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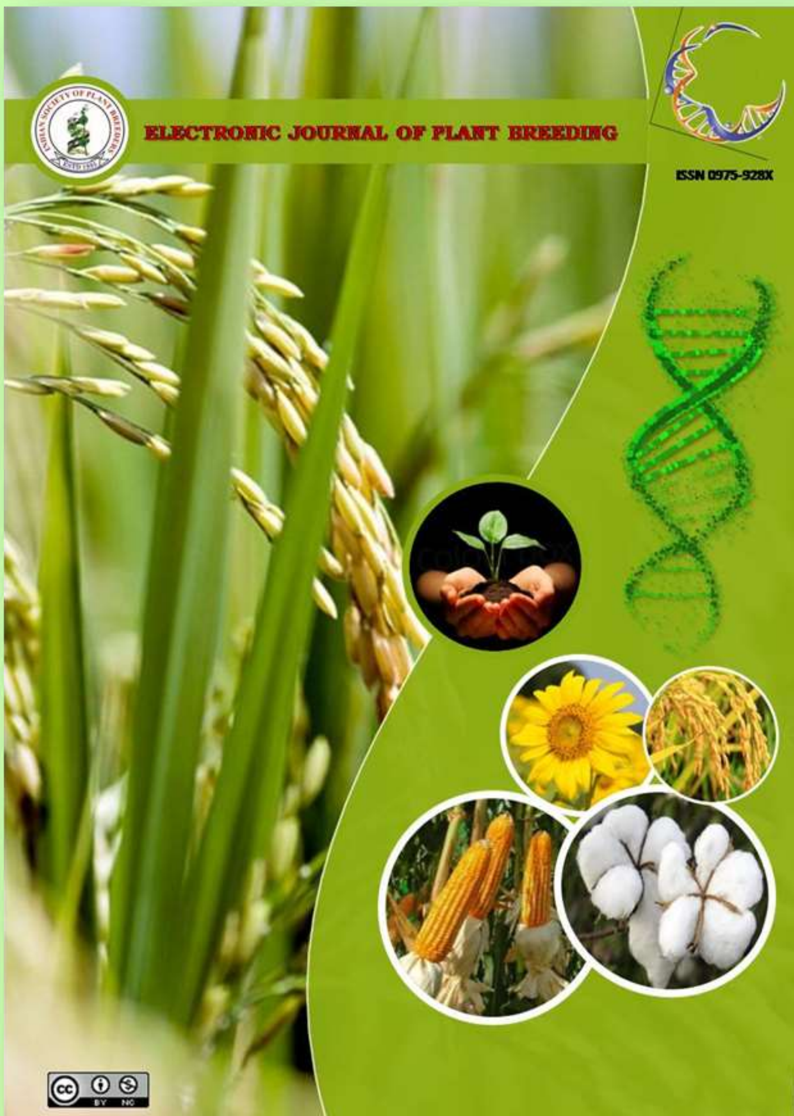

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Research Article

Stability analysis for fodder yield and its contributing traits in forage sorghum [*Sorghum bicolor* (L.) Moench] hybrids

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Abstract
The present study was undertaken with a view to know the G x E interactions and stability parameters in hybrids of forage sorghum for fodder yield and yield attributing traits. Sixty hybrids, 19 parents and 3 checks were evaluated in a randomized block design with three replications with two dates of sowing under four environments during summer and *kharif* 2013. Analysis of variance in individual environment as well as on pooled basis revealed highly significant differences among genotypes, parents and hybrids for all the traits. Stability analysis indicated important role of linear and non-linear components in the contribution of total G x E interaction. The linear portion was considerably high for days to flowering, plant height, number of leaves per plant, stem diameter; green and dry fodder yield per plant. It revealed the prediction of performance of genotypes over environments based on regression analysis could be reliable. The hybrid 27A x SRF 323 was more suitable specifically under good farming conditions for green and dry fodder yield per plant, which had significant b_i above unity, non significant S^2d_i and high mean value. While, hybrids 27A x SPV 2113 and 27A x SRF 327 were more suitable specifically under poor farming situation for green and dry fodder yield per plant. These stable hybrids also recorded stability for one or more of its contributing traits. For earliness, parents 104A and 27A and hybrid 104A x SRF 328 was found suitable for poor environments, where as hybrid 9A x SPV 2113 was found stable in all the environments. The hybrids 14A x SRF 330 and 104A x SRF 317 was found stable for stem diameter, leaf length and leaf width. For number of leaves per plant, hybrids 14A x SRF 323, 14A x SRF 328, 14A x SRF 331, 27A x SPV 1616 and 104A x SRF 317 were found stable. Thereby, these hybrids can be exploited commercially after testing in wide range of environments.

Keywords
Forage sorghum, hybrids, stability, environments, fodder yield

Introduction

Sorghum [*Sorghum bicolor* (L.) Moench] is one of the most important cereals of the semi-arid tropics. The major challenge facing in sorghum research in India is to evolve technologies that will enable transformation of subsistence farming into commercial and profitable production. For accomplishing these objectives, it is crucial to enhance the productivity and stability of sorghum, diversification of the genetic base including hybrid cytoplasm, disease and pest resistance, fodder quality, acid and saline soil adaptability, *etc.* For the systematic and successful breeding programme, the knowledge of genotype x environment interactions and stability parameters is of immense value and provide guidance in the selection of stable and high yielding genotypes. Because of genotype environment interactions, a variety/hybrid does not perform consistently in different agro-climatic situation. These types of situation pose serious difficulty to plant breeders in making proper assessment of varieties/hybrids when the same are compared over a series of environments. Comstock and Moll (1963) statistically confirmed that effect of large G x E interaction could reduce progress from selection. Hence, knowledge of kind and magnitude of G x E interaction had become essential to plant breeder in taking the decisions concerning breeding methods. Even though, stratification of the environment to reduce the G x E interaction and enhance the precision in selection, the interaction of genotype with location in a sub region and with environments within the same year remains very large (Allard and Bradshaw, 1964). Even, if we know the factors responsible for interaction, we can reduce these factors up to certain limit in the field experiments(Sprague, 1966). By this means, the present investigation was undertaken to study the stability performance of parents and newly developed forage sorghum hybrids over different environments.

