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Stability analysis for yield and productivity traits in *rabi* sorghum (*Sorghum bicolor*) under protective irrigation

B V TEMBHURNE[1], P H KUCHANUR[2] and B D BIRADAR[3]

College of Agriculture, Bheemarayanagudi, *Karnataka 585 287*

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ABSTRACT

The phenotypic stability of nine sorghum [*Sorghum bicolor* (L.) Moench] genotypes was studied for grain yield and productivity traits during 2004, 2005 and 2006. Analysis of variance revealed significant differences among the environments indicating adequate heterogeneity of environments and their suitability for evaluating the genotypes. The mean sum of squares for genotypes were also significant for days to 50% flowering, 100-seed weight, grain yield/plant, fodder yield/ha and harvest index revealing genetic variability among genotypes for these traits. The genotype × environment interactions for grain yield and other characters was significant and the significant mean square due to environment (linear) indicated the existence of real varietal differences in characters for regression over the environmental mean. Among the genotypes, SVD 0107 produced the highest mean yield (3 569.80 kg/ha) followed by JP1-1-5 (3 491.60 kg/ha). Considering all the stability parameters, SVD 0107 and JP 1-1-5 exhibited above average stability and DSV 4 registered below average stability for grain yield/ha. Genotype JP1-1-5 showed above average stability for grain yield/ha and wider stability for fodder yield/ha hence, it can be exploited for both grain and fodder purpose.

Key words: G × E interaction, Irrigation, Sorghum, Stability

Rabi sorghum is an important crop of the Deccan Plateau. It is popularly grown in the states of Andhra Pradesh, Karnataka, Maharastra, Tamil Nadu. In India, the area under *rabi* sorghum is 4.8 million ha with a production of 4.1 million tonnes. The productivity is at 971 kg/ha (Chari *et al.* 2009). In Karnataka, area, production and productivity is 1.21 million ha, 1.2 million tonnes and 1 005 kg/ha, respectively.

Rabi sorghum is popularly grown for food and fodder due to its excellent quality of grain and fodder. Though, it is largely grown under residual moisture situations but to some extent it is also grown under protective irrigation. In fact, the resource poor farmers with limited irrigation facilities prefer to grow sorghum rather than maize as it not only requires less moisture but also less fertilizer and plant protection measures. The non-availability of stable genotypes is one of the major reasons for instability in yield of *rabi* sorghum (Prabhakar 2010). The present investigation therefore, was carried out to identify stable and high yielding genotypes of sorghum for cultivation in Deccan Plateau region through stability analysis for grain and fodder yield.

MATERIALS AND METHODS

The field experiment were conducted during *rabi* 2004, 2005 and 2006 at Genetics and Plant Breeding Unit, College of Agriculture, ARS, Bheemarayanagudi in medium black soil. The soils are low in available nitrogen, medium in available phosphorous, but rich in available potassium. Eight sorghum genotypes, viz. Dagadi Solapur, DSV 4, DSV 5, JP 1-1-5, M 35-1, SPV 1359, SVD 0107 and SVD 0108 were evaluated in Randomized Complete Block Design (RCBD) with three replications. The seeds were dibbled at a spacing of 45 cm × 15 cm and the recommended agronomic practices for the region were followed to ensure a healthy crop growth. The trial was conducted under protective irrigated condition. Five plants were randomly selected/plot for recording data on plant height (cm) (measured from the base of the plant to the tip of the plant at the time of physiological maturity), 100 grain weight (g) and grain yield/plant (g). The trait recorded each plot were days to 50% flowering (when anthers dehiscing half-way down the panicle of 50% plants), grain and fodder yield/plot in middle portion of the plot (converted to kg/ha).

[1] Assistant Professor (SS) (e mail:bvtembhurne@gmail.com), Department of Genetics and Plant Breeding, College of Agriculture, Raichur;

[2] Associate Professor (e mail: phkuchanur@gmail.com), Department of Genetics and Plant breeding;

[3] Principal Scientist (srsorghumbreeder@rediffmail.com), All India Co-ordinated Shorghum Improvement Project, RRS, Bijapur

The estimates of harvest index was computed by using the formula of Inamullah *et al.* (2011) and expressed in per cent: HI = GY/BY

Where, HI = Harvest index, GY = Grain yield, BY = Biological yield.

