 1188	59.12	-4.55	170.90 **	25.36	-8.74	8.26 **	73.00	-1.45	13.15
34	1409A x RSV 1200	69.15	2.13	14.42	27.82	0.34	0.08	72.15	-1.49	15.12
35	1409A x RSV 1297	67.58	4.37	40.44 *	28.40	1.73	0.16	76.26	1.34	-10.23
36	1409A x SPV 1359	65.69	-0.30	-1.04	28.39	-1.69	-0.13	72.55	2.50	10.93
37	1409A x RSV 1427	60.14	3.10	14.73	27.19	-2.80	-0.39	66.44	2.02	-2.46
38	1409A x RSV 1460	60.26	6.35	12.05	25.74	2.60	0.76	59.89	-1.32	82.85 **
39	1409A x SPV 1546	59.85	5.25	16.86	26.30	5.91*	-0.42	68.44	-4.65	140.61 **
40	1409A x SPV 1704	62.13	9.86*	-9.42	28.01	2.65	-0.30	74.44	2.56	-1.75
41	1409A x RPOSV 3	35.36	-1.83	40.68 *	19.99	2.49	-0.36	79.00	-2.61	41.09 *
42	1409A x RSSGV43	47.93	-0.53	58.04**	23.18	0.65	0.40	71.11	-2.96	50.07 *
43	1543A x RSV 458	58.27	-0.38	23.47	19.65	3.74	-0.17	62.11	5.47	-5.66
44	1543A x RSV 1006	58.66	4.24	24.45	19.45	1.21	-0.33	67.65	-1.38	-5.90
45	1543A x RSV 1093	70.20	2.84	2.77	21.74	-0.91	-0.02	70.11	0.39	49.48 *
46	1543A x RSV 1130	68.85	0.47	98.59 **	21.48	0.02	-0.21	79.91	1.35	3.21
47	1543A x RSV 1188	77.99	0.12	0.08	22.36	1.13	0.75	87.21	1.80	-10.07
48	1543A x RSV 1200	69.37	3.88	6.26	21.85	1.75	1.29 *	82.00	1.11	24.30

* and ** Significant at 5% and 1% level of probability, respectively.