Material and Methods

The experimental material comprised of 82 genotypes including fertile counter parts of four male sterile lines (9A, AKMS14A, 27A and 104A), 15 male lines (SRF 317, SRF 321, SRF 323, SRF 327, SRF 328, SRF 330, SRF 331, SRF 332, SRF 334, SRF 335, SRF 336, SRF 337,CSV 15, SPV 1616 and SPV 2113), 60 hybrids and three checks (GFS 4, GFS 5 and CSV 21F) were grown in a randomized block design replicated thrice during summer-*kharif*, 2013 at Sorghum Research Station, S. D. Agricultural University, Deesa, Gujarat. The individual environments were created by sowing in two seasons *i.e.*, summer and *kharif* and each season having two different date of sowing with two different dose of fertilizers (Early sowing + 80 : 40 : 00, Late sowing + 100 : 50 : 00) . Each genotype was represented by a single row plot of 4.0 metre length. The inter row and intra row distance was 30 cm and 7.5 to 10 cm, respectively. All the recommended agronomical practices and plant protection measures were followed as and when required to harvest a good crop. Observations were recorded on days to flowering, plant height (cm), number of leaves per plant, stem diameter (cm), leaf length (cm), leaf width (cm), green fodder yield per plant (g) and dry fodder yield per plant (g). Five competitive plants were randomly selected and tagged from each plot of entry for recording observations and average value per plant was computed. The character days to flowering and maturity were recorded on plot basis. The stability parameter b_i and S^2d_i were computed for all parents and hybrids as per Eberhart and Russell (1966) to identify stable parents and crosses for different characters.

Results and Discussion

Analysis of variance revealed that the genotypic component was significant for all characters, which indicated genotypic difference among genotypes tested in different types of environments. The environment component and G x E interaction was also significant for most of the traits. Significant G x E interaction indicated that the genotypes interacted considerably with the changing environmental conditions. The G x E interaction components were relatively larger than the genotypic components and if they were related to predictable environmental factor the breeder searches for a genotypes to must the specific requirements of that environment, while the interaction is small and unpredictable the breeder searches for a genotypes that had general adaptability over the range of environments. Further, G x E interaction component was also significant when tested against pooled deviation revealed that the major components for differences in stability were due to the deviation from linear function (Table 1). The prediction of performance of genotypes over the environments, based on regression analysis for these traits may be very appropriate. However, the linear component of G x E interaction was significant for days to flowering This indicated that genotypes differed genetically in their response to different environment, while, the significant linear component of G x E interaction revealed that the regression coefficient of some hybrids had more or less than unity ($b_i = 1$) and some hybrids were more stable than other over the environments. The linear portion of environment was considerably high for days to flowering, plant height, number of leaves per plant, green and dry fodder yield per plant. This reflected greater importance of linear portion in building up total G x E interactions and the possibility of prediction across the environments for these characters. These results were supported by earlier research workers *viz*., (Patil *et al*., 2006), Narayan (2009), Mungra *et al*. (2011),Umakanth *et al*. (2012).

The stability parameters b_i and S^2d_i were computed for all parents and hybrids as per Eberhart and Russell (1966) to identify stable parents and crosses for different characters. From the present investigation, it was clear that none of the genotypes was stable for all the traits (Table 2a and 2b).Parents 104A and 27A showed significant regression below unity and the least deviation from regression accompanied early flowering. Thus, these parents were identified as suitable for unfavorable environments for earliness. The hybrid 9A x SPV 2113 had lower mean value, non-significant regression coefficient ($b_i = 1$) regression and least deviation from regression indicated suitability of this hybrid in varying environment, whereas the hybrid 104A x SRF 328 had lower mean, significant regression coefficient ($b_i < 1$) and non-significant deviation from regression considered as better in poor environments. The hybrid 27A x CSV 15 was better in favorable environments for earliness with significant regression coefficient ($b_i > 1$) and non-significant deviation from regression. The results were in accordance with Kishore and Singh (2004) and Narayan (2009), Sujatha *et al*. (2016).The character plant height is a major green fodder yield contributing trait. The hybrids *viz.*, 14A x SRF 330, 27A x SRF 321, 27A x SRF 328, 27A x SRF 330, 27A x SRF 336 and 104A x SRF 317 showed average stability because these parent and hybrids had high mean value than check and hybrid mean with non significant b_i and S^2d_i. The hybrid 9A x SPV 2113 with high mean specifically suitable under good farming conditions as it showed below average stability. The most dwarf hybrid9A x SPV 1616 can be specifically adapted for poor farming situation with significant regression coefficient ($b_i < 1$) and non-significant deviation from regression ($S^2d_i = 0$).

The parent SRF 335 and SRF 336 had significant regression above unity and least deviation from regression indicated stable parents for better environments with average more number of leaves per plant. Eight hybrids had non-significant b_i and S^2d_i. The hybrid 14A x SRF 317 had high mean value than average and best checks GFS 5. The hybrids *viz.,* 9A x SRF 336, 27A x SRF 328, 27A x SRF 335, 104A x SRF 327 and 104A x CSV 15 showed non-significant regression coefficient ($b_i = 1$) and least deviation from regression ($S^2d_i = 0$) with more number of leaves per plant, these hybrids considered as average stable. Hybrid 9A x SPV 2113, 27A x SRF 332, and 104A x SRF 328 had higher mean value, significant regression above the unity and least deviation from regression revealed suitability of these hybrids for better environments for number of leaves per plant. The hybrid 104A x SPV 2113 was above average stable for poor environment as it had high mean, significant regression coefficient ($b_i < 1$) and non-significant S^2d_i. The parents SRF 327, SRF 330, SPV 1616 and SRF 328 had thin stem, non-significant regression coefficient ($b_i = 1$) and least deviation from regression indicated stable parents for varying environments, whereas the parent SRF 317,SRF 323 and SRF 335 were found to be specifically stable for favorable environments *i.e.,* below average response to environments for thinnest stem with significant regression coefficient ($b_i > 1$) and least deviation from regression ($S^2d_i = 0$). The parent SRF 321 was average stable with thick stem. The best stable hybrids were 104A x SRF 317, 104A x SRF 337, 14A x SRF 323, 14A x SRF 328, 14A x SRF 331 and 104A x SRF 334 for thinnest stem and favorable in the all environments, they had non-significant regression coefficient ($b_i = 1$) and least deviation from regression ($S^2d_i = 0$).The parents 9A, CSV 15, SRF 335, SPV 1616 and SPV 2113 had non- significant regression ($b_i = 1$) and least deviation from regression with high mean for leaf length so, found suitable under different environmental conditions *i.e.,* average stable. Further, hybrids 14A x SRF 328 and 104A x SRF 317 had high mean values over population mean, non-significant regression coefficient ($b_i = 1$) and least deviation from regression ($S^2d_i = 0$) for leaf length and leaf width with stable performance in varying environmental conditions.