The phenotypic stability parameters; regression coefficients (b_1), and mean square deviations from regression (S^2di) were calculated using the model described by Eberhart and Russell (1966).

RESULTS AND DISCUSSION

The analysis of variance showed that the mean differences among the genotypes were highly significant for days to 50% flowering, 100-seed weight, grain yield/plant, fodder yield/ha and harvest index revealing genetic variability among genotypes for these traits. Analysis of variance also revealed significant difference among environments for all the characters indicating adequate heterogeneity of environments and their suitability for evaluating the genotypes. The mean sum of squares due to genotypes × environment was significant for days to 50% flowering, plant height, grain yield/plant and grain yield/ha when tested against pooled error indicating genotypes interacted strongly with the environments for these traits. Similar results were reported by Prabhakar and Patil (2002), Menshawi (2005), Patil *et al.* (2007), Ezzat *et al.* (2010) and Prabhakar *et al.* (2010).

Variance due to G × E (L) component were significant for all the traits except plant height, fodder yield and harvest index indicating the presence of genetic differences among varieties for their regression on environmental indices and thus further prediction of genotypes will be easy for these characters. The results are in agreement with the finding of Shah and Sharma (2007) for test weight and Prabhakar *et al.* (2010) for days to flowering and grain and fodder yield.

The magnitude of linear component (genotype × environment) was more than non-linear component (pooled deviation) for all the characters except plant height indicating its major role in the expression of these traits and the performance of the genotypes for these traits may be predicted across the environments with great precision. Variances due to pooled deviation were non-significant for all the traits except plant height.

The mean performance of genotypes was statistically analyzed and presented in Table 1. The days to 50% flowering ranged from 81.22 in SVD 0107 to 87.44 in DSV 5 after sowing. Among the genotypes, the highest plant height was obtained in DSV 5 (217.7 cm), while lowest (161.10 cm) in SVD 0107. The 100-seed weight ranged from 2.91 (g) in Dagadi Solapur to 3.44 (g) in M 35-1. However, genotype Dagadi Solapur (36.23 g) recorded highest grain yield/plant and lowest (21.67 g) in DSV 4. The grain yield per ha ranged from 2 821.70 kg in M 35-1 to 3 569.80 kg in SVD 0107. The genotype SVD 0108 registered highest fodder yield (8 892.40 kg/ha) and lowest in M 35-1 (6 001.50 kg/ha). The harvest index ranged from 25.30 in DSV 5 to 32.35 in M 35-1. Genotype SVD 0107 recorded significantly highest grain yield (3569.80 kg/ha) followed by JP1-1-5 (3491.60 kg/ha) over commercial variety M 35-1 (2 821.70 kg/ha) and DSV-5 (2 910.20 kg/ha). However, genotype SVD 0108 (8 892.40 kg/ha) gave significantly highest fodder yield followed by JP 1-1-5 (8 536.70 kg/ha) over M 35-1 (6 001.50 kg/ha). The highest grain yield of genotype SVD 0107 (3 569.80 kg/ha) was recorded due to earliness (days to 50% flowering) and shortest plant height (161.10 cm) among all the genotypes followed by highest harvest index (31.98) except genotype M 34-1 (32.35) for harvest index. Higher values of harvest index (HI) indicated that more dry matter was translocated from leaf and stem to grain in SVD 0107. The results obtained in the present study are in agreement with the findings of Parameshwarappa and Dhanaleppagol (2002) for earliness, Deepalakshmi and Ganesamurthy (2007) for plant height, Tariq *et al.* (2007) and Kumar *et al.* (2010) for harvest index

Table 1 Mean performance of genotypes for yield and productivity traits in *rabi* sorghum