Table 2.1 Contd…

Sl. No.	Genotypes	Grain yield per plant (g)			Panicle length (cm)			Primaries per panicle		
		Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
49	1543A x RSV 1297	87.82	2.58	-7.54	24.30	2.92	0.35	99.67	0.86	-0.80
50	1543A x SPV 1359	66.50	11.34*	-9.13	22.31	1.59	0.87	69.67	6.17	4.86
51	1543A x RSV 1427	65.67	-4.30	19.89	21.60	4.34	-0.40	76.16	1.70	4.85
52	1543A x RSV 1460	65.55	7.68	5.77	20.39	2.05	0.72	76.70	2.64	-8.40
53	1543A x SPV 1546	68.22	5.80*	-9.12	21.10	1.40	-0.40	80.67	0.88	47.05 *
54	1543A x SPV 1704	80.20	0.48	5.62	22.33	1.96	-0.39	90.33	2.02	-10.12
55	1543A x RPOSV 3	34.17	-1.18	85.69 **	15.98	0.44	-0.02	80.27	4.21	20.70
56	1543A x RSSGV43	53.55	-4.04	-6.20	19.01	2.31	-0.22	74.22	3.32	14.77
57	9168A x RSV 458	50.47	-3.97	5.09	20.59	5.62	0.49	50.11	4.10*	-9.57
58	9168A x RSV 1006	54.51	-2.66	-4.74	21.92	0.47	-0.07	68.00	0.74	47.52 *
59	9168A x RSV 1093	56.25	-4.03	9.07	22.10	-0.77	-0.39	63.00	2.72	135.90 **
60	9168A x RSV 1130	62.04	-0.25	-7.05	21.75	1.43	-0.21	70.56	1.61	42.51*
61	9168A x RSV 1188	55.73	-8.67	-6.34	22.08	0.62	-0.42	62.78	1.34	1.65
62	9168A x RSV 1200	57.78	2.80	-6.97	22.31	1.12	0.55	59.89	0.73	5.66
63	9168A x RSV 1297	60.64	-5.60	33.77 *	23.26	0.95	-0.39	55.00	2.62	-9.85
64	9168A x SPV 1359	60.92	3.211	106.66 **	22.84	1.57	-0.00	59.00	0.44	65.35 **
65	9168A x RSV 1427	49.98	-3.60*	-9.43	22.48	-0.32	-0.30	56.78	3.78	-8.54
66	9168A x RSV 1460	54.73	-0.39	-8.79	19.86	4.81	0.61	57.89	-1.35	47.45 *
67	9168A x SPV 1546	60.55	-0.01	10.22	20.70	1.24	-0.42	50.22	-0.11	-3.67
68	9168A x SPV 1704	54.73	-0.10	11.78	22.27	-0.14*	-0.42	59.78	1.42	277.72 **
69	9168A x RPOSV 3	32.22	0.89	13.70	18.51	-4.97	3.49**	60.55	0.56	20.97
70	9168A x RSSGV 43	50.65	-0.91	6.24	19.44	0.90	-0.10	58.22	2.84	14.08
71	CSH 15 R (c)	56.53	3.96	-3.57	20.88	-0.58	0.13	69.62	0.52	-2.16
	Mean (Hybrids)	60.81			22.30			71.53		
72	104A	53.17	2.07	5.14	22.57	3.93	1.63 *	74.44	-3.58	249.21 **
73	1343A	57.10	1.51	4.85	18.94	2.52	0.44	68.91	0.32	1.14
74	1409A	41.31	-0.59	111.39 **	27.79	-2.54	6.24 **	58.78	-3.06	14.13
75	1543A	53.81	2.43	-3.14	19.56	1.13	0.03	69.44	0.06	34.23 *
76	9168A	44.96	1.68	-7.34	19.48	-0.61	0.09	41.67	3.83	49.07 *
77	RSV 458	45.13	0.79	-8.59	14.44	0.11	1.056	43.67	-2.90	25.67
78	RSV 1006	47.79	2.07	-9.11	15.66	0.07	0.08	48.26	-3.10	-5.27
79	RSV 1093	65.52	2.35	-9.01	20.57	-2.56	0.33	69.11	-0.51	-5.41
80	RSV 1130	56.09	4.96	-6.03	18.21	-0.84	2.58 **	54.44	-0.69	158.26 **
81	RSV 1188	60.40	1.24	1.27	19.20	-2.88	3.47**	61.67	0.41	-9.72
82	RSV 1200	56.69	4.53	-8.89	19.67	0.42	0.17	60.67	-1.69	32.38 *
83	RSV 1297	54.26	3.98	-7.12	20.01	-1.39	5.25 **	66.89	-1.06	7.40
84	SPV 1359	58.77	2.66	-8.51	21.50	4.09	-0.15	63.67	-0.07	38.42 *
85	RSV 1427	45.87	2.47	-9.38	18.47	-1.47	1.34 *	71.89	0.81	296.31 **
86	RSV 1460	53.28	5.49*	-9.44	17.76	-0.70	1.96 *	60.00	2.06	10.64
87	SPV 1546	54.15	1.14	5.06	17.30	11.32	7.39 **	74.22	4.35	39.24 *
88	SPV 1704	53.75	-1.93	13.37	18.85	5.86	2.07 *	61.33	1.53	-9.66
89	RPOSV 3	57.35	4.04*	-9.41	16.24	-11.52	7.96 **	75.67	3.71	13.44
90	RSSGV 43	33.59	-0.52	27.09 *	13.76	3.21	-0.29	85.22	0.69	11.03
91	BP 53 (c)	60.46	0.46	-7.86	15.75	0.22	4.15**	65.64	-0.47	8.74
	Mean(Parents)	52.67			18.79			63.78		

* and ** Significant at 5% and 1% level of probability, respectively.

Table 2.2 Stability parameters for panicle weight, harvest index and 1000 grain weight in *rabi* sorghum