For leaf width, the parent SPV 2113 had high mean value with non-significant regression coefficient ($b_i =$ 1) and least deviation from regression ($S^2d_i = 0$) revealed stable parent across environments. Further, hybrids 14A x SRF 337, 104A x SRF 317, 104A x SRF 334 and 14A x SRF 328 had high mean, regression coefficient near unity and non-significant deviation from regression, better for leaf width and identified as average stable. The hybrids 104A x SPV 2113 and 104A x SPV 1616 with high mean, significant regression coefficient ($b_i > 1$) and least deviation from regression ($S^2d_i = 0$) were specifically adapted to favorable farming situation, while high mean value cross 9A x SRF 321 found suitable under poor farming situation with significant $b_i < 1$ and non-significant deviation from regression. With regard to green fodder yield per plant, total four parents exhibited higher mean than their general mean (389.10 g), among those, SRF 317, SRF 323 and CSV 15 reflected below average stability in unpredictable performance over the environments because the b_i values were above unity and significant non-linear component. None of the stable parent was found to be specifically good under average response to environments for this trait. The hybrids 27A x SPV 2113 and 27A x SRF 323 had high mean and S^2d_i value non significant which showed their stability in the poor ($b_i = -0.55^*$) and the favourable ($b_i = 3.49^*$) environments, respectively. The above results are in conformed to findings of Patel and Patel (2010), Kher *et al*. (2008), Yadav *et al*. (2010), Vange *et al*. (2014) and Shiri (2016).

For dry fodder yield, three hybrids *viz.,* 9A x SRF 328, 14A x SPV 2113 and 104A x SPV 2113 had high mean than population mean, non-significant regression coefficient ($b_i = 1$) and significant deviation from regression therefore, these hybrids produced more dry fodder yield per plant in average environments with unpredictable performance. The hybrids 27A x SRF 323 and 9A x SRF 334 showed above average dry fodder yield per plant with high mean, significant regression coefficient ($b_i > 1$) and non-significant S^2d_i value may be good donor for stability for this trait. Further, the hybrid 27A x SRF 327 with significant regression below unity ($b_i < 1$) and non-significant deviation from regression exhibited more dry fodder yield per plant in poor environments. Best parents and hybrids having general adaptability, Specific adaptability favorable environments and Specific adaptability unfavorable environments for different characters are presented in Table 3.Considering highest mean values, regression around unity and least deviation from regression, it

was observed that none of the genotypes was stable for all the characters in the present study. Therefore, any generalization could not be made regarding stability of genotypes for all the characters. In order to identify stable genotypes, actual testing over wide range of environments including poor and good is necessary because the mean yield of each genotype depends on the particular set of agronomical practices used in the study. While making selection, attention should be given to the phenotypic stability of characters which were directly related to green and dry fodder yield per plant particularly number of leaves per plant, plant height, leaf length and leaf width, so as to achieve maximum stability of various component trait reflecting into fodder yield stability were also reported by various researchers *viz*., Umakanth *et al*. (2012) and Aruna *et al*. (2016).

In the present study, the hybrid 27A x SRF 323 was found to be stable in favorable situations for green and dry fodder yield per plant. The hybrids 27A x SPV 2113 and 27A x SRF 327 were found to be stable in specifically poor environments indicates its potential to be exploited under dry farming conditions for green and dry fodder yield per plant, respectively. Thereby, these hybrids can be exploited commercially after testing in wide range of environments.

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Table 1.Analysis of variance (mean squares) for phenotypic stability for different characters in forage sorghum

Source of variation	df	Days to flowering	Plant height (cm)	Number of leaves per plant	Stem diameter (cm)	Leaf length (cm)	Leaf width (cm)	Green fodder yield per plant (g)	Dry fodder yield per plant (g)
Genotypes (G)	**81**	149.381**	4396.420**	3.516**	1.113**	148.665**	1.685**	31221.708**	3092.642**
Environments (E)	**3**	867.403**	17446.755**	91.424**	4.193**	1973.260**	23.580**	94314.461**	8692.615**
G x E	**243**	29.688**	579.841**	1.435**	0.521**	44.270**	0.726**	8856.271**	831.236**
E + (G x E)	**246**	39.904*	785.535*	2.532**	0.0567	67.794*	1.005	9898.444	927.107
Environments (linear)	**1**	2601.08**	52345.889**	274.257**	12.589**	5919.688**	70.733**	282959.720**	26080.000**
G x E (linear)	**81**	44.176**	695.327	1.712	0.0528	43.532	0.692	10309.156	947.829
Pooled deviation	**164**	22.177**	515.696**	1.281**	0.512**	44.095**	0.734**	8030.584**	763.501**
Pooled error	**648**	2.084	105.469	0.518	0.206	23.925	0.243	644.722	52.998

*** & ** Significant at 5 and 1 per cent levels of significance, respectively.**

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Table 2a.Estimates of stability parameters for days to flowering, plant height and number of leaves per plant and stem diameter