Variety	DFF	PHT	HSW	GYPP	GYH	FYH	HI
SPV 1359	84.67	213.10	3.41	25.48	29 68.20	7 986.50	27.60
SVD 0107	81.22	161.10	3.06	30.05	3 569.80	7 721.00	31.98
JP1-1-5	86.33	194.50	3.31	31.54	3 491.60	8 536.70	28.08
SVD 0108	82.11	190.90	3.14	28.26	3 059.60	8 892.40	25.75
Dagadi Solapur	83.33	184.10	2.91	36.23	3 074.20	6 833.60	32.12
M 35-1	81.33	190.20	3.44	23.25	2 821.70	6 001.50	32.35
DSV 4	87.33	209.6	3.19	21.67	3 338.20	7 662.20	31.31
DSV 5	87.44	217.7	3.24	23.62	2 910.20	8 446.80	25.30
Population mean	84.22	195.10	3.21	27.51	3 154.20	7 760.10	29.31
SE	0.13	19.50	0.07	0.01	209.50	565.30	1.58
CD (*P*=0.05)	0.28	41.82	0.15	0.021	449.38	1 212.56	3.39

DFF, Days to 50% flowering; PHT, plant height (cm); HSW, hundred seed weight; GYPP, grain yield/plant; GYH, grain yield/ha (kg); FYH, fodder yield/ha (kg); HI, harvest index

Table 2 Estimates of environmental indices for each character under different environment

Characters	Environments		
	2004	2005	2006
Days to 50% flowering (DFF)	0.15	–5.31	5.15
Plant height (cm)	7.21	21.44	–28.65
100-seed weight (g)	0.28	–0.03	–0.25
Grain yield/plant (g)	0.00	6.78	–6.78
Grain yield (kg/ha)	1 190.70	–178.76	–1 011.95
Fodder yield (kg/ha)	397.32	1 371.80	–1 769.12
Harvest index	6.46	–3.71	–2.75

and Mahajan *et al.* (2011) for both earliness and harvest index.

The estimates of environmental indices (Table 2) expressed as deviation from grand mean indicated that 2004 (1 190.70) was the most favourable for grain yield/ha, 100-seed weight (0.28) and harvest index (6.46). However, year 2005 (1 371.80) was favourable for fodder yield/ha, plant height (21.44) and grain yield/plant (6.75). While, favourable days to 50% flowering (5.15) was observed in 2006.

Various workers have used different measures of stability. In the present study, the stability is assessed by the parameters suggested by Eberhart and Russell (1966). The stability parameters for various characters are presented in Tables 3, 4. The genotypes, viz. SVD 0107 and JP1-1-5 recorded higher mean grain yield per ha than population mean, higher magnitude (more than unity), regression coefficient (*bi*) and non-significant S^2di, indicating their better adaptability to rich environments (above average stability). However, genotype DSV 4 was suitable for adaptation to poor environment (below average stability) as it recorded *bi* value significantly less than unity, higher mean grain yield per ha and non-significant S^2di (Fig 1). Filho *et al.* (2010) suggested yield was dependent on environment and identified stable hybrids for all environment supports the above finding for grain yield.

The genotype, JP1-1-5 recorded more mean fodder yield than population mean with bi $\simeq$ 1 and non-significant S^2di revealing good stability. However, SVD 0108 was found to be suitable for favorable environment and genotypes, viz.

Table 3 Mean performance and stability parameters for different yield and productivity traits in *rabi* sorghum