Sr. No.	Genotypes	Panicle weight(g)			Harvest index(%)			1000-grain weight(g)		
		Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
1	104A x RSV 458	65.82	-0.33	11.01	24.92	0.70*	-2.15	46.05	1.33	5.00 **
2	104A x RSV 1006	73.93	2.41	120.95**	22.17	1.41	2.84	44.72	-0.88	6.11 **
3	104A x RSV 1093	83.14	1.12	0.45	23.74	0.78	1.63	45.88	1.17	4.26 **
4	104A x RSV 1130	72.07	-1.52	38.94*	24.96	0.23	-1.28	45.96	-0.16	17.71 **
5	104A x RSV 1188	77.84	-3.77	40.47*	27.74	-0.28	-1.26	46.01	-2.17	3.95 **
6	104A x RSV 1200	73.17	1.63	-0.49	32.45	0.16	-1.92	43.04	2.23	19.44 **
7	104A x RSV 1297	73.23	0.54	-1.33	32.33	1.17	-2.15	41.77	2.33	1.00
8	104A x SPV 1359	66.25	0.60	12.84	26.54	2.05	-1.51	46.54	-0.55	-0.34
9	104A x RSV 1427	71.79	1.87	-1.00	27.57	-0.21	-2.10	45.34	1.31	5.34 **
10	104A x RSV 1460	72.24	0.77	-5.85	30.15	1.87*	-2.14	41.88	1.71	6.15 **
11	104A x SPV 1546	76.97	2.63	-5.74	36.47	-1.37	-0.67	42.62	1.55	22.91 **
12	104A x SPV 1704	68.64	0.08	-1.83	26.07	2.88	-1.68	43.26	2.56*	-0.53
13	104A x RPOSV 3	34.88	4.81	-5.55	24.61	1.80	4.85	40.33	0.60	30.12 **
14	104A x RSSGV 43	57.06	-3.73	2.80	24.28	2.54	0.06	42.08	0.88	-0.05
15	1343A x RSV 458	75.74	-0.05	7.61	29.50	-3.86	4.52	45.47	2.39	20.91 **
16	1343A x RSV 1006	75.89	2.64	-4.65	22.41	-0.48	1.54	42.94	0.39	4.32 **
17	1343A x RSV 1093	86.80	-4.26	69.40**	28.51	-3.22	3.21	43.86	0.83	0.49
18	1343A x RSV 1130	76.21	0.17*	-8.34	29.15	-0.21	2.39	43.14	0.65	18.48 **
19	1343A x RSV 1188	84.55	0.98	-0.76	29.52	-4.29	6.27*	44.33	1.52	3.73 **
20	1343A x RSV 1200	104.77	3.06	-6.27	37.94	0.55	-2.07	45.24	0.05	0.69
21	1343A x RSV 1297	72.86	8.65	73.24**	21.93	1.57	-1.43	44.12	1.49	-0.04
22	1343A x SPV 1359	103.05	2.53*	-8.37	37.78	2.29	-1.92	47.98	0.01	3.65 **
23	1343A x RSV 1427	93.09	-0.92	1.49	36.93	2.24	1.17	41.55	-0.21*	-0.53