Sr. No.	Genotypes	Days to flowering			Plant height (cm)			Number of leaves per plant			Stem diameter (cm)		
		μ	b_i	S^2d_i	μ	b_i	S^2d_i	μ	b_i	S^2d_i	μ	b_i	S^2d_i
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	(12)	(13)	(14)
1.	9A	74.08	-0.63	41.22**	144.00	1.62	799.47**	10.40	0.54	0.34	6.61	-5.50	2.77**
2.	14A	65.25	-0.98	75.54**	111.83	0.06	163.13**	10.74	-0.32	1.83**	6.11	-0.08	1.18**
3.	27A	71.00	0.95*	0.84	116.08	0.65	249.60**	9.86	-0.23	0.23	6.28	-4.55	1.50**
4.	104A	70.83	0.56*	-0.49	151.42	0.15	121.70*	9.97	0.27	0.01	6.20	2.93	0.71**
5.	SRF 317	83.42	0.01	0.90	215.50	0.38	2690.1**	12.83	1.44	1.14**	5.64	3.12*	-0.00
6.	SRF 321	75.50	-0.32	111.17**	210.00	-0.82	289.30**	9.64	0.21	0.03	6.02	1.27	0.03
7.	SRF 323	73.17	-0.08	206.02**	194.33	2.13	743.12**	12.66	-0.23	0.87**	5.59	1.73*	-0.05
8.	SRF 327	67.33	2.53	60.27**	225.17	1.73*	-5.12	9.55	1.11	0.09	5.22	2.31	0.02
9.	SRF 328	78.83	0.29	5.59**	180.00	3.06	469.44**	10.41	0.32	0.10	5.78	0.23	-0.01
10.	SRF 330	61.08	1.99	72.01**	220.67	0.58	68.40	8.10	0.47	0.34*	5.46	0.81	0.12
11.	SRF 331	72.58	2.17	14.81**	198.17	-0.16	28.37	9.38	-0.20	0.68**	5.26	0.30	0.40**
12.	SRF 332	62.58	2.06	6.91**	233.50	2.15	649.97**	10.09	1.66	7.87**	5.76	0.89	0.77**
13.	SRF 334	64.58	1.69	5.53**	208.58	2.71*	68.65	9.89	0.41	0.36*	5.13	-0.88	0.53**
14.	SRF 335	80.00	-0.55	33.94**	217.58	0.18	423.01**	11.31	1.62*	0.18	5.43	1.19*	-0.06
15.	SRF 336	77.92	-1.00	8.29**	242.33	0.28	710.31**	10.77	1.28**	-0.16	5.68	2.30	0.27**
16.	SRF 337	55.00	2.46	37.79**	152.33	2.40	445.61**	6.89	0.74	0.68**	3.81	2.08	0.39**
17.	CSV 15	73.92	0.72	1.81*	199.75	-0.06	896.11**	11.28	1.30	0.76**	5.88	1.91	0.34**
18.	SPV 1616	71.67	-0.43	18.82**	202.75	0.26	469.28**	11.44	1.61	0.93**	5.57	-1.57	0.13
19.	SPV 2113	72.92	0.13*	-0.01	220.00	-0.72	1548.55**	11.43	1.51	1.99**	5.79	-0.64	0.26**
20	9A x SRF 317	77.50	-0.93*	-0.32	231.50	1.24*	-4.63	11.06	1.47	1.52**	6.06	3.72	0.36**
21.	9A x SRF 321	65.25	0.72	22.63**	227.67	2.20	1078.92**	9.99	0.60	0.68**	5.72	-1.00	0.06
22.	9A x SRF 323	80.42	0.13	0.42	249.25	0.70	577.72**	10.82	3.28*	0.85**	6.35	2.40	0.15*
23.	9A x SRF 327	72.25	0.56	0.58	242.17	2.16	359.72**	10.51	0.81	1.12**	5.81	3.18	0.17*
24.	9A x SRF 328	73.25	0.02	25.44**	256.50	1.65	609.52**	10.32	1.32*	-0.10	5.69	1.05	0.96**
25.	9A x SRF 330	72.58	0.44	30.48**	240.33	0.53	110.46*	11.14	1.00	3.04**	5.83	1.58	0.11
26.	9A x SRF 331	78.75	1.18	8.20**	269.00	2.03	222.30**	11.24	1.94	3.79**	6.19	-0.57	0.46**
27.	9A x SRF 332	75.08	1.58	24.88**	244.67	0.58	470.91**	10.44	1.40	5.06**	5.70	-0.04	0.47**
28.	9A x SRF 334	71.58	0.67	9.60**	273.75	1.99*	52.32	11.02	1.31	1.74**	6.38	1.11	0.21*
29.	9A x SRF 335	77.58	0.54	5.13**	250.00	1.17	787.11**	10.39	0.63	0.52*	5.64	-0.69	0.18*
30.	9A x SRF 336	67.33	2.52	53.56**	239.00	4.16*	452.97**	10.82	0.69	0.03	6.06	3.34	0.75**
31.	9A x SRF 337	61.25	2.33	42.44**	227.25	2.66	789.23**	10.32	1.57	3.36**	5.16	-0.25	1.87**
32.	9A x CSV 15	70.25	1.06	2.66**	222.67	0.96	246.30**	10.43	0.80	0.85**	5.72	1.10	0.63**
33.	9A x SPV 1616	81.92	-0.69	5.12**	98.25	-0.35*	1.64	10.95	-0.49	3.33**	5.14	3.02	0.51**
34.	9A x SPV 2113	66.42	0.23	0.37	242.58	2.21**	-18.80	10.86	1.09*	-0.04	6.16	-2.16	0.38**
35.	14A x SRF 317	79.50	-0.88	13.49**	228.58	1.09	499.15**	11.81	-0.61	0.29	6.14	-0.49	0.28**
36.	14A x SRF 321	70.08	3.04**	1.89*	243.83	1.06	272.05**	10.53	1.42	1.52**	5.97	1.91	0.11
37.	14A x SRF 323	77.33	1.67	51.26**	245.00	0.74	116.44*	10.74	1.06	1.56**	5.77	-1.68	0.03
38.	14A x SRF 327	69.08	3.03	16.25**	233.25	1.83*	40.70	10.13	1.25	3.16**	5.96	5.25	0.24*
39.	14A x SRF 328	74.92	-0.30	9.99**	225.50	-0.61	138.04**	10.57	0.12*	-0.13	5.49	1.87	-0.01
40.	14A x SRF 330	76.75	0.43	4.21**	229.92	0.25	22.38	11.04	0.06	0.39*	6.06	-0.77	0.13
41.	14A x SRF 331	75.50	2.68	20.19**	227.75	-1.20	293.44**	10.66	0.32	2.17**	5.75	2.57	0.12
42.	14A x SRF 332	78.25	0.50	30.79**	237.25	1.47	78.28*	12.21	1.75	0.56*	6.90	0.88**	-0.06