Variety	Days to 50% flowering			Plant height (cm)			100-seed weight (g))			Grain yield/plant (g)		
	Mean	bi	S ^{2}di	Mean	bi	S ^{2}di	Mean	bi	S ^{2}di	Mean	bi	S ^{2}di
SPV 1359	84.67	1.24	–1.34	213.10	0.74	–125.50	3.41	1.40	–0.03	25.48	1.24	–7.37
SVD 0107	81.22	1.05	–1.36	161.10	0.93	2675.1**	3.06	1.23	0.00	30.05	0.97	–7.37
JP 1–1–5	86.33	1.59	–1.28	194.50	1.17	3703.10	3.31	1.28	–0.02	31.54	2.17	–7.37
SVD 0108	82.11	0.77	–1.35	190.90	1.15	–104.20	3.14	–0.21	–0.03	28.26	0.67	–7.37
Dagadi Solapur	83.33	0.57	–1.35	184.10	0.93	680.30*	2.91	1.28	–0.03	36.23	1.04	–7.37
M 35–1	81.33	0.93	–1.31	190.20	0.95	–35.00	3.44	1.63	–0.03	23.25	0.71	–7.37
DSV 4	87.33	1.27	–1.31	209.6	1.25	1383.50**	3.19	0.49	–0.03	21.67	0.52	–7.37
DSV 5	87.44	0.57*	–1.34	217.7	0.88	–55.80	3.24	0.91	0.01	23.62	0.67	–7.37
Population mean	84.22			195.10			3.21			27.51		
SE	0.13	0.03		19.50	0.80		0.07	0.27		0.01	0.001	

** P = 0.05, * P = 0.01, bi, regression coefficient; s2di, deviation from regression coefficient

Table 4 Mean performance and stability parameters for different yield and productivity traits in *rabi* sorghum

Variety	Grain yield (kg/ha)			Fodder yield (kg/ha)			Harvest index		
	Mean	bi	S ^{2}di	Mean	bi	S ^{2}di	Mean	bi	S ^{2}di
SPV 1359	2968.20	0.826	–42012.60	7986.50	0.87	–1227717.00	27.60	1.25	–5.754
SVD 0107	3569.80	1.452	20254.70	7721.00	1.10	–1655816.00	31.98	1.39	–9.32
JP 1–1–5	3491.60	1.636	–101731.00	8536.70	1.00	–339736.40	28.08	1.84	11.65
SVD 0108	3059.60	1.027	–52277.60	8892.40	1.41	–1711728.00	25.75	0.98	–9.46
Dagadi Solapur	3074.20	0.869	19369.10	6833.60	1.43	–1638423.00	32.12	0.95	–4.25
M 35–1	2821.70	0.899	–68072.10	6001.50	0.43	834786.80	32.35	0.74	–9.99
DSV 4	3338.20	0.430*	–153257.50	7662.20	0.87*	–1713064.00	31.31	0.25	–6.30
DSV 5	2910.20	0.859	–145920.30	8446.80	0.81	–1140635.00	25.30	0.60	–8.02
Population mean	3154.20			7760.10			29.31		
SE	209.50	0.20		565.30	0.40		1.58	0.28	

** P = 0.05, * P = 0.01, bi = regression coefficient, s2di = deviation from regression coefficient

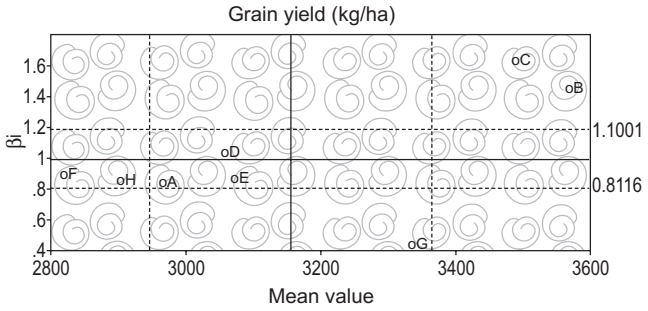

Fig 1 Relationship of grain yield with regression coeficient

A, SPV 1359; B, SVD 0107; C, JP 1-1-5; D, SVD 0108; E, Dagadi Solapur; F, M 35-1; G, DSV 4; H, DSV 5

SPV 1359 and DSV 5 were suitable for poor or unfavourable environment for fodder yield.

From the present study, it is concluded that the genotype SVD 0107 recorded highest grain yield due to earliness and shortest plant height with high harvest index. These two traits that exerted the greatest influence upon the grain yield were important components in *rabi* sorghum. The genotype SVD 0107 was found to be adaptable for favourable conditions for grain yield per ha, whereas JP1-1-5 is a dual-purpose genotype as it was stable for favourable condition for grain yield and wider adaptability for fodder yield.

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