24	1343A x RSV 1460	85.47	2.03	8.27	35.77	2.21	1.55	45.19	2.09	-0.09
25	1343A x SPV 1546	77.16	7.78	-1.69	31.44	-1.67	3.61	40.83	0.51	34.22 **
26	1343A x SPV 1704	96.69	-0.09	6.42	36.95	1.19	0.10	41.88	1.57	14.38 **
27	1343A x RPOSV 3	53.53	0.43	15.97	21.78	0.74	-1.61	42.93	3.01	5.46 **
28	1343A x RSSGV43	72.76	-6.97	90.56**	27.69	-0.58	1.46	41.50	0.04	20.67 **
29	1409A x RSV 458	60.03	2.55	232.74**	35.60	-1.02	10.62*	41.39	1.72	6.10 **
30	1409A x RSV 1006	75.77	7.02	58.32**	28.97	1.12	-1.84	43.33	1.91	16.85 **
31	1409A x RSV 1093	84.30	-3.50	23.73	36.26	2.26	-2.08	45.51	0.77	0.25
32	1409A x RSV 1130	73.49	0.90	-0.73	24.47	0.71	-1.56	46.29	1.58	0.43
33	1409A x RSV 1188	73.94	0.31	214.17**	29.73	4.75	6.86*	44.46	0.85	0.42
34	1409A x RSV 1200	84.78	1.44	4.27	39.29	-0.26*	-2.14	40.94	1.78	11.15**
35	1409A x RSV 1297	79.68	5.39	-5.97	32.66	3.57	4.44	42.60	1.27	4.69 **
36	1409A x SPV 1359	78.00	-0.50	-1.35	34.59	2.30	-1.86	45.08	0.90	1.71 *
37	1409A x RSV 1427	74.47	2.60	-6.69	34.32	2.61	0.46	42.55	0.79	-0.33
38	1409A x RSV 1460	73.19	6.08	83.29**	30.44	-1.15	9.95*	39.92	1.74	2.26 *
39	1409A x SPV 1546	76.38	3.31	-6.82	33.43	0.74	1.31	39.59	-1.08	0.61
40	1409A x SPV 1704	74.74	8.17	69.25**	33.75	-1.20	-2.06	42.42	1.54	12.34 **
41	1409A x RPOSV 3	45.00	-0.92	61.19**	17.75	1.24	-2.13	40.31	-2.11*	-0.54
42	1409A x RSSGV43	58.64	-1.62	21.26	29.10	-0.10	-5.70	36.43	1.87	2.20 *
43	1543A x RSV 458	70.23	-1.12	6.90	32.99	-0.99	4.73	44.99	2.57	0.25
44	1543A x RSV 1006	71.48	4.56	3.17	34.52	-0.28	-1.85	44.25	1.58	1.13
45	1543A x RSV 1093	86.66	1.99	-4.32	31.91	-0.89	-0.40	44.61	2.21	5.79 **
46	1543A x RSV 1130	82.04	0.48	34.01*	28.39	-0.68	0.34	48.36	1.74	0.51
47	1543A x RSV 1188	94.49	-0.13	-6.26	36.31	1.14	-0.87	45.88	0.99	-0.44
48	1543A x RSV 1200	81.95	3.72	43.26*	33.16	1.14	-0.63	41.06	0.53	11.26 **