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43.	14A x SRF 334	79.58	0.21	3.33**	193.75	-1.39	7369.89**	11.24	0.99	2.34**	6.01	2.90	0.36**
44.	14A x SRF 335	81.00	-0.17	2.95**	216.00	-0.42*	-10.13	12.33	-0.07	0.35*	6.38	-0.04	0.81**
45.	14A x SRF 336	73.67	0.82*	-0.17	219.25	-1.39	278.51**	11.52	-0.21	3.82**	5.87	1.98	0.23*
46.	14A x SRF 337	61.42	1.22	9.29**	215.75	1.08	1199.79**	11.15	1.46	0.72**	6.17	1.22	0.48**
47.	14A x CSV 15	68.33	2.05*	2.92**	209.17	0.72	75.28*	10.65	1.67	0.42*	6.17	1.26	1.57**
48.	14A x SPV 1616	65.17	1.68	31.42**	211.83	0.93	171.49**	11.35	0.84	0.41*	6.12	3.85	2.90**
49.	14A x SPV 2113	70.17	2.22	30.85**	207.42	-0.47	210.92**	10.44	0.51	0.35*	6.17	2.28	0.89**
50.	27A x SRF 317	73.25	2.41*	5.70**	268.75	0.71	394.56**	11.85	0.94	0.70**	7.07	1.80	1.85**
51.	27A x SRF 321	69.17	-0.23	16.50**	232.83	0.79	25.95	9.87	0.38	1.45**	5.68	5.51	0.95**
52.	27A x SRF 323	70.42	2.90	15.17**	237.42	2.73*	96.67*	11.46	2.13	1.64**	6.56	3.75*	-0.02
53.	27A x SRF 327	66.58	2.62	22.83**	240.58	-0.31	1032.35**	10.51	1.33	0.49*	5.88	-1.15	0.60**
54.	27A x SRF 328	69.83	0.44	36.02**	246.83	1.15	48.36	10.84	0.38	0.25	5.84	2.10	0.02
55.	27A x SRF 330	65.92	0.98	3.68**	252.08	0.86	10.91	10.68	1.18	5.02**	6.09	-0.46	-0.04
56.	27A x SRF 331	67.83	0.90	26.26**	240.67	0.36	336.13**	11.10	0.93	1.13**	6.05	1.04	0.01
57.	27A x SRF 332	72.50	2.50	23.61**	251.00	1.17	317.36**	11.73	2.44*	0.12	6.43	1.06	0.16*
58.	27A x SRF 334	74.25	2.87	29.20**	258.67	1.13	562.56**	11.54	2.19*	0.35*	6.35	0.73	0.98**
59.	27A x SRF 335	78.00	-1.57	15.17**	235.67	1.42	921.32**	11.38	0.31	0.02	5.62	-0.62	0.46**
60.	27A x SRF 336	73.33	0.64	79.73**	250.25	1.15	52.42	11.81	0.75	1.87**	5.76	4.55	0.15*
61.	27A x SRF 337	64.08	2.10	8.89**	237.33	1.67	1719.46**	10.42	1.58	1.61**	5.99	1.45	0.06
62.	27A x CSV 15	67.75	1.25*	0.25	231.58	1.50	527.05**	10.17	0.47	0.94**	6.35	0.40	0.56**
63.	27A x SPV 1616	69.17	2.65*	1.56*	236.25	1.97*	-9.54	10.32	1.44*	0.01	5.82	-0.42	0.11
64.	27A x SPV 2113	70.00	2.85*	4.45**	239.08	1.93	118.38*	10.64	1.65	0.43*	5.87	-1.44	0.04
65.	104A x SRF 317	79.50	0.73	7.24**	246.17	0.98	61.47	11.58	1.31	0.43*	5.77	1.01	-0.04
66.	104A x SRF 321	74.67	1.13	28.75**	251.00	1.94*	20.69	10.60	0.91	0.96**	5.97	-0.65	0.30**
67.	104A x SRF 323	76.17	1.39	60.89**	232.25	1.48	866.02**	10.71	1.44	0.21	5.96	1.43	0.18*
68.	104A x SRF 327	71.00	-1.18	21.18**	241.33	1.39	34.12	11.01	0.69	0.01	6.20	0.05	0.22*
69.	104A x SRF 328	69.08	0.94*	-0.08	237.50	1.15	990.34**	11.14	2.06*	0.12	6.36	1.74	0.30**
70.	104A x SRF 330	67.83	1.90*	3.29**	229.00	-0.03	185.14**	10.63	1.68**	-0.10	5.71	2.33	0.34**
71.	104A x SRF 331	72.50	3.00	38.89**	235.58	0.97	664.09**	11.07	1.13	1.52**	6.09	1.88	0.67**
72.	104A x SRF 332	75.33	0.96	59.84**	230.67	0.62	594.89**	11.22	2.18*	0.62*	5.99	-0.72	0.63**
73.	104A x SRF 334	71.50	0.03	11.79**	212.92	0.38	620.68**	10.50	1.01	0.55*	5.47	0.02	0.05
74.	104A x SRF 335	77.75	1.69*	4.11**	238.50	0.09	840.35**	10.76	0.99	0.84**	5.66	-0.73	0.45**
75.	104A x SRF 336	74.83	0.37	9.25**	238.33	0.94	138.94**	10.93	0.62	0.58*	5.13	2.02	0.30**
76.	104A x SRF 337	65.08	2.71	18.10**	207.92	2.41	271.93**	9.80	1.64	0.58*	5.02	1.04	0.05
77.	104A x CSV 15	68.08	1.44	12.14**	220.83	1.61	145.60**	11.07	1.56	0.30	6.18	1.96	0.59**
78.	104A x SPV 1616	68.42	1.12	18.53**	228.25	2.20	177.17**	10.61	1.42*	0.14	6.01	0.91	0.01
79.	104A x SPV 2113	68.75	1.49	4.61**	231.67	1.07**	-33.61	11.11	0.88*	-0.05	6.46	0.60	0.35**
80.	GFS 4 check	47.25	0.89	10.30**	156.92	1.35	158.47**	7.09	0.78	1.03**	3.75	0.19	0.63**
81.	GFS 5 check	73.83	0.04	1.33	215.50	0.26	206.52**	11.43	0.63	3.02**	4.88	1.16	0.20*
82.	CSV 21F check	75.92	-0.11	1.83*	245.17	0.80*	-17.32	10.96	1.47	1.75**	4.99	2.81	0.41**
	Mean	71.63	1.00	-	222.70	1.00	-	10.73	1.00	-	5.84	1.00	-
	S.Em.±	0.27	0.84	-	0.13	0.90	-	0.65	0.62	-	0.41	0.18	-

*, ** Significant at 5 and 1 per cent levels of significance, respectively

Table 2 b.Estimates of stability parameters forleaf width, leaf length, green and dry fodder yield per plant

Sr. No.	Genotypes	Leaf width (cm)			Leaf length (cm)			Green fodder yield per plant (g)			Dry fodder yield per plant (g)		
		μ	b_i	S^2d_i	μ	b_i	S^2d_i	μ	b_i	S^2d_i	μ	b_i	S^2d_i
[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]
1.	9A	6.80	-0.27	0.23*	75.47	1.03	2.44	317.50	0.03	422.39	90.00	-0.03	84.28**
2.	14A	7.55	0.65	0.96**	65.13	0.27	18.47*	247.92	-1.00	1813.59**	83.33	-1.00	254.21**
3.	27A	7.06	-0.54	1.03**	64.92	0.69	26.95*	223.25	-1.89*	254.00	61.42	-1.71*	21.00
4.	104A	7.58	-0.32	0.72**	58.24	1.24	7.20	341.25	3.37	6486.02**	102.67	3.25	759.02**
5.	SRF 317	6.76	0.46	0.18*	70.82	0.43	7.98	412.92	2.47	1600.72**	133.67	2.63	141.80**
6.	SRF 321	7.62	0.51	3.19**	73.58	1.02	19.28*	336.08	-2.93	3881.78**	120.83	-3.62	751.68**
7.	SRF 323	6.43	0.96	0.29*	78.17	0.79	61.68**	423.33	2.68	4248.24**	117.92	2.54	342.64**
8.	SRF 327	7.03	2.13*	0.08	64.23	1.51	41.36**	305.00	2.44*	163.55	83.83	2.29**	-2.38
9.	SRF 328	7.50	-0.19	0.05	78.37	-0.20	52.15**	354.42	0.44	-129.43	115.00	0.49	-13.00
10.	SRF 330	6.50	0.50	0.28*	63.03	0.55	24.69*	251.25	1.40	829.31**	119.58	1.92	207.59**
11.	SRF 331	7.12	1.09	1.07**	65.28	0.00	6.53	270.92	0.77	862.41**	93.25	0.93	92.50**
12.	SRF 332	5.67	0.98	0.45**	67.09	1.56*	-4.49	333.42	1.77	12504.03**	96.58	1.49	1100.79**
13.	SRF 334	6.55	1.19	0.41**	60.95	1.62	16.58*	239.92	0.17	3982.22**	65.83	0.07	315.59**
14.	SRF 335	6.35	-0.29	0.38**	81.30	-0.24	-5.48	276.50	-0.17	1502.05**	99.67	-0.19	199.10**
15.	SRF 336	5.84	0.62	0.46**	68.03	0.84	30.04**	350.92	0.16	10536.03**	120.67	-0.12	1193.15**
16.	SRF 337	5.44	-1.05*	0.03	51.66	0.72	73.38**	133.42	0.38	3953.59**	41.67	0.28	411.60**
17.	CSV 15	7.70	1.63	1.92**	76.42	1.19	-1.79	401.25	3.52	16359.96**	141.17	3.89	2202.36**
18.	SPV 1616	7.16	0.54	0.43**	73.90	0.83	10.55	356.83	-0.86	7587.22**	110.17	-1.11	643.81**
19.	SPV 2113	7.85	1.08	-0.00	77.40	1.63	12.25	428.92	-1.65	8024.01**	140.33	-1.75	855.97**
20	9A x SRF 317	7.22	0.05	0.32**	76.36	1.72	64.08**	454.17	3.50	4529.99**	160.92	4.07	589.27**
21.	9A x SRF 321	7.92	0.08	-0.04	74.50	1.83	9.49	399.17	-0.42	6736.96**	115.83	-0.55	629.39**
22.	9A x SRF 323	7.04	2.08	0.61**	77.95	1.32	48.14**	422.67	2.61	1086.57**	135.67	3.89	347.93**
23.	9A x SRF 327	7.39	1.08	0.89**	78.63	1.19	11.38	406.75	2.06	10129.67**	135.33	2.19	1116.40**
24.	9A x SRF 328	6.34	-0.44	0.180*	80.61	2.00	9.57	470.42	1.00	14163.14**	147.42	0.95	1351.21**
25.	9A x SRF 330	7.72	2.18	0.500**	76.49	1.76	9.13	448.33	2.72	12423.91**	110.17	2.44	648.29**
26.	9A x SRF 331	7.53	2.14*	-0.013	83.40	0.63	10.88	499.50	-0.12	1867.78**	171.67	-0.07	246.89**
27.	9A x SRF 332	7.80	0.91	0.773**	77.22	2.09	11.31	458.67	-1.06	7933.44**	121.00	-0.83	576.20**
28.	9A x SRF 334	7.62	1.98*	0.079	79.32	2.39*	12.28	429.33	3.67*	689.29*	117.92	3.45**	15.38
29.	9A x SRF 335	6.87	0.65	-0.035	79.08	2.11*	-1.49	412.42	1.72	19915.40**	136.42	2.06	2217.53**
30.	9A x SRF 336	7.36	0.53	0.060	71.36	1.00	118.15**	304.00	1.24	6551.72**	76.25	0.92	435.24**
31.	9A x SRF 337	6.69	0.27	2.054**	63.38	2.03	205.90**	356.92	2.38	10830.89**	92.00	1.80	760.57**
32.	9A x CSV 15	7.23	1.84*	-0.014	75.60	1.60*	1.83	399.25	1.46	1525.51**	106.67	1.28	116.30**
33.	9A x SPV 1616	6.49	0.10	1.719**	72.04	0.12	3.88	133.67	1.64	2411.05**	33.83	1.39	146.68**
34.	9A x SPV 2113	8.17	2.22	0.586**	79.25	2.02*	4.68	526.00	1.35	18649.44**	146.92	1.47	1273.00**
35.	14A x SRF 317	7.24	1.88	0.340**	76.12	0.55	98.53**	432.00	-0.53	17353.41**	139.58	-0.32	1977.52**
36.	14A x SRF 321	7.68	1.93	0.167*	77.41	1.98**	-7.29	375.00	2.25	1439.46**	98.08	1.96	58.28*
37.	14A x SRF 323	7.55	1.48	0.860**	76.47	1.80*	-1.54	488.50	-1.22	7905.16**	131.50	-0.86	536.22**
38.	14A x SRF 327	7.37	1.30	0.505**	68.80	1.01	-2.45	389.33	3.95	11534.51**	113.92	3.75	979.79**
39.	14A x SRF 328	7.24	0.99	-0.033	74.16	-0.22	4.71	392.92	-0.56	11885.32**	133.33	-0.46	1654.29**
40.	14A x SRF 330	8.20	1.03*	-0.053	74.23	-0.25	7.34	480.83	0.13	4106.66**	170.25	0.04	679.62**
41.	14A x SRF 331	7.34	1.04	1.676**	70.22	0.31	20.83*	366.08	0.51	23621.97**	124.08	0.83	2907.49**