* and ** Significant at 5% and 1% level of probability, respectively.

Table 2.2 Contd…

Sr. No.	Genotypes	Panicle weight(g)			Harvest index(%)			1000-grain weight(g)		
		Mean	b_i	S^2di	Mean	b_i	S^2di	Mean	b_i	S^2di
49	1543A x RSV 1297	106.99	3.52	-3.38	37.07	1.13	-0.50	46.67	0.95	1.47
50	1543A x SPV 1359	79.76	9.90	97.67**	31.85	0.89*	-2.15	48.54	1.35	0.29
51	1543A x RSV 1427	77.60	-3.321*	-8.03	33.18	0.44	-1.37	45.78	0.38	12.29**
52	1543A x RSV 1460	80.53	6.50	0.03	34.16	-0.07	-1.29	42.95	1.88	-0.21
53	1543A x SPV 1546	82.06	5.33	39.27*	32.65	1.15	-1.69	42.08	-0.31	5.07 **
54	1543A x SPV 1704	94.27	1.44	9.93	37.19	1.80	1.08	47.99	1.68	1.88 *
55	1543A x RPOSV 3	44.60	1.43	73.64**	16.88	2.56	-1.07	41.35	-0.77	14.54 **
56	1543A x RSSGV43	67.12	-3.53	33.53*	27.94	4.16	-0.09	43.16	0.25	1.61*
57	9168A x RSV 458	62.82	-4.291*	-7.82	20.82	3.51	-0.58	42.50	2.03*	-0.53
58	9168A x RSV 1006	67.31	-4.20	-4.37	22.22	1.92	-1.86	42.42	2.32	9.96**
59	9168A x RSV 1093	69.37	-2.05	41.65*	24.66	2.04	-1.81	42.36	0.29	6.66**
60	9168A x RSV 1130	82.83	1.13	-7.74	32.77	4.62	1.90	42.17	1.86	0.85
61	9168A x RSV 1188	69.06	-7.13	64.79**	18.19	-0.14	-1.08	42.23	2.54	-0.09
62	9168A x RSV 1200	71.91	2.95	-5.72	29.54	0.35*	-2.15	40.24	0.93	4.77 **
63	9168A x RSV 1297	74.55	-3.18	92.78**	21.90	-0.73	-1.58	45.26	1.54	15.68**
64	9168A x SPV 1359	74.28	0.69	68.41**	21.38	-0.35	8.07*	41.77	1.19	4.91 **
65	9168A x RSV 1427	63.05	-3.90	28.87*	22.72	3.09	-0.72	41.76	0.75	-0.55
66	9168A x RSV 1460	68.69	-2.23	-4.41	20.79	0.75	-1.33	41.99	0.01	-0.46
67	9168A x SPV 1546	75.11	0.68	-1.80	25.76	2.12	-1.23	43.36	2.76*	-0.48
68	9168A x SPV 1704	67.18	0.06	33.63*	25.24	2.49	0.23	41.78	0.98	-0.48
69	9168A x RPOSV 3	40.75	-0.67	32.71*	23.43	2.98	2.51	39.10	-0.66	4.41**
70	9168A x RSSGV 43	63.05	-1.33	-3.66	18.94	2.84*	-2.12	39.20	0.90	0.12
71	CSH 15 R (c)	72.42	1.65	-8.32	26.83	2.03*	-2.14	42.44	1.53	0.30
	Mean (Hybrids)	74.37			28.94			43.29		
72	104A	66.46	0.80	2.93	28.72	0.70	-1.81	37.81	0.66	6.52 **
73	1343A	71.05	1.67	2.33	30.05	1.79	-1.86	31.26	2.30	3.56 **
74	1409A	53.45	1.53	140.07**	32.22	-0.66	11.05*	26.57	-0.40	6.23**
75	1543A	66.43	2.29	1.20	31.16	0.54	4.32	36.57	-1.55	0.95
76	9168A	58.73	2.67	-8.25	28.06	2.11	0.55	27.40	0.37	-0.34
77	RSV 458	58.77	0.17	-2.82	27.57	1.74	-1.61	42.22	0.97	17.57 **
78	RSV 1006	60.80	3.22	-2.23	24.63	1.64	-2.02	37.34	2.32	1.91 *
79	RSV 1093	78.41	1.15	-5.96	26.63	2.33*	-2.15	40.28	3.44	-0.11
80	RSV 1130	69.81	0.08	-7.81	25.69	0.56*	-2.14	41.64	0.24	6.10 **
81	RSV 1188	76.02	-0.41	-4.37	24.96	2.24	-1.59	44.22	1.56*	-0.54
82	RSV 1200	72.58	3.14	-3.91	23.60	-0.10	-2.05	38.94	0.89	18.18 **
83	RSV 1297	69.97	3.09	-5.35	24.85	0.87	-1.03	38.54	2.01	8.67 **
84	SPV 1359	74.15	1.84	-1.35	22.54	2.14	-1.90	40.53	0.05	0.98
85	RSV 1427	60.68	1.19	-5.36	24.51	3.00	-0.97	38.52	0.39	11.14**
86	RSV 1460	67.69	3.98	23.48	21.43	0.13	-1.86	41.12	2.97	7.40 **
87	SPV 1546	68.59	2.23	-7.06	22.83	0.51	-1.15	31.91	-1.43	8.09 **
88	SPV 1704	66.66	-2.33	-5.83	23.08	0.12*	-2.15	40.86	0.66*	-0.55
89	RPOSV 3	72.44	3.43	-2.01	24.19	4.02	0.14	42.48	2.81	0.95
90	RSSGV 43	44.73	-1.77	3.41	24.85	3.04	3.68	27.22	-1.54	1.14
91	BP 53 (c)	73.87	-0.07	-5.03	28.84	0.40	-1.80	41.49	0.48	0.92
	Mean(Parents)	66.56			26.02			37.35		