42.	14A x SRF 332	7.91	1.21	0.430**	69.82	-0.26	19.33*	541.25	0.24	2231.10**	149.83	0.20	180.81**
43.	14A x SRF 334	7.61	3.03	0.802**	68.73	-1.17	67.24**	432.33	3.42	46416.45**	144.00	3.94	5093.45**
44.	14A x SRF 335	7.78	1.51	1.282**	71.89	-0.89	36.29**	504.33	-0.16	38243.64**	164.42	0.16	4545.94**
45.	14A x SRF 336	7.08	1.58	1.406**	68.26	0.25	43.59**	398.83	-1.22	21675.54**	136.83	-0.86	2201.08**
46.	14A x SRF 337	8.02	0.38	0.010	68.89	1.14	33.56**	381.58	1.52	3260.45**	104.67	1.35	279.16**
47.	14A x CSV 15	7.13	0.61	3.564**	72.47	1.56	5.20	410.33	-0.50	2992.40**	118.83	-0.40	277.79**
48.	14A x SPV 1616	7.21	-0.33	1.955**	71.31	0.52	11.77	354.83	1.60	371.48	81.58	1.08	5.03
49.	14A x SPV 2113	7.55	0.79	4.46**	77.77	0.35	19.76*	474.25	1.35	7079.15**	119.58	1.20	511.62**
50.	27A x SRF 317	7.50	0.71	0.37**	68.60	2.40	74.45**	545.42	-3.30	11718.57**	134.50	-2.68	692.68**
51.	27A x SRF 321	6.65	-0.10	0.09	70.64	-0.18	189.66**	326.83	2.01	657.54*	111.42	2.25*	61.31*
52.	27A x SRF 323	7.30	1.27	3.50**	71.41	1.41	5.89	481.83	3.49**	-116.23	155.50	3.79**	-10.98
53.	27A x SRF 327	8.08	1.39	0.16*	69.04	1.43*	-1.84	471.75	-2.33*	681.88*	126.42	-2.07*	28.38
54.	27A x SRF 328	7.08	1.11	0.11	73.06	0.28	205.16**	392.42	1.94	1186.51**	99.42	1.75	38.32*
55.	27A x SRF 330	7.18	1.62	0.12	73.73	2.11*	-2.98	380.00	-2.03*	100.03	100.25	-1.77**	-13.69
56.	27A x SRF 331	6.95	1.36	0.05	80.15	0.66	106.79**	390.17	-0.29	3619.09**	106.75	-0.27	207.53**
57.	27A x SRF 332	6.97	1.71	0.25*	71.67	1.06	33.06**	415.17	-0.10	1088.56**	105.17	-0.10	40.43*
58.	27A x SRF 334	7.49	0.05	0.56**	69.55	0.91	30.83**	472.33	3.85	17898.10**	130.42	3.28	1660.64**
59.	27A x SRF 335	6.92	0.31	-0.03	76.21	-0.38	94.13**	365.33	2.64	7047.89**	123.08	3.05	765.23**
60.	27A x SRF 336	6.48	1.15	0.99**	71.20	0.43	150.51**	380.75	2.74	3047.41**	122.00	2.84	390.34**
61.	27A x SRF 337	7.48	2.26	0.29**	67.89	0.93	56.24**	422.92	1.13	45220.65**	107.42	0.68	2735.47**
62.	27A x CSV 15	6.83	-0.54	0.07	79.11	1.97	8.00	448.75	-0.19	6627.90**	119.00	-0.42	468.20**
63.	27A x SPV 1616	7.79	2.17	0.59**	77.60	1.78	7.22	441.92	1.69	12030.48**	134.58	1.49	1187.17**
64.	27A x SPV 2113	7.71	2.20	1.12**	76.79	1.91*	-5.11	413.25	-0.55*	210.02	105.58	-0.44*	-2.35
65.	104A x SRF 317	7.63	0.74	-0.01	72.36	0.73	8.42	419.25	-0.10	3163.04**	123.00	-0.21	271.09**
66.	104A x SRF 321	7.56	1.84	1.40**	73.04	1.85	45.31**	443.25	0.76	14851.25**	108.25	0.49	956.25**
67.	104A x SRF 323	7.57	1.06	0.24*	66.32	2.14*	7.75	388.83	-0.07	9880.10**	106.00	0.27	517.95**
68.	104A x SRF 327	7.46	2.67	0.41**	73.05	1.13	36.51**	437.17	0.79	2746.15**	130.75	0.85	235.20**
69.	104A x SRF 328	8.18	1.04	0.17*	72.89	0.97	32.73**	490.42	3.85*	897.79**	135.17	3.21*	145.41**
70.	104A x SRF 330	6.90	0.41	0.86**	72.50	0.90	23.90*	367.08	1.70	14377.94**	100.33	1.37	1169.97**
71.	104A x SRF 331	7.04	-0.73	0.56**	72.10	0.43	-0.44	438.50	2.70	8016.20**	128.50	2.49	846.83**
72.	104A x SRF 332	6.82	1.12	0.26*	66.45	0.95	14.96	456.42	3.14	15728.71**	155.92	3.17	1003.85**
73.	104A x SRF 334	7.29	1.16	0.06	70.50	1.46	110.69**	329.50	-0.34	1599.65**	89.00	-0.29	94.61**
74.	104A x SRF 335	7.09	1.94	0.19*	71.74	1.41	83.67**	358.08	-1.52	4412.01**	119.42	-1.81	376.64**
75.	104A x SRF 336	6.40	1.67	0.06	72.11	0.36	0.05	319.00	2.15	3076.35**	113.42	2.43	426.02**
76.	104A x SRF 337	6.68	1.02	0.41**	64.19	1.05	40.26**	294.83	1.93	3296.20**	89.25	1.94	415.08**
77.	104A x CSV 15	7.69	1.76	0.28*	68.47	1.11*	-6.99	450.67	2.84	26440.75**	135.75	2.66	2653.12**
78.	104A x SPV 1616	7.86	2.02*	0.07	73.23	1.23	67.32**	472.08	3.21	7246.38**	131.17	2.79	711.38**
79.	104A x SPV 2113	8.47	2.62*	0.03	72.76	0.53	58.05**	529.75	0.81	2539.63**	145.67	0.70	192.56**
80.	GFS 4 check	4.54	-0.91	0.24*	53.82	0.21	169.01**	84.00	-0.16	2177.03**	25.08	-0.18	162.51**
81.	GFS 5 check	7.44	1.54	1.20**	87.95	1.46	25.65*	390.17	0.68	5090.69**	138.33	0.84	820.51**
82.	CSV 21F check	6.29	0.62	1.47**	72.74	1.39	16.85*	340.00	3.36**	-127.30	116.17	3.57**	-10.71
	Mean	7.20	1.00	-	72.18	1.00	-	389.10	1.00	-	116.45	1.00	-
	S.Em.±	0.49	0.92	-	0.38	0.78	-	0.52	0.15	-	0.16	0.15	-

*, ** Significant at 5 and 1 per cent levels of significance, respectively

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Table 3. Stability of performance of parents and their hybrids for different characters in forage sorghum

Characters	No. of parents/ hybrids showed stability	Best parents and hybrids (Ideal genotypes) having general adaptability	Specific adaptability favorable environments	Specific adaptability unfavorable environments
Days to flowering	**4(P)** **7(H)**	SRF 317 9A x SPV 2113*	27A x CSV 15*	104A*, 27A*, SPV 2113 104A x SRF 328*, 14A x SRF 336
Plant height	**4(P)** **15(H)**	SRF 330, SRF 331, 14A x SRF 330*, 27A x SRF 321*, 27A x SRF 328*, 27A x SRF 330*, 27A x SRF 336*, 104A x SRF 317*,104A x SRF 327*	SRF 327*, SRF 334, 9A x SRF 317*, 9A x SRF 334*, 9A x SPV 2113*, 14A x SRF 327*, 27A x SPV 1616*, 104A x SRF 321*, 104A x SPV 2113*	9A x SPV 161, 14A x SRF 335
Number of leaves per plant	**8(P)** **16(H)**	9A, 104A, 27A, SRF 321, SRF 328 9A x SRF 336*, 14A x SRF 317*, 27A x SRF 328*, 27A x SRF 335*, 104A x SRF 323, 104A x SRF 327*, 104A x CSV 15*	SRF 335*, SRF 336*, 9A x SRF 328, 9A x SPV 2113*, 27A x SRF 332*, 27A x SPV 1616, 104A x SRF 328*, 104A x SRF 330, 104A x SPV 1616	14A x SRF 328, 104A x SPV 2113*
Stem diameter	**8(P)** **20(H)**	SRF 321, SRF 327*, SRF 328*, SRF 330*, SPV 1616*, 14A x SRF 323*, 14A x SRF 328*, 14A x SRF 331*, 27A x SPV 1616*, 104A x SRF 317*, 104A x SRF 334*, 104A x SRF 337*	SRF 317*, SRF 323*, SRF 335* 27A x SRF 323	14A x SRF 332
Leaf length	**9(P)** **30(H)**	9A*, 104A, SRF 317, SRF 331, SRF 335*, CSV 15*, SPV 1616*, SPV 2113*, 9A x SRF 331*, 9A x SRF 321*, 9A x SRF 327*, 9A x SRF 328*, 14A x SRF 328*, 14A x SRF 330*, 9A x SRF 332*, 27A x CSV 15*, 104A x SRF 317*	SRF 332, 9A x SRF 334*, 9A x SRF 335*, 9A x CSV 15*, 14A x SRF 321*, 14A x SRF 323*, 27A x SRF 330*, 27A x SPV 2113*	
Leaf width	**4(P)** **19(H)**	SPV 2113*, SRF 328*, 9A x SRF 336*, 9A x SRF 335, 14A x SRF 328*, 14A x SRF 337*, 27A x SRF 328, 104A x SRF 317*, 104A x SRF 334*	SRF 327,, 9A x SRF 331*, 9A x SRF 334*, 9A x CSV 15*, 14A x SRF 330*, 104A x SPV 1616*, 104A x SPV 2113*	SRF 337, 9A x SRF 321*
Leaf : Stem ratio	**2(P)** **5(H)**	27A x SRF 327	SRF 335*, SPV 2113*, 14A x SRF 323*, 104A x SRF 323,	9A x SRF 321, 104A x SPV 1616
Green fodder yield per plant	**4(P)** **4(H)**	14A x SPV 1616	SRF 327, 27A x SRF 323*	9A, 27A, SRF 328, 27A x SRF 330, 27A x SPV 2113*
Dry fodder yield per plant	**3(P)** **6(H)**	SRF 328, 14A x SPV 1616	SRF 327, 9A x SRF 334*, 27A x SRF 323*	27A, 27A x SRF 327*, 27A x SRF 330, 27A x SPV 2113

*Genotype's mean value is higher than population mean.

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