* and ** Significant at 5% and 1% level of probability, respectively.

Table 2.3. Stability parameters for protein content in *rabi* sorghum

Sl. No.	Genotypes	Protein content (%)			Sr. No.	Genotypes	Protein content (%)		
		Mean	b_i	S^2di			Mean	b_i	S^2di
1	104A x RSV 458	10.31	3.82	0.40 **	49	1543A x RSV 1297	8.22	1.82	0.78 **
2	104A x RSV 1006	9.33	2.35	2.71 **	50	1543A x SPV 1359	8.83	-2.89	0.78**
3	104A x RSV 1093	8.64	-2.07	0.06	51	1543A x RSV 1427	8.31	1.46	1.42 **
4	104A x RSV 1130	9.86	3.46	0.35 *	52	1543A x RSV 1460	8.06	-1.57	0.17
5	104A x RSV 1188	9.83	0.62	1.45 **	53	1543A x SPV 1546	6.77	4.18	0.02
6	104A x RSV 1200	9.08	4.43	0.04	54	1543A x SPV 1704	8.76	-2.50	0.95 **
7	104A x RSV 1297	9.29	3.22	-0.04	55	1543A x RPOSV 3	8.41	1.50	0.99 **
8	104A x SPV 1359	10.11	0.16	0.06	56	1543A x RSSGV43	8.40	-1.45	0.09
9	104A x RSV 1427	9.09	0.80	-0.05	57	9168A x RSV 458	10.56	-1.14	3.17 **
10	104A x RSV 1460	8.94	-1.37	0.17	58	9168A x RSV 1006	11.50	4.71	0.90 **
11	104A x SPV 1546	9.14	4.07	0.20 *	59	9168A x RSV 1093	10.02	-1.04	1.13 **
12	104A x SPV 1704	9.00	-2.66	0.13	60	9168A x RSV 1130	10.25	0.29*	-0.06
13	104A x RPOSV 3	9.05	-2.18	0.37 **	61	9168A x RSV 1188	11.07	5.67	1.95 **
14	104A x RSSGV 43	9.03	-2.40	1.84 **	62	9168A x RSV 1200	10.70	-1.68	3.33 **
15	1343A x RSV 458	8.25	-0.92	1.52 **	63	9168A x RSV 1297	12.01	-4.19*	-0.05
16	1343A x RSV 1006	8.21	2.89	0.25 *	64	9168A x SPV 1359	11.02	1.66	0.54 **
17	1343A x RSV 1093	8.85	1.74	-0.03	65	9168A x RSV 1427	10.72	2.39	0.88 **
18	1343A x RSV 1130	8.52	0.69	-0.06	66	9168A x RSV 1460	10.06	3.29	-0.05
19	1343A x RSV 1188	9.37	2.64	0.33 *	67	9168A x SPV 1546	9.48	0.09	-0.04
20	1343A x RSV 1200	8.28	3.11	0.24*	68	9168A x SPV 1704	9.41	-1.11	0.69 **
21	1343A x RSV 1297	8.31	1.57	-0.01	69	9168A x RPOSV 3	9.83	2.15	0.78 **
22	1343A x SPV 1359	9.77	4.01	0.36 **	70	9168A x RSSGV 43	9.44	3.82	-0.00
23	1343A x RSV 1427	6.67	-0.77	1.10 **	71	CSH 15 R (c)	8.93	-1.67	4.70
24	1343A x RSV 1460	8.01	1.11	1.46 **		Mean (Hybrids)	9.14		
25	1343A x SPV 1546	6.37	-0.18	1.31 **	72	104A	8.29	2.17	1.95 **
26	1343A x SPV 1704	8.10	2.42	0.59 **	73	1343A	7.83	3.91	0.50 **
27	1343A x RPOSV 3	8.35	-3.69	-0.01	74	1409A	8.11	3.88	0.46 **
28	1343A x RSSGV43	8.52	0.76	1.16 **	75	1543A	8.27	3.68	-0.04
29	1409A x RSV 458	9.94	-1.71	0.09	76	9168A	8.36	4.20	-0.01
30	1409A x RSV 1006	8.53	0.34	0.53 **	77	RSV 458	7.42	4.39	-0.02
31	1409A x RSV 1093	10.35	2.21	0.23 *	78	RSV 1006	8.62	-4.24	2.06**
32	1409A x RSV 1130	9.67	-3.32	0.45 **	79	RSV 1093	7.32	-4.11	0.08
33	1409A x RSV 1188	9.60	-3.24	0.40 **	80	RSV 1130	6.99	-2.07	0.36**
34	1409A x RSV 1200	7.63	4.99	0.97 **	81	RSV 1188	7.21	2.63*	-0.06
35	1409A x RSV 1297	9.41	-2.98	-0.03	82	RSV 1200	7.18	-1.18	2.90**
36	1409A x SPV 1359	9.09	-3.04	0.24 *	83	RSV 1297	7.24	-2.35	0.80**
37	1409A x RSV 1427	7.96	3.11	0.15	84	SPV 1359	8.30	4.59*	-0.06
38	1409A x RSV 1460	8.22	2.44*	-0.06	85	RSV 1427	8.31	2.93	0.80**
39	1409A x SPV 1546	8.79	2.97	0.91 **	86	RSV 1460	8.39	6.60	0.29*
40	1409A x SPV 1704	10.57	1.14	0.01	87	SPV 1546	8.45	-0.06*	-0.06
41	1409A x RPOSV 3	9.65	4.98	0.30 *	88	SPV 1704	8.59	1.77	-0.00
42	1409A x RSSGV43	11.21	3.02	-0.01	89	RPOSV 3	8.19	0.79	0.66**
43	1543A x RSV 458	8.28	2.03	0.07	90	RSSGV 43	8.19	1.88	3.76**
44	1543A x RSV 1006	8.42	2.44	0.51 **	91	BP 53 (c)	9.48	-0.51	3.11**
45	1543A x RSV 1093	8.78	3.37	0.02		Mean(Parents)	8.04		
46	1543A x RSV 1130	8.76	3.65	0.20 *					
47	1543A x RSV 1188	9.29	0.54	1.03 **					
48	1543A x RSV 1200	7.74	-2.33	0.25 *					

* and ** Significant at 5% and 1% level of probability, respectively